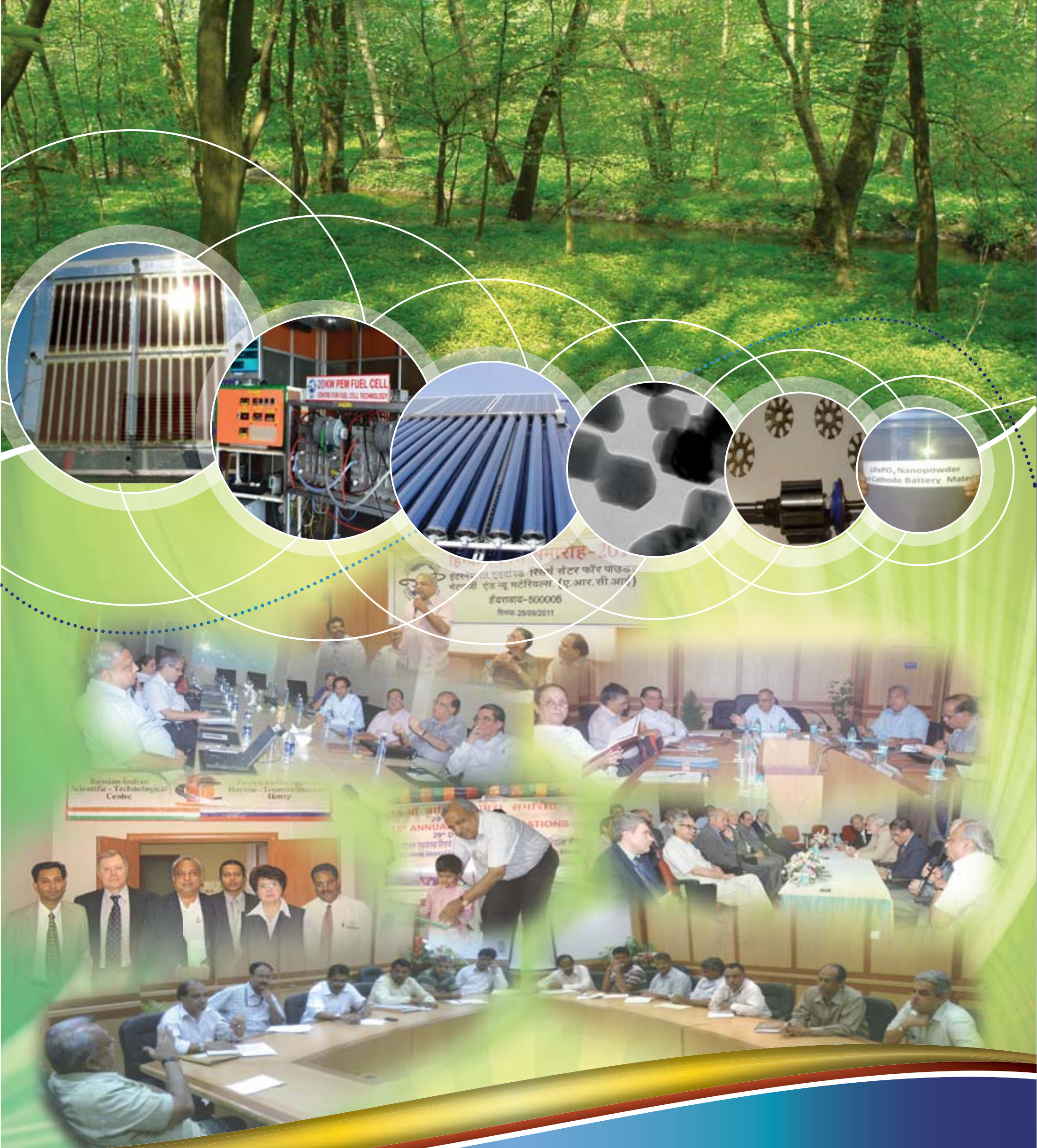

ए आर सी आई
ARCI

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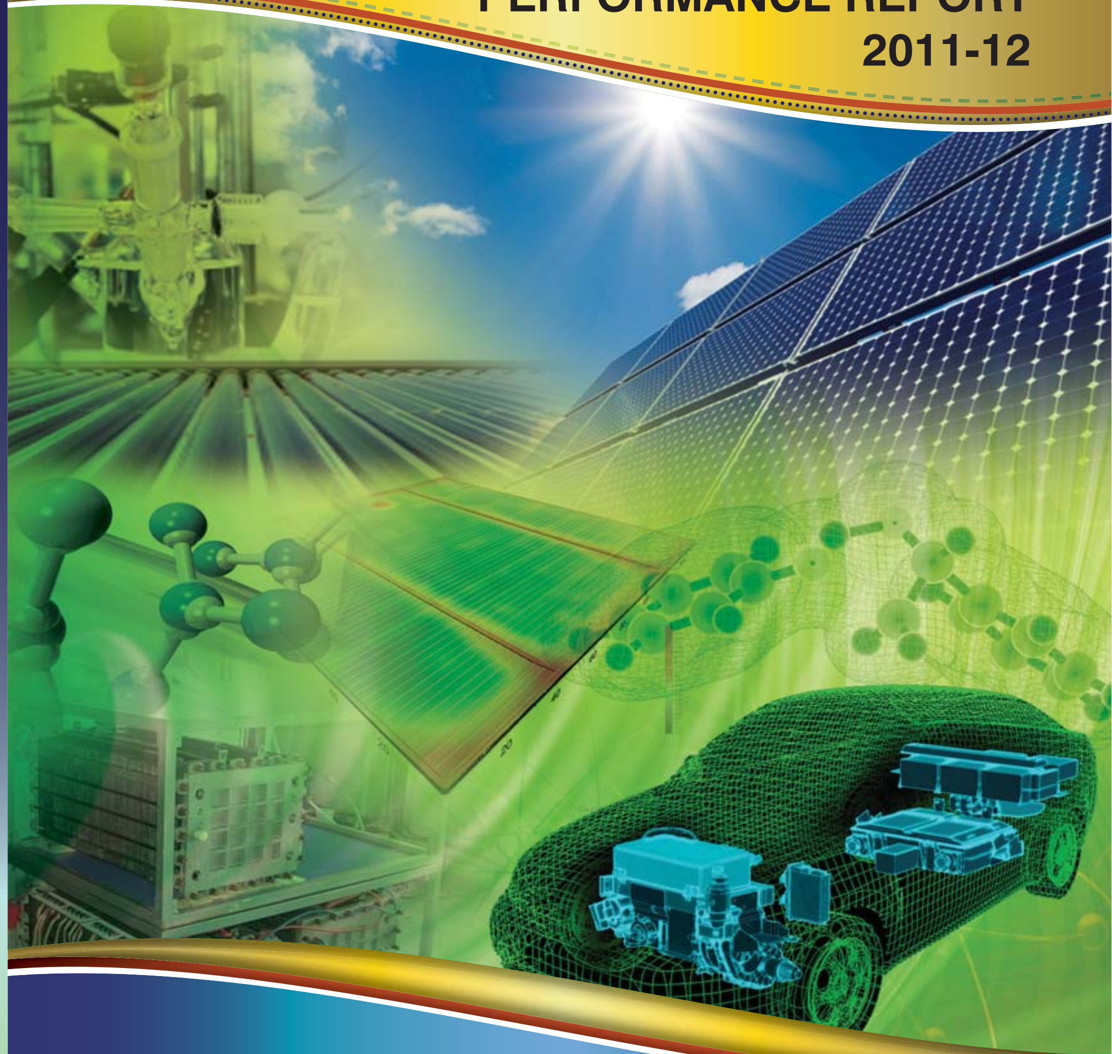
ARCI PERFORMANCE REPORT 2011-12

PERFORMANCE REPORT 2011-12



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ARCI is an autonomous R&D institute of Department of Science and Technology (DST), Government of India, set up with a mission to develop unique, novel and techno-commercially viable technologies in the area of advanced materials and subsequently transfer them to industries.

THRUST AREAS

Nanomaterials

Engineered Coatings

Ceramic Processing

Laser Materials Processing

Fuel Cells

Sol-Gel Coatings

Solar Energy Materials

Automotive Research

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Director's Report

Over the years, ARCI has developed and transferred technologies relevant to virtually all engineering segments to a large number of private industries. In addition, ARCI's technology development efforts have also led to several niche products being supplied to both public and strategic sector organisations. To ensure that multi-disciplinary inputs can be readily harnessed for any of its targeted development efforts, ARCI has formed Centres of Excellence (COEs) in many generic areas related to materials and materials processing, like nanomaterials, ceramics, engineered coatings, carbon materials, sol-gel coatings and laser materials processing. Each of these COEs has been involved in the development of advanced materials-based technologies pertaining to their core expertise. However, ARCI had not consciously focused on any single industrial or social sector for intensive research & technology development. The above scenario changed after 2005, when the Centre for Fuel Cell Technology (CFCT) was established by ARCI in Chennai. More recently, a Centre for Solar Energy Materials (CSEM) and as well as a Centre for Automotive Energy Materials (CAEM) have also been established. Unlike the COEs formed earlier, the above COEs are intended to specifically focus on the development of materials, products and systems for alternate energy and automotive sectors, respectively. CAEM has been set up in Chennai in consideration of the fact that it represents one of the biggest auto clusters in the country.

The establishment of CSEM and CAEM was dictated by the detailed discussions that took place during the last two Governing Council meetings, on the basis of which it was decided that ARCI would address the automotive sector and alternate energy sector more comprehensively, by having all the COEs align their programmes to meet the needs of the above two sectors. While some distributed automotive and energy relevant activities had been previously ongoing in some of ARCI's existing COEs, the decision to specifically target the two sectors will give a fillip to initiation of major programs in these important areas.

The decision to focus ARCI's efforts towards the above sectors was reached after due deliberation. The Indian automotive sector has witnessed explosive growth over the last two decades and is expected to become the third largest in the world after USA and China by the year 2030. If such a scenario becomes a reality, the Indian auto companies (both the vehicle and auto component manufacturers) will have to lead technology development and not have the luxury of buying technologies from abroad since the technology developers would in all probability prefer to enter the Indian market on their own, given the large and commercially appealing Indian market size. The Indian auto industries have, therefore, realized the importance of carrying out their own R&D in frontier areas relevant to the auto sector and also come to appreciate the need for high quality manpower trained in skills required by the auto industry. The Government has also proactively launched a number of pre-competitive research & generic technology development programmes, including the recent one on National Electric Mobility, to provide impetus to the above. It is felt that, given the above scenario, it will be most appropriate for ARCI to utilize its expertise and infrastructure in niche areas to meaningfully contribute to the automotive sector. The various activities to be taken up at ARCI addressing the automotive sector will include the following:

- Establishment of Li-Ion battery line
- Development of magnetic materials for AC Motors
- Development of thermoelectric materials
- Surface engineering for automotive applications
- High strain rate & crash worthiness studies on automotive materials
- Development of light metal alloy automotive components
- Development of high-performance automotive filters
- Development of cerametallic friction facings for automotive applications
- Development of 5 kW fuel cell power pack with thermal management for transportation applications
- Laser and laser hybrid welding of automotive sheet materials
- Development of Al alloy-CNT composites for fastener applications

Activities relating to establishing the Li-Ion battery line on leased space at the IIT Madras Research Park have already been initiated.

Another area which demands a concerted R&D effort in the country pertains to the alternate energy sector. The Government has launched the National Solar Energy Mission to encourage industries to establish solar-based power stations with the guarantee that the power generated can be connected to the grid and that the solar power company will be paid for the grid connected power at rates higher than the normal electricity cost. Windmill based power generation is already well-established in the country. However, on the whole, Indian R&D in the alternate energy sector is in a stage of infancy, especially when compared to the considerable R&D efforts being devoted to areas like the nuclear energy. There is a dire need to carry out application and product based R&D and also to train and develop qualified manpower in the broad area of alternate energy. Therefore, alternate energy represents another sector which is being targeted for intense effort with initial focus on solar energy, so that ARCI can not only assume a leadership role in this field of immense national relevance but also spur indigenous development. The solar energy activities will span both solar photovoltaics and concentrated solar power (CSP). The range of alternate energy related programmes that will be pursued by ARCI will include the following:

- Establishment of pilot line for fabrication of CIGS thin film solar cells
- Ink printed CIGS films for thin film PV application.
- Electrodeposition of CIGS & CZTS layers
- Development of antireflective and self-cleaning coatings for solar panels
- Establishment of facilities for performance evaluation and testing of solar cells/devices
- Development of SiC receiver tubes for CSP
- Development of solar selective coatings for CSP applications
- Honeycomb-based tubes for solar tower
- Establishment of test rig for evaluation of receiver tubes
- Mesoporous metal oxide photoanode for solid state DSSCs
- Development and demonstration of 20 kW PEM fuel cell for stationary applications
- YSZ electrolyte honeycombs for SOFC applications
- Hydrogen generation
- Setting up of a DC feed house

Several of the above activities have already made substantial progress.

During the past year, the various COEs of ARCI have also initiated research and technology development programmes relevant to alternate energy and automotive sectors, based on their respective strengths. These programmes will be further augmented during the years ahead either as in-house (from grants-in-aid) programmes to build technical infrastructure, government sponsored pre-competitive R&D with a partner industry where applicable or through technology development programmes largely funded by the industry. The overarching objectives of all these programmes shall be to develop technologies and products for the industry and/or to create expert human resource in areas relevant to the automotive and alternate energy sectors.

Governing Council Meeting in progress

The Annual report of ARCI for the year 2011-12 reflects the above shift in our focus and provides a brief overview of the wide spectrum of R&D activities already being pursued by the COEs of ARCI that are relevant to the automotive and alternate energy sectors. It is hoped that, by the end of the 12th plan period, ARCI will be a name to reckon with among the researchers and industries in these two areas. The following table compares the performance of ARCI during the past year (2011-12) with that in the preceding year (2010-11), in terms of both research and technology development output in the form of publications and patents, as well as on human resource training efforts.

As in the past, I would like to place on record the constant support ARCI that has received from DST and the Governing Council. I also take this opportunity to thank all the employees of ARCI for their unstinted cooperation and dedication to work. Without such support, ARCI could not have earned the reputation for being an institute that delivers what it promises.

Parameters		2010-11	2011-12
No. of Employees		170	170
No. of Scientists		66	67
No. of Publications*		125	129
Indian Patents**	Granted	22	22
	Filed	28	35
International Patents**	Granted	3	5#
	Filed	3	3
Scientists with Ph.D.		34	39
Scientists Registered for Ph.D.		15	15
No. of Deputations Abroad		35	41

Parameters	2010-11	2011-12
No. of ARCI Personnel who Attended Conferences/ Seminars/Training Courses (in India)	214	243
ARCI Fellows***	25	30
ARCI Trainees	25	33
M. Tech./ B. Tech. Project Students	39	26

*Includes journal publications, conference proceedings and chapters in books
**Cumulative figures up to the end of financial year
***ARCI Fellows also includes Research Scholars
includes same patent granted in multiple countries

G. Sundararajan

(G. Sundararajan)

RESEARCH AND TECHNOLOGY HIGHLIGHTS

Establishment of a Facility for Pilot-scale Fabrication of CIGS Thin Film Solar Cells and Their Characterization

Sanjay R Dhage and R Easwaramoorthy, Centre for Solar Energy Materials

The past decade has witnessed the emergence of solar photovoltaic (PV) technology as a potentially major contributor for meeting the future energy demand throughout the world. The robust and continuous growth experienced in the area of PV during the last ten years is also expected to continue in the coming years. India's Jawaharlal Nehru National Solar Mission (JNSM), launched in January 2010 in order to achieve the government's target of generating 22 GW (20 GW on-grid; 2 GW off-grid) of solar power by 2022, is likely to further spur the development of PV technology in the country.

Due to reduced material and energy input that they demand, the thin-film PV technologies provide distinct advantages over crystalline silicon-based PV technologies. In terms of cost per watt and efficiency, the Copper Indium Gallium Selenide (CIGS) is considered to be a most promising thin-film PV technology. The efficiency evolution of CIGS during the last two years has been the most impressive among the thin-film materials. However, several challenges persist, including reducing the manufacturing costs of CIGS modules and ensuring faster transfer of R&D results to industrial production. Due to the fact that the CIGS manufacturing process is more complex and less standardized than that associated with other types of solar cells, it is necessary to evolve a simpler processing route and keep the manufacturing cycle as flexible as possible. ARCI has decided to adopt a multi-pronged approach while initiating a major program on CIGS-based solar cells that involves (a) comprehensively understanding and then improving existing manufacturing processes (b) developing new process technologies that promise to be cost-effective and environment friendly (c) and systematically benchmarking new processes developed by ARCI with existing ones.

As a part of the above major initiative, ARCI has begun to establish a dedicated pilot line for CIGS thin film solar cells. The pilot line will be capable of handling both glass as well as flexible substrates and will enable ARCI to produce devices based on CIGS thin films. The line will also serve as a benchmark facility for other simultaneously ongoing R & D efforts related to development of two alternate CIGS thin film processes, involving electrodeposition and CIGS inks, that obviate the need for vacuum and selenization treatment. The major process steps involved in CIGS thin film solar cell fabrication are illustrated in Fig. 1.

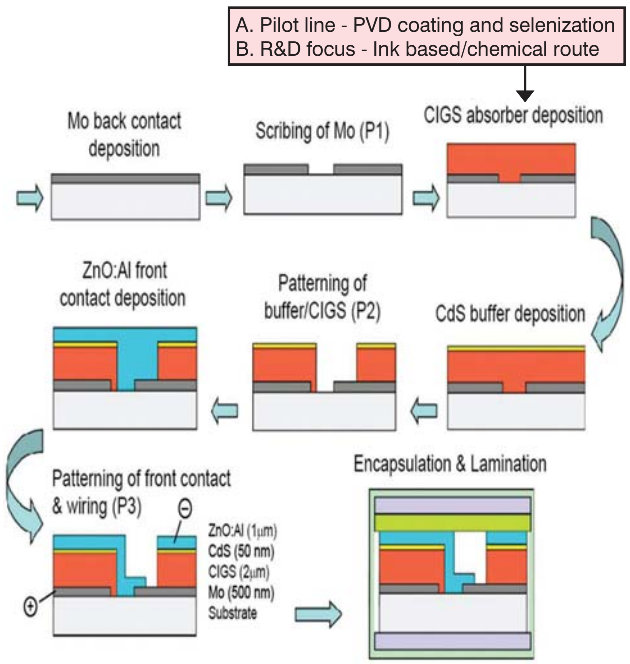


Fig. 1 Process schematic for the fabrication of CIGS thin film solar cells

The CIGS pilot line being established at ARCI will be a unique facility in country, tooled for handling substrates up to a size of 300 mm x 300 mm in a clean room of 100,000 class. The major equipment comprising the line include a Sputter coating system, Evaporator-RTP, Chemical bath deposition (CBD) system, Scriber, laminator and glass washing machine. The line is also being complemented by sophisticated characterization and performance assessment tools such as an XRF, I-V testing system and environmental chamber.

A brief description of various equipment being established at the Centre for Solar Energy Materials (CSEM) as part of the pilot line for CIGS thin film solar cell fabrication, as well as the test facilities been created for evaluation of the solar cells, is provided on the accompanying page.

Some of the equipment that constitute a part of the pilot line for CIGS thin film solar cells have already been installed in the clean room at CSEM. The entire facility is expected to be fully operational by January 2013.

Sputter coater: The in-line sputter coater is tooled for deposition of Mo, CuGa, In, ZnO and AZO on substrates of size 300 mm x 300 mm using pulsed DC rotary tube magnetrons. The sputter coater comprises a loading station, preheating station, two load lock chambers, two extension chambers, two deposition chambers (for metal and oxide deposition) and an unloading station. As film thickness and uniformity are critical, the film deposition parameters can be precisely varied and controlled in the sputter coater to achieve high quality films with excellent electrical and optical properties.

Sputter coater

Evaporator-RTP: The system contains two process chambers for the sulfurization/ selenization process; one chamber is used for deposition of Se/S by thermal evaporation using Se/S powder while the other chamber is used for obtaining the CIGS compound using rapid thermal processing. As sulfurization/selenization is a crucial step after deposition of CuGa and In using the sputter coater and determines the quality CIGS thin film, deposition and RTP parameters can be varied in order to get high quality and uniform CIGS thin films with the desired thickness of 1.5-2 micron.

Evaporator-RTP

Chemical bath deposition system: This equipment is to be used for the deposition of CdS buffer layer by chemical bath deposition. As the buffer layer needs to be with p-type semiconductivity and high transmission properties, the equipment enables deposition of quality CdS buffer layers of about 80-100 nm from salt precursors within few minutes of reaction time.

Chemical bath deposition unit

Scribing system: The scribing system enables pattering of CIGS thin film solar cells at various stages and is also used for edge deletion. The system, comprising a 1064 nm laser as well as a mechanical scribing head, can make monolithically integrated CIGS thin film solar cells with minimum dead zone and large effective area. Generally, scribe P1 on Mo film is done using the laser whereas scribe P2 for CIGS absorber and buffer and P3 for AZO are accomplished using mechanical needle.

Scribing system

Glass washing machine: 300 mm x 300 mm glass is to be predominantly used as substrate for the initial CIGS thin film solar cell activity at ARCI. The quality of the glass as well as cleanliness of the substrate surface are very important and determine the functionality of solar cells. The glass washing machine is used to degrease the glass surface to improve its chemical inertness prior to coating.

Glass washing machine

Laminator: This machine is to be used for lamination of CIGS thin film solar cells on glass or flexible substrates. A CIGS thin film solar cell on a glass substrate can be laminated using standard cure or fast cure using ethyl vinyl alcohol (EVA) as an encapsulant and tempered glass on top to protect against extreme environmental sensitivity. The testing of laminatd module can be done as per IEC standards. The encapsulant ensures a good bond with the glass and forms an optical bridge between the glass and the cells.

Laminator

XRF: As the film thickness, uniformity and composition at various stages of the process are very crucial, the X-ray fluorescence (XRF) spectrometer is to be used for the analysis of thickness and uniformity of various films e.g. Mo, CuGa, In, ZnO, AZO and composition of CIGS and CdS.

XRF

I-V testing system: A Class AAA I-V testing system, with an illumination area of 300 mm x 300 mm, is being set up to test the performance of solar cells and monolithicaly integrated CIGS modules as per certified test standards such as IEC 60904-9, JIS C 8912 and ASTM E 927-05 for Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance.

I-V testing system

Environmental chamber: An environmental chamber is also being established to test the performance of solar cells and monolithicaly integrated CIGS modules as per certified tests such as IEC 61215, IEC 61646, IEC 61730 etc. These tests are meant to assess influence of exposure to thermal, humidity-freeze, mechanical load, twisted mounting surface, hail impact and high voltage isolation.

Environmental chamber

CIGS Thin Film Based Solar Cells From Precursor Inks

Sanjay R Dhage, Center for Solar Energy Materials

Thin film photovoltaic modules represent the next evolutionary step towards cost-effective generation of electricity from sunlight. Thin film Copper Indium Gallium diSelenide (CIGS) has been established as a leading contender to achieve that goal. Off late, researchers from Germany's Centre for Solar Energy and Hydrogen Research – ZSW – have claimed to achieve CIGS thin-film solar cell efficiency of 20.1%. Commercially available CIGS modules demonstrate around 10-13% efficiency, but ongoing research and development on CIGS technology could help realize 15% efficiency at commercial module levels within the next few years. The schematic of an active layer sequence ZnO:Al/i-ZnO/CdS/CIGS/Mo/Substrate of CIGS thin film PV cell is shown in Fig. 1.

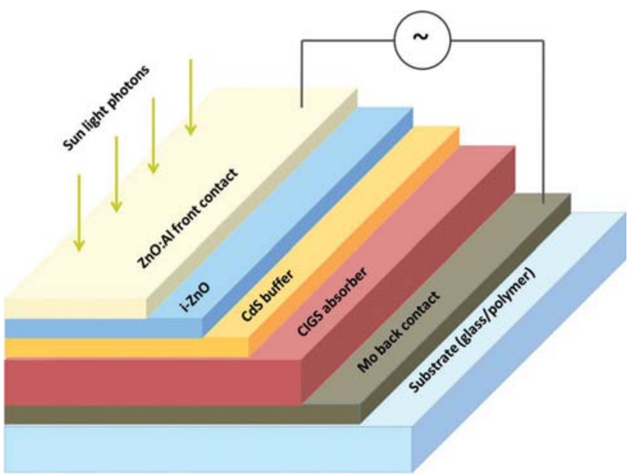


Fig. 1 Schematic structure of CIGS thin film based solar cells

The most common method of fabricating CIGS thin film is the sequential evaporation of metals. Several researchers have attempted various techniques other than co-evaporation to develop CIGS absorber layers. For example, sequential sputtering of precursors, reactive sputtering in H_2Se, hybrid sputtering and evaporation, Rapid Thermal Processing (RTP), Stacked Elemental Layer (SEL) technique, selenisation of amorphous CuIn-O precursors, sprayed metal oxide precursors followed by selenisation, electrodeposition and CIGS thin film preparation from nanoparticles precursors have all been reported. However, in all the above mentioned methods, toxic selenisation and vacuum treatment are unavoidable. The general disadvantage of most of the direct absorber layer formation techniques is the fact that high substrate temperatures (i.e. 300-550°C) need to be maintained during film growth. The high temperature processing and selenisation treatment used in solar cell fabrication are neither cost-effective nor easily scalable for high volume production.

One of the efforts recently initiated at ARCI is aimed at developing environmentally viable and cost-effective process for CIGS thin film preparation without vacuum and selenisation. In this context, the flash lamp technique is being used for the treatment of a CIGS precursor ink constituted of its particles. The process of CIGS film making from CIG metallic alloy and Se nanoparticles by flash light treatment is carried out at room temperature without vacuum and eliminates the selenisation step. Figure 2 shows the XRD pattern of Se nanoparticles, $Cu(In_{0.7}Ga_{0.3})$ (CIG) metallic alloy nanoparticle precursors, and an as-prepared CIGS film using flash light treatment, clearly showing planar reflections of CIGS in good agreement with the reported references (JCPDS No. 35-1102). Surface morphology of a CIGS film prepared by flash light treatment is also shown in Figure 2. An overall surface morphology of compact grains separated by grain boundaries with very few voids is seen. The morphology of larger grains clearly indicates diffusion and sintering of the particles in the film. The advantages of the current process are very short reaction time (milliseconds) and compatibility with temperature-sensitive flexible substrates without vacuum or selenisation treatment. Thus, Flash light treatment for the preparation of CIGS thin films has great potential to replace existing vacuum based processing routes.

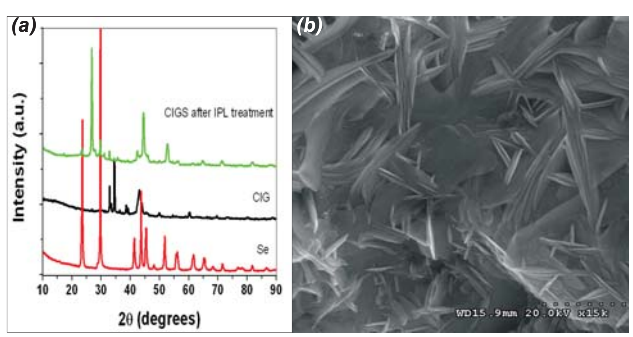


Fig. 2 (a) XRD pattern of Se nanoparticles, CIG metallic alloy nanoparticle precursor materials, and CIGS film prepared using flash light; (b) Surface morphology of the CIGS film prepared from CIG and Se nanoparticle ink

Pulse Electrodeposition of CIGS Thin Films for Solar Cell Applications

M Sreekanth and B V Sarada, Centre for Solar Energy Materials

There has been an overwhelming interest in solar cells as a source of renewable energy in the last few decades since the limitations of fossil energy resources are now widely recognised. For terrestrial power applications, the economics and superior energy balance favour thin film options to harvest solar power. Among the thin-film technologies, amorphous hydrogenated silicon (a-Si:H) and the polycrystalline heterojunction systems CdS/CuxS, CdS/CdTe and CdS/$CuInSe_2$, are already in pilot production. However, solar cells with an absorber layer made from Cu(In, Ga)Se_2 are the most rapidly growing materials among the Cu-based chalcopyrites. $CuInSe_2$, with its high optical absorption coefficient is a good choice for use as a microcrystalline absorber material. Inclusion of Ga atoms on the In site, such that the ratio of Ga/(Ga + In) is around 0.20 and shifts the bandgap from 1.04 to 1.15 eV, which is nearly perfect for a single junction cell. Today, thin-film solar cells having a Cu(In, Ga)Se2 absorber layer have demonstrated with laboratory efficiencies up to ~20%. Due to attractive properties of CIGS, various vacuum-based fabrication techniques have been developed. However, there is a need for cheaper fabrication processes to reduce the cost of solar cells due to the high cost of vacuum techniques. Among the non-vacuum based technologies, electrodeposition is an appealing technique as it enables use of low cost equipment, besides providing efficient materials utilization and scalability for large-area thin-film deposition.

In the present work, pulse electrodeposition is employed for the preparation of CIGS thin films on Molybdenum substrate. The effect of chemical bath concentration, pulse parameters and deposition potential on the formation of CIGS thin-film of desired stoichiometry has been studied. Deposited films were annealed at 550°C under Ar atmosphere. SEM-EDS, XRD and Raman spectroscopy techniques were used to study the morphology and crystallinity of CIGS thin films. Results showed a spherical particle-like morphology and near ideal stoichiometry with the required chalcopyrite structure. Thus, it has been demonstrated that pulse electrodeposition, with optimized pulse parameters can result in a dense absorber layer with near ideal stoichiometry (Cu – 24.52 In – 18.41 Ga – 6.35 Se – 50.72 corresponding to $Cu_{0.98}In_{0.73}Ga_{0.25}Se_{2.03}$) and required phase constitution.

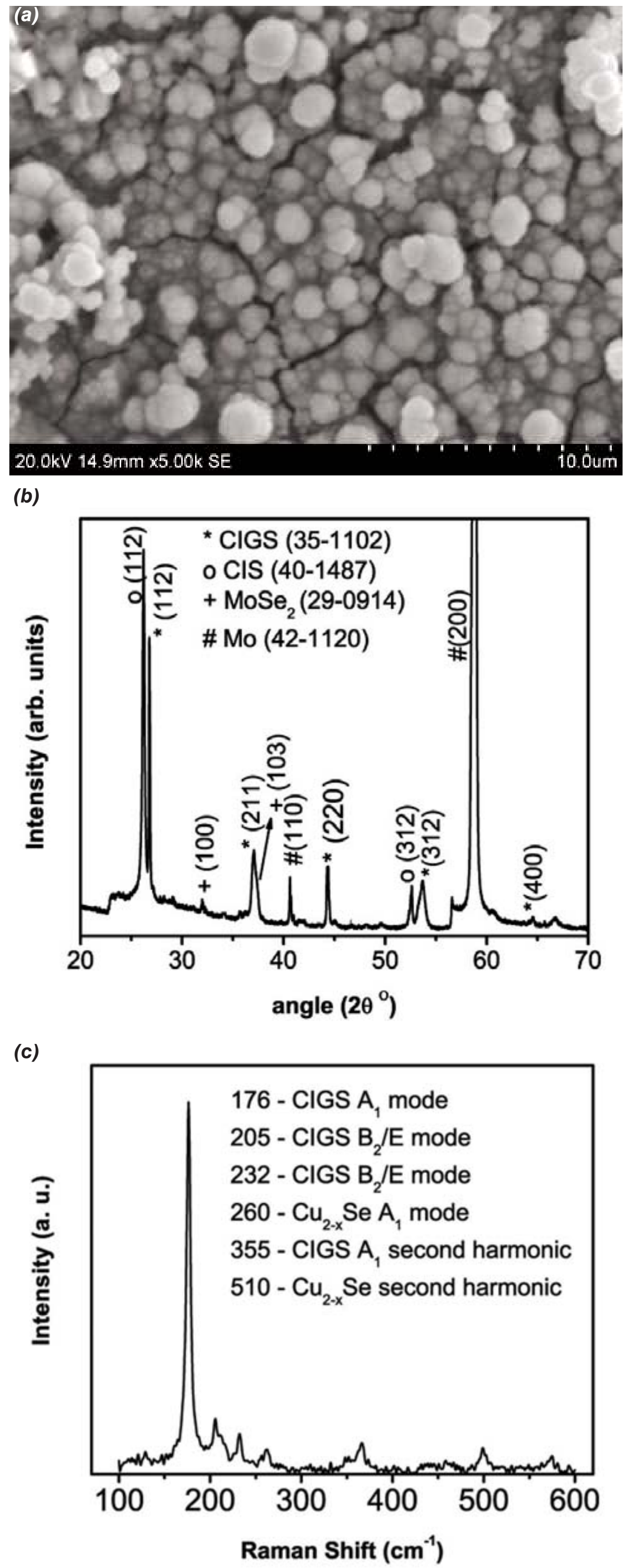


Fig. 1 (a) SEM micrograph, (b) XRD pattern and (c) Raman spectrum of pulse-electrodeposited and annealed CIGS thin film

Preparation of CZTS Thin-films by Pulse Electrodeposition for Photovoltaic Applications

Girish Salian and B V Sarada, Centre for Solar Energy Materials

While solar cells based on single-crystal silicon or III-V group semiconductors exhibit very high efficiency, the cost of electricity produced by crystalline silicon panels is still significantly higher than the cost of today's grid power. In order to increase the use of solar power, there is a need for new technologies to both decrease the cost and increase the efficiency of photovoltaics. Thin film solar cells offer the opportunity to lower the price of solar energy by using small amounts of materials and adopting low cost manufacturing technologies. $Cu(In,Ga)Se_2$ thin-films have attracted much attention in this respect. However, this compound contains less abundant and expensive materials, such as Indium (In) and Gallium (Ga) which can potentially inhibit cost-effective large-scale production. The toxicity of Selenium (Se) is also an added concern.

To overcome these limitations, alternative materials have been researched in order to substitute the expensive elements, In and Ga with more earth-abundant elements. The quaternary semiconductor Cu_2ZnSnS_4 (CZTS) thin films have drawn much attention in recent years as a possible low-cost photovoltaic material due to its high absorption coefficient of 104 cm^{-1} and a direct band gap of 1.4–1.5 eV. The abundance and non-toxicity of the constituent elements also makes large-scale deployment of the device feasible.

Electrodeposition is a potentially attractive preparation method to obtain a low-cost absorber layer of CZTS. The electrodeposition process can provide a high quality film with very low capital investment. This high-rate process uses low-cost starting materials and is based on automatic purification of the deposited materials during plating. It also enables large-area, continuous, multi-component, low-temperature deposition at controlled rates and effective material utilization.

In the present work, CZTS thin-films were synthesised using pulse electrodeposition on a Molybdenum substrate. The chemical concentration of the precursors, the pulse parameters and the deposition potential were optimised to obtain a near ideal stoichiometry. The absorber layer was annealed in Argon atmosphere at 550°C for 1 hour. The morphology and stoichiometry were studied using SEM (Fig.1) and EDS (Fig.2), respectively. Results revealed near-ideal stoichiometry of the film with the morphology revealing presence of spherical particles. Pulsed electrodeposition was thus found to facilitate preparation of CZTS thin-films with very less porosity, good adhesion and near-ideal stoichiometry. These films are now being studied for their performance.

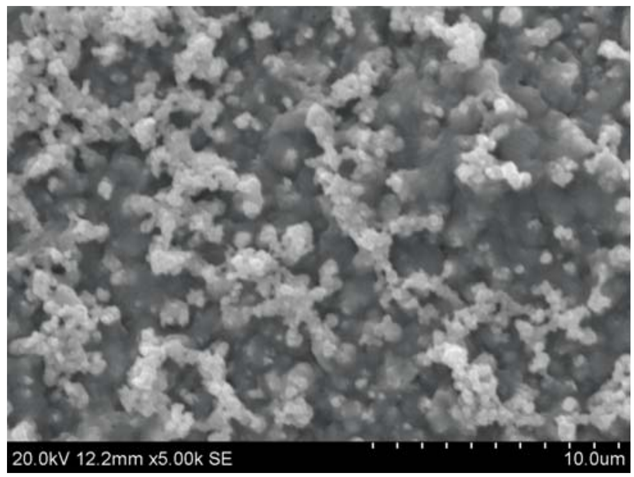
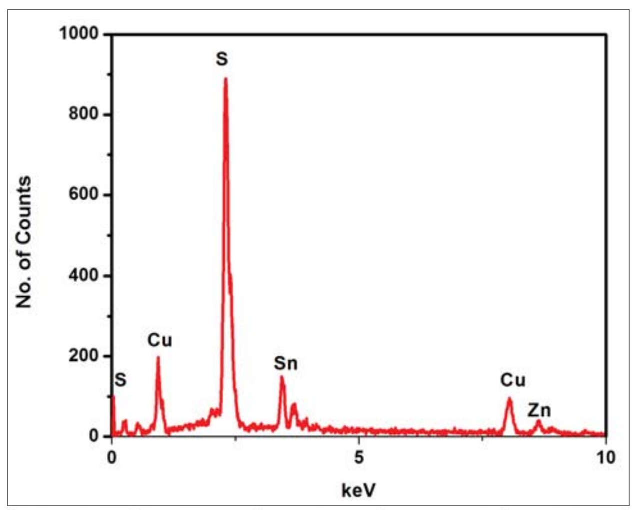


Fig.1 SEM micrograph of CZTS thin-film prepared by pulse electrodeposition



Cu	Zn	Sn	S	$Cu_{1.67}Zn_{0.7}Sn_{0.79}S_{4.83}$
20.96 %	8.86%	9.94%	60.24%	

Fig. 2 EDS spectrum of CZTS thin-film prepared by pulse electrodeposition

Mesoporous Metal Oxide Photoanode for Solid-state Dye-sensitised Solar Cells

Easwaramoorthi Ramasamy and Anil Kumar Bharwal, Centre for Solar Energy Materials

Dye-sensitised Solar Cells (DSCs) based on nano-crystalline TiO_2 photoanode and liquid redox electrolyte offer a low-cost, high-performance route of converting solar energy to electric energy. State-of-the-art DSCs convert more than 12% of incident solar light into useful electric energy under standard test conditions (Air Mass 1.5G, 100 mW cm^{-2}). Nevertheless, the presence of corrosive iodine/tri-iodide redox couple in a liquid electrolyte, to regenerate the dye molecule, presents practical challenges. Besides, high energy UV light liberates electrons and creates a hole in the TiO_2 photoanode which, in turn, irreversibly oxidizes the dye molecule and accelerates photovoltaic performance degradation.

Several interesting approaches are being investigated to improve efficiency and durability of DSCs. Replacing liquid electrolyte with solid-state Hole Transporting Material (HTM), such as an inorganic p-type semiconductor or a conducting polymer, is gaining momentum. The common problem in the replacement of liquid electrolyte by solid-state HTM is incomplete pore-filling of the photoanode. As the photoanode thickness is significantly less than that of light absorption depth (about 20 μm), solid-state DSCs exhibit incomplete light harvesting and only ~7% efficiency.

From the solid-state DSC point of view, an ideal photoanode material needs to harvest most of the incident photons and should facilitate the infiltration of HTMs into the deep pores of the photoanode. Herein, we demonstrate that mesoporous SnO_2 can serve as an ideal candidate material for efficient and stable solid-state DSCs. More positive conduction band edge position and high electron mobility (100-200 cm2V-1S-1) of SnO_2 can facilitate electron injection from photoexcited dye molecules and electron transport to current collector substrate, respectively.

Mesoporous SnO_2 spheres were synthesised by self-assembly reaction of sucrose/SnCl4 aqueous solution in an autoclave maintained at 190^{o}C for 24 hours followed by residual carbon removal at 600^{o}C. The particle size and porosity were tuned by controlling the precursor ratio and synthesis parameters. The diameter of the SnO_2 spheres was noted to be in the range of 1-2 μm. The high resolution FESEM image in inset of Fig.1 suggests that SnO_2 microspheres are made up of SnO_2 nanoparticles with an average diameter of about 30 nm. The crystalline phase in mesoporous SnO_2 spheres was evaluated from X-ray diffraction spectra and all diffraction peaks can be well indexed to a rutile SnO_2 structure. BET surface area and pore size of SnO_2 microspheres are found to be 70 m2g-1 and 12 nm, respectively. The intrinsic disadvantages of SnO_2 material, namely low isoelectric point and fast electron recombination kinetics, were successfully overcome by Mg doping. Introduction of Mg into the SnO_2 framework effectively passivated the sub-band edge surface states and also increased the isoelectric point without disturbing their microstructural features as evidenced from XRD, BET surface area and UV-Vis analysis.

The photoanodes made of custom-tailored, Mg-doped SnO_2 microspheres exhibit higher dye loading and strong light scattering ability in the long wavelength region than that of control samples prepared with SnO_2 nanoparticles. The results establish that optimum light harvesting and HTM infiltration can be achieved through use of a mesoporous photoanode. Fabrication of efficient and stable solid-state DSC (Fig.2) is now underway.

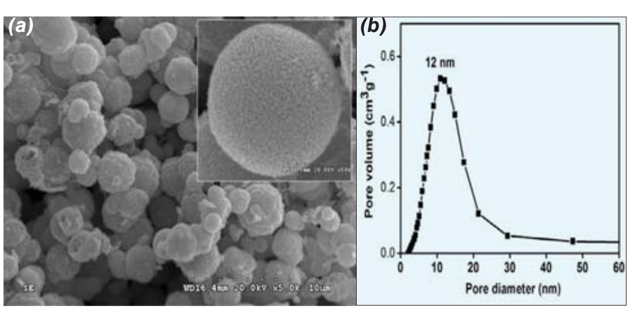


Fig.1 (a) SEM image of Mg-doped SnO_2 microspheres and (b) BJH pore size distribution curve

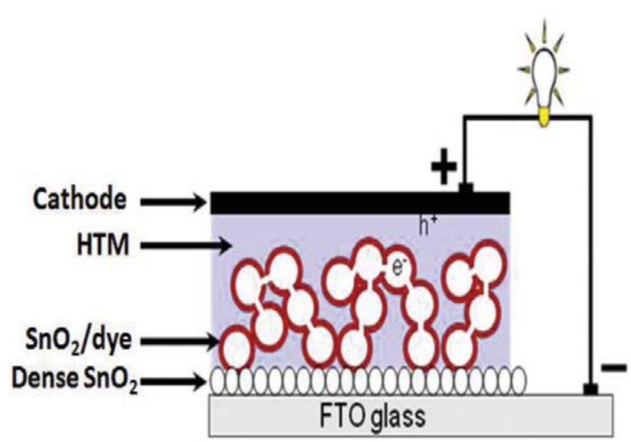


Fig.2 Schematic of solid-state DSC with hole transporting material layer

Processing and Performance Evaluation of SiC Tubes For Solar Thermal Absorber Applications

Bhaskar Prasad Saha, Centre for Non-Oxide Ceramics

In order to meet the growing scarcity of power supply, the Government of India has taken several recent initiatives to develop alternate energy resources. ARCI has also initiated several activities aimed at playing a leading role both in the area of concentrated solar power (CSP) and solar photo voltaics. A major activity at ARCI concerns comprehensive development and demonstration of a SiC-based solar thermal receiver, which is a key element of any solar thermal power plant, operating at temperatures up to 1000°C, compatible with use of pressurized water/air/oil/molten salts as a solar thermal receiver must possess excellent solar thermal absorption (>98%), low emissivity (<0.4), and high conductivity. Silicon carbide, with appropriate surface modification through judicious selection of surface coatings, has been found to have excellent solar absorbance and moderate emittence. This, coupled with the inherent physical, chemical, thermal, and mechanical properties of SiC, makes it an outstanding candidate as a central solar absorber for CSP applications. Moreover, the considerable expertise in the area of SiC and infrastructure for its processing available at ARCI provide additional motivation to pursue the above activity.

The key components of the program aimed at demonstrating the efficiency of SiC tubes for solar thermal absorber applications include the following:

(i) development of process for drawing SiC tubes up to 1.5 m length and 20 mm diameter with wall thickness of 3 to 6 mm

(ii) development and optimization of process for welding/joining of SiC tubes, involving both SiC-SiC and SiC-metal joints

(iii) development and optimization of suitable coating technology compatible for SiC to achieve high solar absorbance(>95%) and low emittence (<0.2)

(iv) comprehensive testing and evaluation of bare and coated, single and welded/joint SiC tubes using a self designed test rig.

SiC tubes of 650 mm length have already been processed using cold iso-static pressing followed by sintering. These tubes were subjected to brazing using an in-house developed alloy strip. Brazing was carried out in vacuum at 1350°C. Figure 1 (a) & (b) show the sintered and braze joined SiC tubes. X-Ray mapping of brazed joint showing distribution of different elements is shown at Figure 2. Elemental distribution of brazed joints is given at Table 1. Detailed thermo-mechanical property evaluation of the tubes is in progress. Development of coatings by sol-gel and cathodic arc physical vapour deposition is also ongoing. The design of a test rig for evaluating receiver tube performance has been already completed and the rig is expected to be installed shortly.

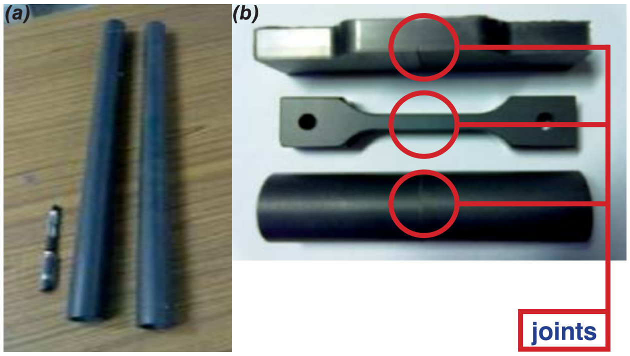


Fig. 1 (a) Sintered SiC tube (b) braze joined SiC parts

Table 1 Distribution of elements at different locations shown in the microstructure

	C-K	Si-K	Ni-K	W-L
Location 1	56.26	15.53	27.91	0.30
Location 2	66.19	13.75	19.80	0.26
Location 3	42.75	56.90	0.26	0.09

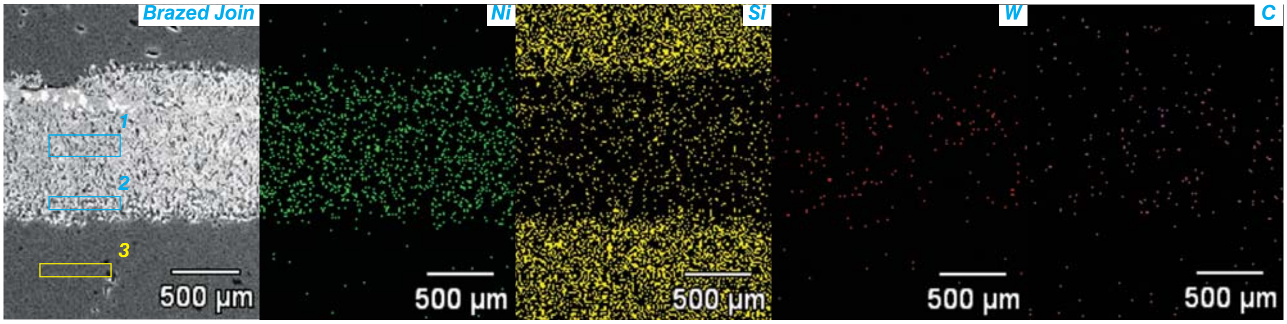


Fig. 2 X-Ray mapping of brazed joint showing distribution of different elements

Sol-Gel Multifunctional Coatings for Renewable Energy Sector

a) K R C Soma Raju, D Sreenivas Reddy, R Subasri and G Padmanabham, Centre for Sol-Gel Coatings
b) Nikhil Barua, K Murugan, R Subasri and G Padmanabham, Centre for Sol-Gel Coatings

The Centre for Sol-Gel Coatings has focussed on development of following functional coatings for solar thermal applications through the sol-gel route:

a) Development of Solar Selective Coatings on Stainless Steel Absorber Tubes

A solar selective coating is characterised by a high absorbance (≥95%) over the solar spectral range and low thermal IR emittance (<14%). Usually, a multilayer stack is generated so as to provide the solar selectivity. A typical stack, as represented in the inset of Fig. 1, was generated through sol-gel route on flat stainless steel SS 304 substrates in the present development. The substrate surface finish, coating thickness, deposition conditions and heat treatment parameters were optimised to obtain maximum absorbance and minimum emittance. The average absorbance obtained for the selective coatings over the wavelength range 300-1500nm was 94±1% and thermal IR emittance was 14±1% as shown in Fig. 1. The coatings were found to be stable after 20 cycles of thermal cycling, in air, at 350°C and showed good corrosion resistance by withstanding 80 hours of salt spray testing carried out according to ASTM B117. The developed coatings were further deposited on 1m long tubes (as shown in inset of Fig. 1) and heat loss tests revealed that the optical efficiency for solar to thermal energy conversion was 60%, which is at par with the currently available chrome based coatings. The present development was found to be promising for scale-up also.

b) Development of Antireflective Coatings (ARC) on Borosilicate Cover Glass Tube (BSC)

ARC is used to reduce the reflection from substrates, to improve the transmission. They consist of a thin interferential layer whose refractive index is between the substrate and air, or a multi-layer stack comprising alternating layers of high and low refractive index. From a technology development point of view, developing a single layer, low refractive index coating is preferred over a multilayered coating stack for anti-reflective applications, where the porosity in the single layer coating has a gradient from the substrate-coating interface towards the coating-air interface. In an attempt to develop such a graded index coating on BSG substrates, porous silicate-based anti-reflective coatings were generated using the sol-gel route and characterised with respect to their visible light transmittance. Optimised coating thickness, heat treatment conditions yielded 97% visible light transmittance of coated BSG vis-à-vis 92% for the bare BSG substrate. The pencil scratch hardness of the coating was determined to be 5H. The durability of the ARC was evaluated by performing crockmeter tests (scratching under 9N load using fibres), that showed 1% deterioration in transmittance after 1000 cycles of testing according to AATCC test method 8. Ellipsometric studies on the AR coated BSG showed the gradient in refractive index from 1.53 to 1.37 for a layer thickness of 300nm (as shown in inset of Fig. 2).

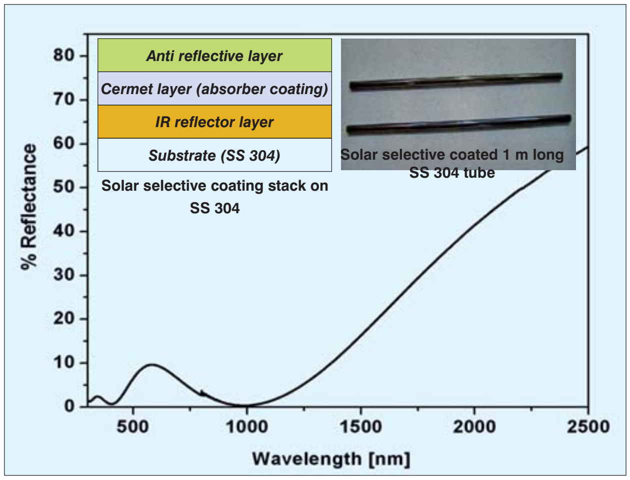


Fig. 1 Spectral dependence of reflectance of the solar selective coating

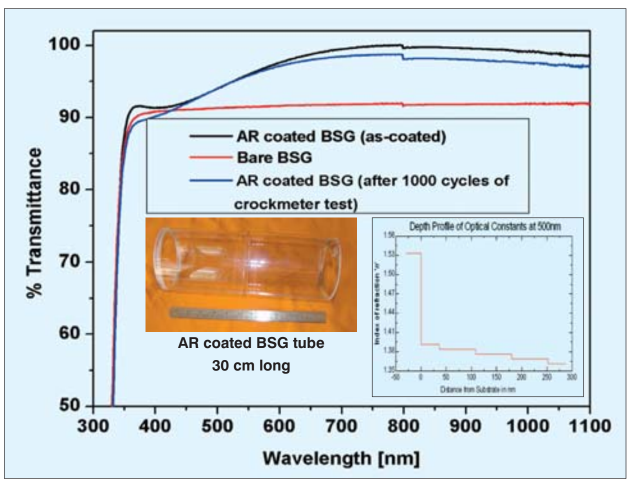


Fig. 2 Visible light transmittance of ARC on coated borosilicate cover glass tubes before and after crockmeter testing compared with that of bare BSG

Development of Functional Coatings for Concentrated Solar Power (CSP) Applications

S Sakthivel, Centre for Solar Energy Materials

Of late, Concentrated Solar Power (CSP) has been perceived as a vital technology for power production. In principle, it works like a conventional power plant that uses steam to drive a turbine with the one important difference that the steam is produced solely from the energy harnessed from the Sun and not by utilization of rapidly dwindling natural resources.

In CSP technology, functional coatings like selective solar absorber, anti-reflective, easy-to-clean, low emissive coatings etc., play a key role in converting sunlight to thermo-electric power either directly or indirectly. As a part of its CSP program, ARCI is working to reduce the cost (fixed as well as operational) and efficiency of parabolic trough solar thermal power technology. One of the approaches is to operate the CSP system using a cost-effective solar receiver tube and parabolic trough mirror. This comprises development of low-cost solar functional coatings with superior optical properties, thermal stability and weather resistance. The Centre for Solar Energy Materials (CSEM) is attempting to develop low-cost solar functional coatings by using different economic processes such as chemical, thermal, hydro-thermal and sol-gel.

Of all the solar functional coatings, development of a high performance solar absorber coating is particularly complicated and challenging, especially since it has to fit all the desirable characteristics for a CSP system. A spectrally selective absorber coating for CSP should be thermally stable (above 400°C, ideally in air), have a high solar absorptance (>0.95) and a minimal thermal emittance (< 0.15 at 400°C). The development of an appropriate Anti-Reflective coating (AR) for CSP is also crucial and the coating must transmit maximum light (>96%) over a broad range of wavelengths (300-1500nm) and various incidence angles.

Table: Properties of some of the best solar functional coatings

Coating	Properties	
Solar absorber coating	95 % Abs	0.14 Thermal emissivity
Gradient AR coating	95.8 % T	< 2% R (specular)
Self cleaning coating	94.5% T	Water contact angle 104°

Presently, ongoing R&D efforts in the centre aim to develop three important solar functional coatings, namely selective solar absorber, anti-reflective and easy to clean coatings by using the aforementioned economic processes. Some of these have already been successfully developed, both in lab and pilot scales.

Fig.1 Pilot scale development of selective solar absorber coatings

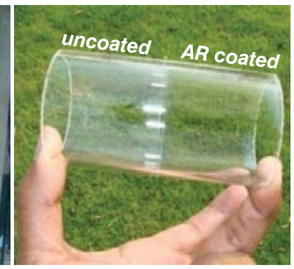


Fig.2 Gradient index AR coatings on glass tube

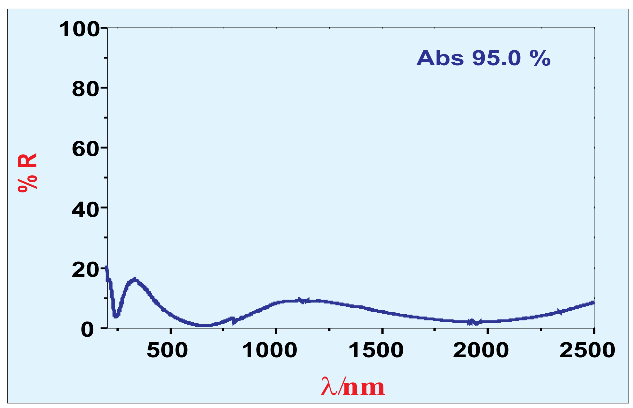


Fig. 3 Solar absorptance spectrum of a high selective solar absorber coating

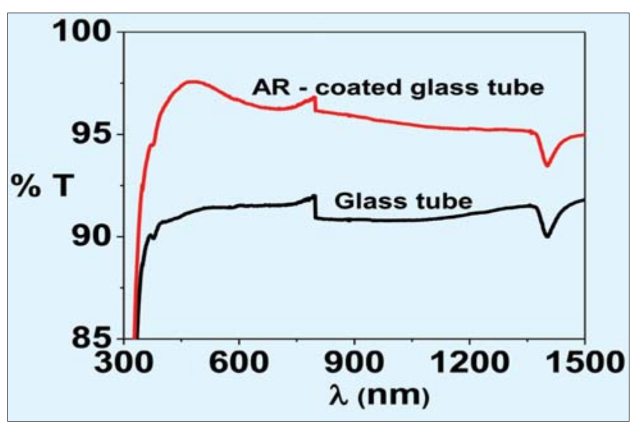


Fig. 4 Wide angle transmittance of gradient index anti-reflective (AR) coating

Field trials with collaborating industries are currently in progress. Concurrently, new categories of coatings with multi-functional attributes are also under development.

Development of Super Hard Nitride Thin Film Absorber Coatings for Solar Thermal Applications

Krishna Valleti and Murali Krishna, Centre for Engineered Coatings

The recent advancements in solar concentrator and heat exchange fluid technologies concurrently demand cost-effective absorber coatings, which permit operational temperatures > 400°C. Development of hard nitride coatings such as TiN, TiAlN, TiAlCrN, AlSiN using Cathodic Arc Physical Vapour Deposition (CAPVD) on cutting tools is well known. These nitride coatings exhibit high temperature stability and wear resistance in the following increasing order of merit: TiN (600°C) < TiAlN (800°C) < TiAlCrN (900°C) < AlSiN (1200°C). Despite the fact that CAPVD grown nitride thin films are widely used to impart aesthetic, barrier, wear and corrosion protective properties, the suitability of these films for solar energy applications has not been well studied. Therefore, an attempt has been made to develop high temperature stable (up to 700°C in ambient atmosphere) solar selective hard nitride coatings using cylindrical CAPVD. Initially, different mono-layer films such as TiN, CrN, AlSiN, TiAlN, TiCrN, TiAlCrN, TiAlSiN and CrAlSiN thin films were deposited and analysed for micro-structure, electrical resistivity and optical properties such as absorption (α), emission (ε), refractive index (n) and extension coefficient (k). The results are shown in Table 1.

Table 1 Optical properties of various CAPVD thin films

Coating	Absorption, α	Resistivity, ρ (10-3 Ω cm)	n (@ 620 nm)	k (@ 620 nm)
TiN	27	2.4	-	-
CrN	47	1.0	-	-
AlSiN	54	17.1	1.95	0.1
TiAlN	71	40.0	3.17	2.6
TiAlSiN	63	0.3	-	-
TiAlCrN	69	6.4	1.88	1.5

TiAlN and TiAlCrN were found to exhibit good absorption (~70%) at 500-700nm and 400-1500nm wavelength ranges, respectively, while AlSiN exhibits good transmission (~82%) over entire optical range (300-2500nm). Based on the above outcome, an ordered multi-layer structure is generated for obtaining optimum solar selectivity. The multi-layer structure, with substrate/TiAlCrN/TiAlN/AlSiN sequence as shown in schematic (Fig. 1), exhibits highest solar thermal efficiency (α/ε) of 12 with α = 91-92%, ε = 7-8% (Fig. 2), with ambient atmosphere stability up to 700°C. Fig. 2 also depicts the thickness dependence of optical properties of the same films. While the above mentioned results pertained to nitride films deposited on copper substrates, the high temperature stability has been studied by growing the same coating on steel substrates (Fig. 3) and hence, there is little difference in the properties shown (absorption 90% and emission 18%). Unlike other existing selective coatings, the observed high temperature stability of the designed multi-layer structure is found to be superior and is attributed to the inherent high temperature stabilities of nitrides coatings, and their nano composite structure as shown in Fig. 4. In conclusion, the present study highlights the promise of utilizing nitride multi-layers for solar selective/energy applications.

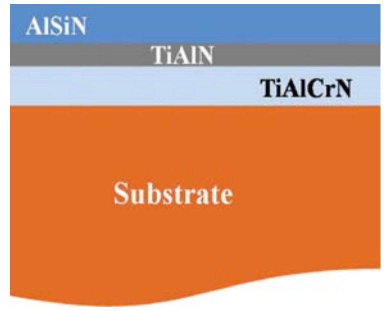


Fig. 1: Schematic of a multi-layer solar selective coating

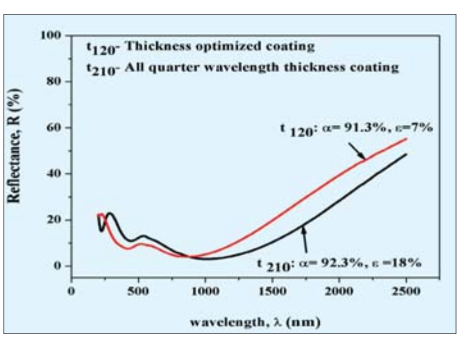


Fig. 2 Absorption spectra (in terms of reflectance) of formulated solar selective coating showing effect of overall coating thickness on optical properties

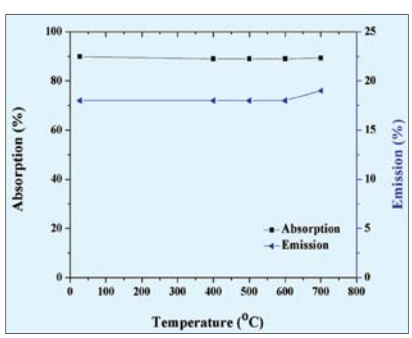


Fig. 3 Absorption and emission properties of designed thin film nitride solar selective multi-layer coating with respect to different heat treatments (up to 700°C)

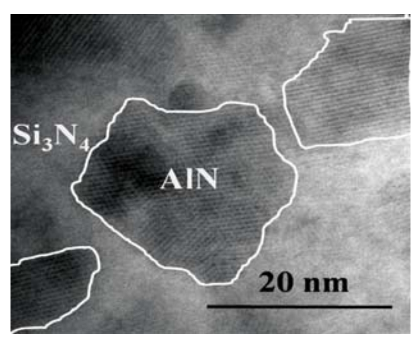


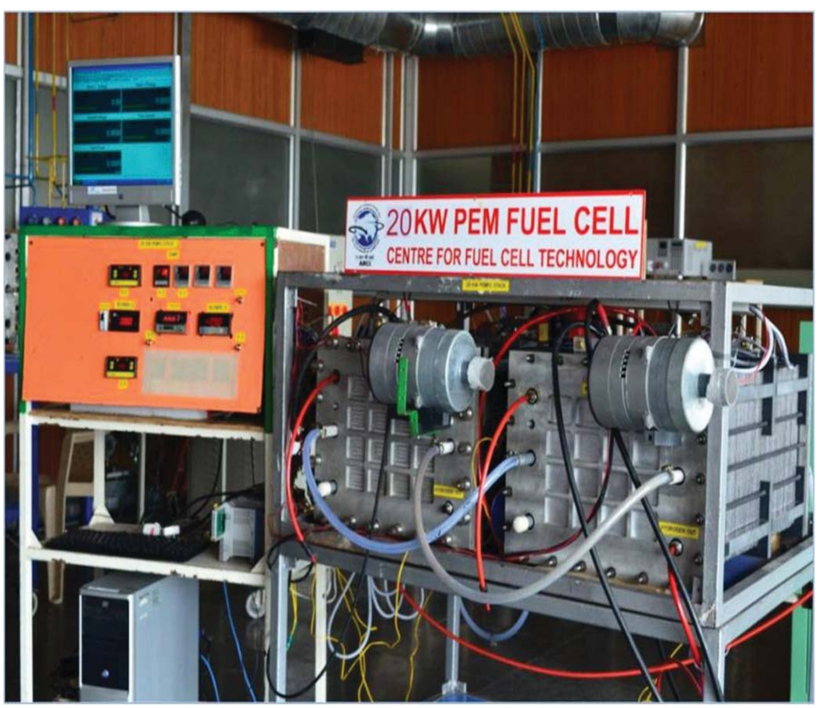
Fig. 4 TEM surface micrograph of AlSiN thin film depicting the presence of nanocomposite structure

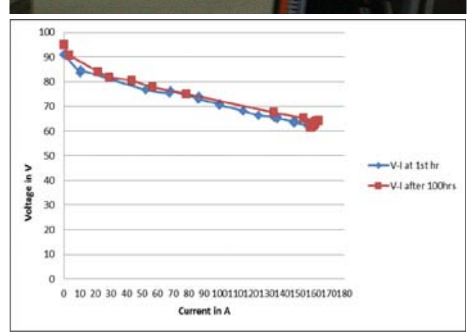
Development and Demonstration of 20 kW PEM Fuel Cell System For Stationary Applications

R Arvind Vivek, Jiflin Das, B Sasank Viswanath, Balaji Rengarajan, N Rajalakshmi and K S Dhathathreyan
Centre for Fuel Cell Technology

The Centre for Fuel Cell Technology (CFCT) has been at the forefront of developing Polymer Electrolyte Membrane (PEM) fuel cells for different applications in the country. Besides technology demonstration, the Centre is striving to make the systems more robust, simple to operate and durable. During the year, the Centre has consolidated the fabrication process for 10kW and three such modules were built. During this period, the Centre built a 20kW system for stationary application using a modular approach. Two modules of 10kW are connected in series electrically with two parallel air supply modules. The fuel supply is from a single manifold with uniform distribution for both the modules with a single mass flow controller. The coolant supply is in series connection with proper flow controllers and temperature measurements. The system is provided with a test control system with a load following facility to cater to the reactant supply pertaining to the electricity demand. The control system has additional features to protect the fuel cell modules from with reverse current, over current, low voltage, high temperature, etc.

The modules come with an inherent data logging system for individual cell monitoring, coupled with a control logic circuit. This control and monitoring system is specifically designed to suit the various parameters that need to be controlled or monitored during long operation of the stack. The rated capacity of the stack is 20kW DC power, and the peak power 22.5kW. This water cooled 20kW stack has been operated for 24 hours continuously and for about 100hrs intermittently. Developing an inverter suitable for fuel cells is highly challenging, as off-the-shelf inverters are not suitable for use with fuel cells. In collaboration with an industry, an inverter suitable for the 20KW system has been now developed. The inverter delivers 3 -phase AC power supply. Integration of the inverter with the fuel cell is in progress. A detailed analysis of the operation is being carried out to determine the value proposition of PEM fuel cells in certain niche segments like backup power, forklifts, etc. Analysis includes the application requirements in terms of cost and performance, lifecycle costs of PEM fuel cells against competing alternatives. The other objective is to leverage data processing and analysis capabilities from the fuel cell testing demonstration projects, in order to establish a baseline of real world fuel cell operation and maintenance data, and identify technical barriers. It is also proposed to collect data from multiple systems in terms of load and their fluctuations, response of fuel cells, hydrogen supply etc.





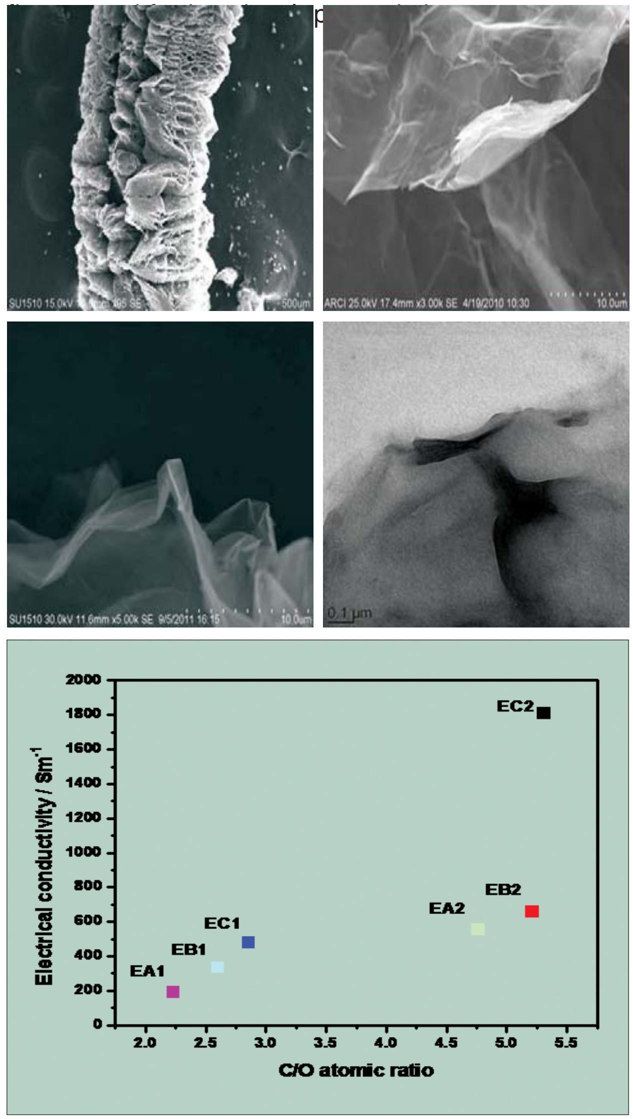
20 kW fuel cell inverter with control system

20 kW stack durability test – 100 hrs

Development of Functionalised Graphite Sheets as Fuel Cell Catalyst Supports

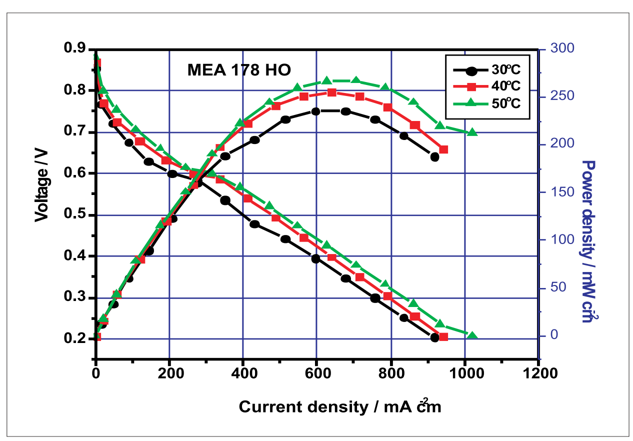
P Karthika, N Rajalakshmi and K S Dhathathreyan, Centre for Fuel Cell Technology

Graphene, a flat monolayer of carbon atoms that are tightly bonded together through covalent bond into a 2D honeycomb lattice, can be used as a catalyst support for fuel cells due to advantages such as high surface area, conductivity, attraction towards many oxygen containing groups, solubility in many polymers and solvents, enhanced interaction between Pt and graphene, stability and the possibility of more active Pt sites etc. However, the important issues to be addressed are separation of individual graphene sheets, functionalisation of graphene sheets, uniform dispersion of platinum nanoparticles on graphene sheets and homogeneous dispersion of materials with minimal restacking, and the role of functional groups on Graphene Oxide (GO)/Reduced Graphene Oxide (RGO) and presence of defects. The main objective is to tailor the characteristic properties of graphene sheets via various oxidation methods in order to optimise reactant ratio during graphene oxidation and to decrease the number of graphene layers in order to use them as catalyst support for electro catalysts. The SEM image of pure exfoliated graphene, graphene oxide and their electrical conductivity with respect to various Carbon (C)/Oxygen (O) ratio is shown below.



SEM image of pure exfoliated graphene, graphene oxide and their electrical conductivity w.r.t. various C/O ratio

Many functional groups assist in exfoliating individual sheets, resulting in the loss of ordered lattice structures in the sheets. If the graphene sheets stay the functional groups increase the interplanar distance between the sheets. The functional groups act as anchoring sites for the platinum particles onto the graphene sheets during the synthesis of Pt/graphene. The Raman spectra revealed the complete oxidation by the total disappearance of 0.34nm interplanar spacing and the appearance of a new one with a 0.84nm, depending on the oxygen content of GO. The number of graphene layers was found to be ~4-5 layers. Pt supported on reduced graphene oxide samples showed good thermal stability compared to carbon supported samples as can be seen from the thermogravimetry studies. The PEMFC polarisation studies revealed a current density in the range of 400-500mA/sqcm at 0.6V and a maximum current density of 1.0A to 1.6A/cm^2 at 0.1V, depending on the C/O ratio of the graphene samples. The results are shown in the accompanying



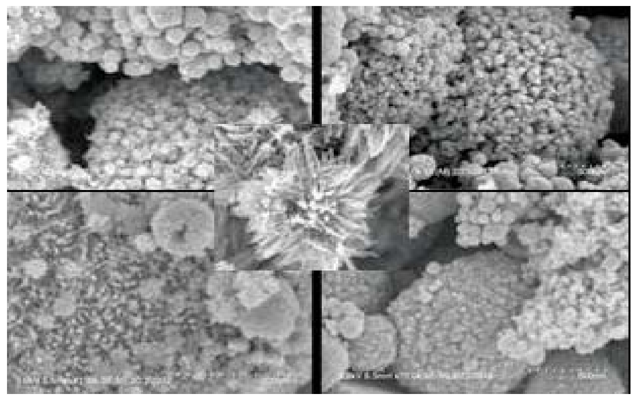
Fuel cell performance with Pt supported on Graphene

Development of Mesoporous and Nanoporous Materials for Fuel Cells

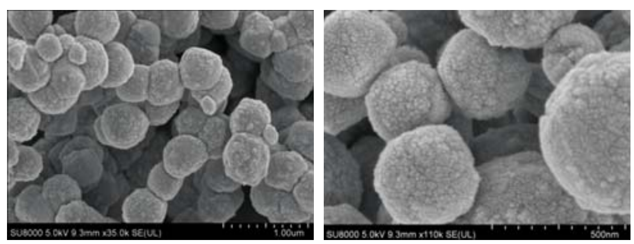
R Delma Jones, Raman Vedarajan and K S Dhathathreyan, Centre for Fuel Cell Technology

PEM Fuel Cell have been already demonstrated in a number of applications ranging from hand held instruments, to transportation and stationary power generation, and every year the number of units that reach the public space continues to increase. In spite of the large application potential, PEM Fuel Cells have not penetrated the market. One of the major reasons is the cost of the fuel cell. According to several cost studies, cost reduction for PEM fuel cell power train depends on component technologies, system layout, system simplification and increased quantities of production. Main contribution to fuel cell system costs is the stack cost. Successful cost reduction depends on minimisation of stack active area which primarily depends on the catalysts used. Platinum has been the catalyst of choice from the early days. The advent of high surface area carbon resulted in the development of Platinum supported on carbon for use in fuel cells. Although Pt/C have been successfully used in many fuel cell development, a limit seems to have been reached with respect to the enhancement of Electrochemical Surface Area (ECSA). In frequent start-stop operation for the fuel cells, performance losses have been observed which has been attributed carbon corrosion. Further, thickness of the electrodes (linked to ohmic losses) is determined by the particle size of the catalyst. Therefore in recent years, there has been great interest in using unsupported nanostructured platinum in fuel cells. The strategies used include tailoring new nanostructures with high Specific Surface Area (SSA)/high Specific Activity (SA). Several structures such as nanotubes, nanowires, nano-flowers, meso/nano porous structures, nano-cubes, and nano-tetrahexahedrons have been explored. However, most of the studies reported have been restricted to half-cell studies and no attempt has been reported to make these catalysts in large quantities for practical use. CFCT has initiated work in this direction specifically to address these issues, and mesoporous platinum catalyst has been prepared. A simple chemical process yielded platinum nanoflowers.

Preliminary electrochemical studies show high ECSA. Further investigations are underway. In another study, the hard template synthetic method was used to prepare mesoporous platinum with rhombic dodecahedral morphology. These show a very high ECSA of $82.99 m^2/g$.

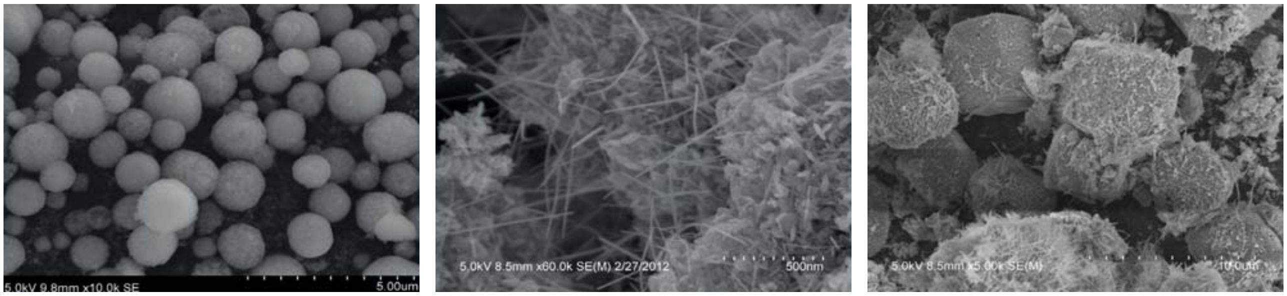


SEM Picture of platinum nanoflowers produced at different experimental conditions



Low and high magnification SEM images of the mesoporous Pt prepared by the hard template method

As part of this work, mesoporous MnO_2 has also been synthesised. The objective is to evaluate the influence of various nanostructures (nanorods, hollow spheres, hollow cubes) of MnO_2 on Oxidation and Reduction Reaction (ORR).



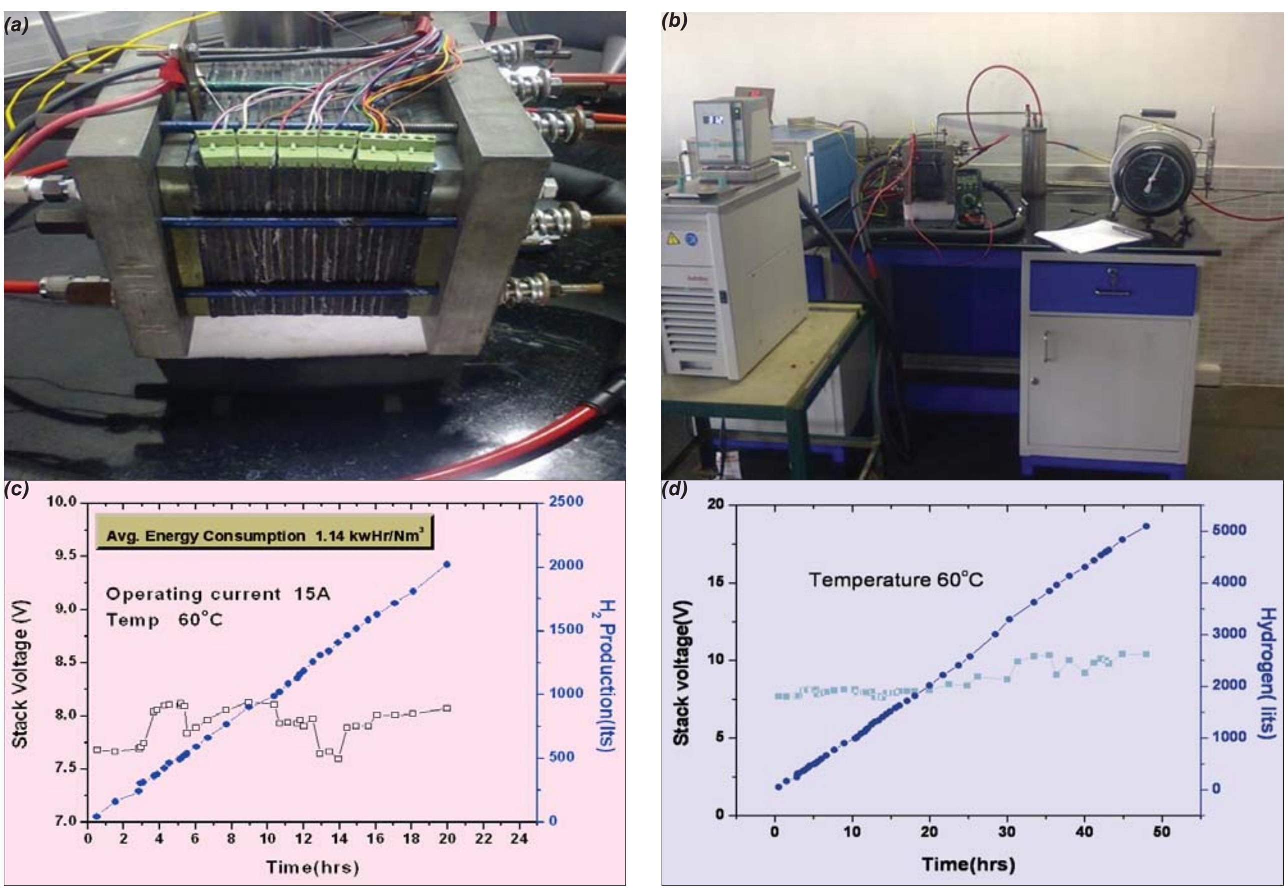
SEM pictures of MnO_2 hollow spheres, rods and cubes

Development and Demonstration of a 100 l/hr Hydrogen Generator

R Balaji, K Ramya and K S Dhathathreyan, Centre for Fuel Cell Technology

Electrolysis of water is one of the techniques to produce pure hydrogen. This process has a high over- potential to overcome the activation barriers. The main obstacle in the commercial exploitation of water electrolysis for large-scale hydrogen production is the high electricity consumption, which makes the process economically unattractive except in niche areas. The cost of the hydrogen produced by electrolysis is based on the fixed cost of the components used for assembly of the stack and the operation cost. CFCT has developed an alternate approach to reduce the operation cost to produce hydrogen by using depolarisers. In this novel method, the electricity consumption can be drastically reduced to 60%, thereby making the electrolysis process economically viable. Hydrogen production using this method is also suitable for portable power applications, as the electrolysis can start instantaneously on application of current and can produce hydrogen at a low temperature.

The electrodes were specifically engineered to meet the hydrogen and oxygen evolution at various electrodes with suitable catalysts. Several studies have been carried out to optimise various parameters such as voltage, current density, concentration of the depolariser, temperature etc., for hydrogen production. Based on the optimised condition observed in a single cell of 30cm^{2}electrode, large area electrodes were developed. A PEM electrolyser stack (made from 16 cells of 150cm^2 electrode area) was fabricated, delivering 100l/hr hydrogen. The developed PEM electrolyser stack performance was tested for about 50 hours and the corresponding energy consumption is <2.0kwhr/Nm^3. The performance of the stack was also tested by operation of the stacks at various current densities and extended duration. One of the significant feature of this development is that the expensive titanium/platinised titanium used as bipolar plates in conventional PEM water electrolyser has been replaced by electro-graphite thus offering a pathway for cost reduction of these electrolysers.

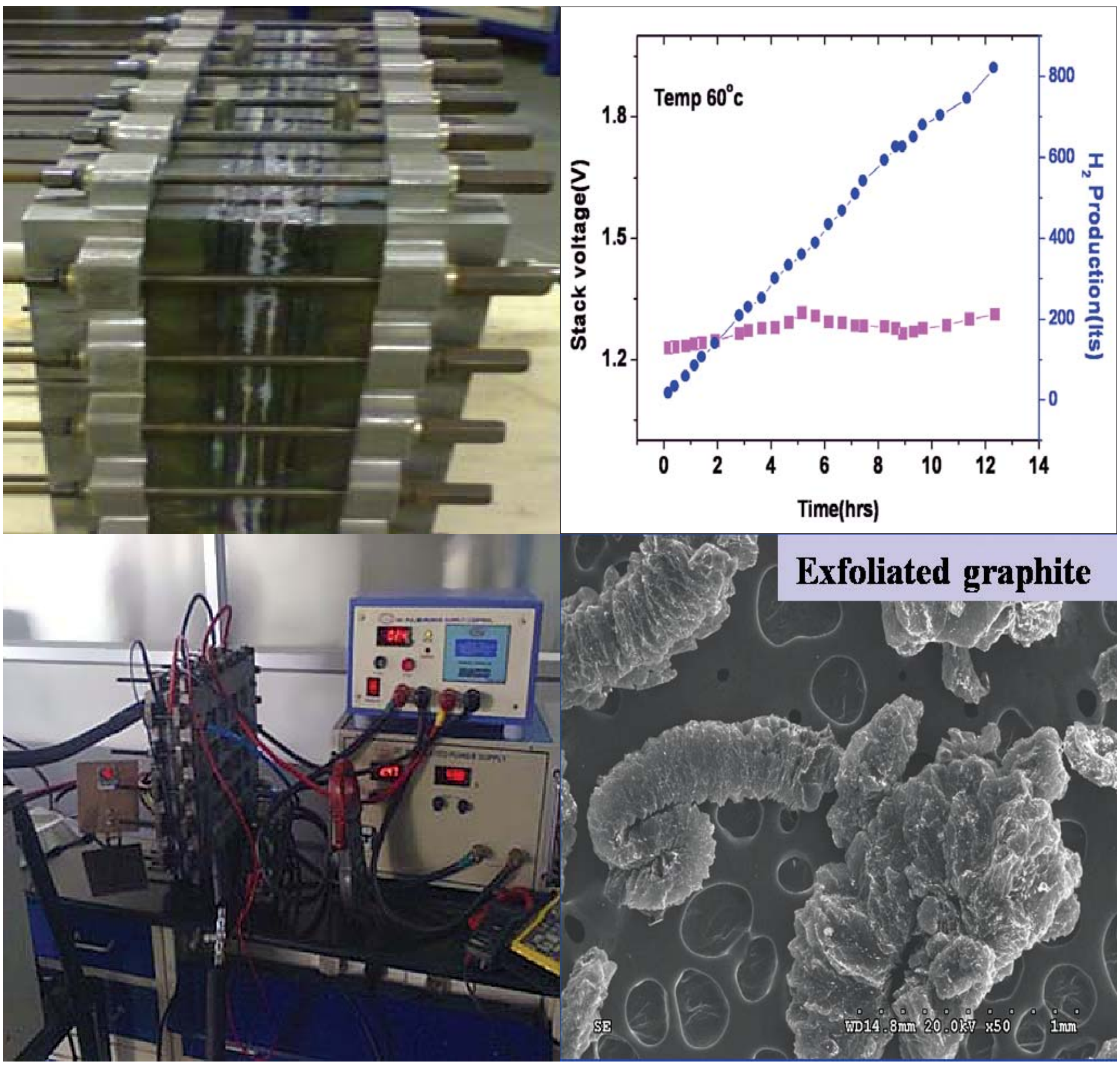


(a) Electrolyser unit (b) test set-up (c) performance test results and (d) durability assessemnt data

Development of Polymer Electrolyte Membrane (PEM) Based Hydrogen Generator Using Exfoliated Graphite (EFG) Material as Bipolar Plates

R Balaji, K Ramya and K S Dhathathreyan, Centre for Fuel Cell Technology

CFCT has developed a process know-how for making bipolar plates from exfoliate graphite, which have been successfully demonstrated in a large number of PEM fuel cell stacks in the capacity range up to 10KW. CFCT has now demonstrated that the bipolar plates made from EFG can be also used in hydrogen production units. This has resulted in considerable cost reduction of the electrolyser unit. A two-cell assembly using electrodes developed specifically for an electrolyser and exfoliated graphite bipolar plate was tested successfully and found that the performance was comparable with graphite plates in addition to cost and weight benefits. The weight benefit could be up to 50% depending on the proper choice of plate density and cost benefit could range from 15-20%. Simultaneously the electrode areas were scaled up from 150 sq.cm to 770 sq.cm, to see the feasibility of these plates for electrolyser development. Further improvements in the cell performance are under progress.



Hydrogen generator with EFG plates – 100 l/ hour

Development of Efficient Cd-chalcogenide/Ferrite Photoelectrode System for Sustainable Solar PEC Hydrogen Production and Solar Cell Application

Pramod H Borse, Rekha Dom and Alka Pareek, Centre for Nanomaterials

Hydrogen constitutes an integral part of many green-energy solutions that address future energy needs provided it is generated from a renewable source. Photoelectrochemical (PEC) hydrogen generation, using renewable sources such as water and solar radiation, is thus important. This photo-assisted electrolysis needs identification of efficient and stable materials. Sulfides are known as efficient PEC, but lack the desired stability. On the contrary, metal oxides (wide band-gap) are highly stable but are poorly active under solar light. Thus, the commercial fate of the desired solar H_2-energy technology lies in identifying, fabricating and implementing low-cost, efficient and stable material systems.

ARCI has initiated efforts aimed at developing the low cost nanostructured ferrite and chalcogenide films to address the issue of PEC H_2 production. The photoanodes are being used for their direct implementation in a medium-scale PEC H_2 reactor.

Fig. 1 (A) shows the actual large-area nanostructured films used for the fabrication of the photo-electrodes for PEC H_2 generator. Presently, a typical photoanode dimension of length >10cm has been targeted and demonstrated. The films showed nanostructured-tubule like morphology as indicated in Fig. 1(B). The H_2 generation and electricity generation results from these films display their potential as commercially viable options. Further, performance improvement is being targeted by film nano-structuring and by tuning the surface morphological components. We have also successfully demonstrated a test case of hydrogen generation using large area electrodes.

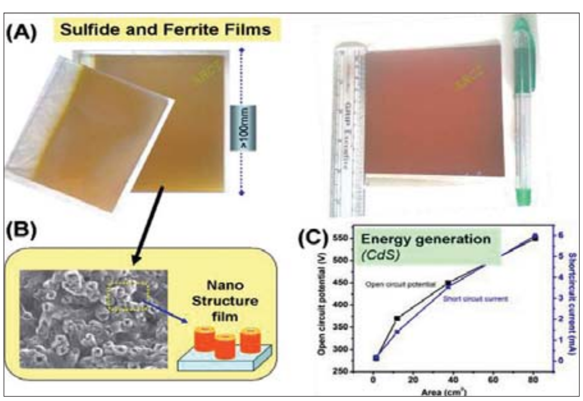


Fig. 1 (A) Top palette showing large area films used to fabricate scale-up photoelectrode; (B) The surface morphology of the nanostructure film.; (C) The solar electric generation from these films under natural sunlight between 11a.m.- 2 p.m. (March 2012) at ARCI, Hyderabad (Andhra Pradesh, India; 78.47°E, 28.28°N), with irradiation density of 0.020Wcm^{-2}. This indicates feasibility of producing large area electrode for solar energy application

The chemical-based bath and spray methods are especially important in the context of developing an economical deposition methodology. Fig. 2 shows the photocurrent generated from the film deposited using two different chemical-based film deposition techniques. The main focus of the study is to employ the low-cost film deposition techniques, and to demonstrate their commercial viability to generate the solar energy conversion systems, while targeting the desired performance.

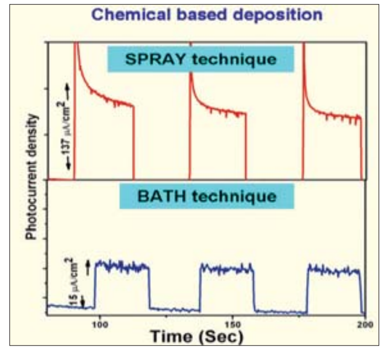


Fig. 2 Comparison of PEC performance of the films deposited using different chemical-based techniques.
Source-Monochromator (300Watts,Xe-lamp)

Development of improved photoanodes requires access to phase and dimension control, as it can tune the band energetics, electrical properties and phase composition of an electrode. Fig. 3 shows the case of a nano-composite developed that can be utilised for solar H_2 generation under direct sunlight. The ferrite composite photoanode generated very high photocurrents as displayed in Fig. 3(A). The wavelength dependent efficiency of such a photoanode is compared with its bulk counterpart. Inset of Fig.3 (A) shows the schematic of such a nano-composite.

Thus, developed films have been utilised to fabricate the photo-electrodes. They are being further modified to develop a scaled-up version of the device. It is desirable to enhance the Solar-to-Hydrogen (STH) efficiency for the stable systems. Such nanostructured composites are expected to be eco-friendly as well as economical and thus are promising for technological energy applications.

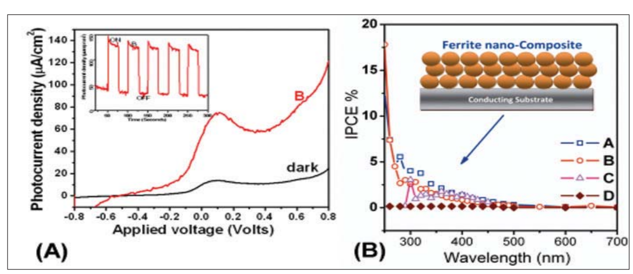


Fig. 3: (A) The PEC characterisation of the nanocomposites ferrite photoanode displaying efficient performance as demonstrated by chronoamperometry curve in the inset; (B) The wavelength dependent efficiency is displayed in IPCE curve. Inset-Schematic of nanocomposite electrode

Thermal Gel Casting of 8 mol% Yttria Stabilized Zirconia Electrolyte Honeycomb for SOFC Applications

K Rajeswari, M Buchi Suresh and Roy Johnson, Centre for Ceramic Processing

The Honeycomb-Shaped Solid Oxide Fuel Cell (HCSOFC) design is considered to be one of the innovative concepts for the miniaturisation of cell size because of its monolithic structural advantages. The major difficulty in exploiting the Solid Oxide Fuel Cells (SOFC) commercially is the long start-up time for which various cell configurations are proposed to arrive at practical solutions. HCSOFC is one of the most promising designs among the proposed configurations due to their low relative densities and inherent high geometrical and active surface areas. Honeycomb cellular structures are generally produced by Viscous Plastic Processing (VPP) such as extrusion processing, which involves the shaping of a formable paste through a specially designed die. The honeycomb structures thus produced provide high geometrical surface area and also generally exhibit higher porosities even after sintering at high temperatures.

Colloidal processing of ceramics is a common and practical pathway for defect-free, complex shaping and densification. Thermal gelation property of cellulose-based derivatives has been exploited for ceramic extrusion and injection moulding by earlier workers. However, thermal gelation characteristics of methyl cellulose solutions have only been explored recently for the colloidal forming of ceramic suspensions. In the present study, thermally induced gelation of methylcellulose was exploited by irradiating the zirconia slurry containing 0.2wt% of methyl cellulose with microwaves within a teflon mold. Irradiation with microwaves resulted in the volumetric heating leading to a homogeneous gelation. Green honeycomb samples thus obtained were further sintered and samples were characterised for their sintered density and microstructure. Honeycomb properties such as relative density, wall thickness and surface-to-volume ratio were also evaluated. Further, the electrical properties of the zirconia electrolytes were measured by AC impedance measurements.

Sintered 8YSZ honeycombs fabricated by thermally induced gelation of methyl cellulose are shown in Fig. 1 (a-b) and properties of the sintered honeycombs such as channel diameter, wall thickness and surface–to-volume ratio along with overall dimensions and weight are shown in Table-1. Fig. 2 shows the temperature dependence of complex impedance spectrum (Nyquist plots). Three distinct semicircles corresponding to the conduction from grain interior, grain boundary and electrode were observed in the low temperatures. Honeycomb structures due to its unique monolithic structures, minimum heat capacity per unit weight by the virtue of its low relative densities and high surface to volume ratio in comparison to the solid counter parts permits rapid heat transfer leading to quick start up times and reduced thermal gradients contributing towards the better efficiencies. Thus honeycomb-based electrolyte structure due to its unique configuration and in combination with the flexibility in processing can be explored for the development of novel and compact designs of solid oxide fuel cells with enhanced performance.

Table 1 Cellular parameters of green and sintered 8YSZ honeycombs

Sample ID	Green	Sintered
Channel Diameter (cm)	3.80	3.00
Wall thickness (cm)	1.46	1.20
Surface to volume ratio (cm^2/cm^3)	1.96	2.77

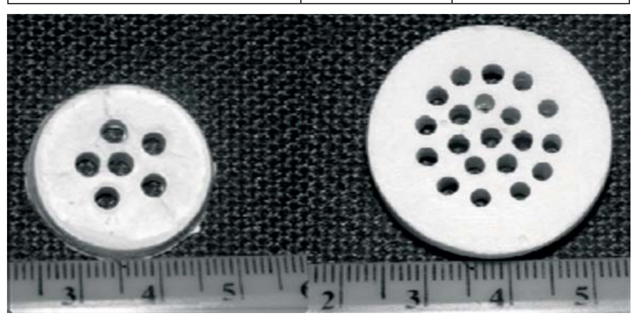


Fig. 1 Sintered 8YSZ honeycomb samples

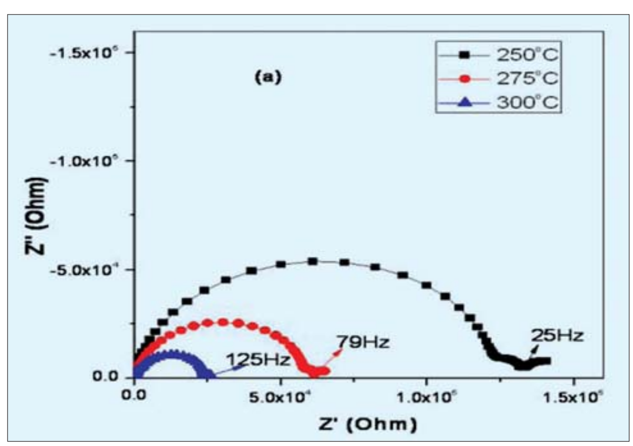


Fig. 2 Nyquist plots of sintered honeycomb

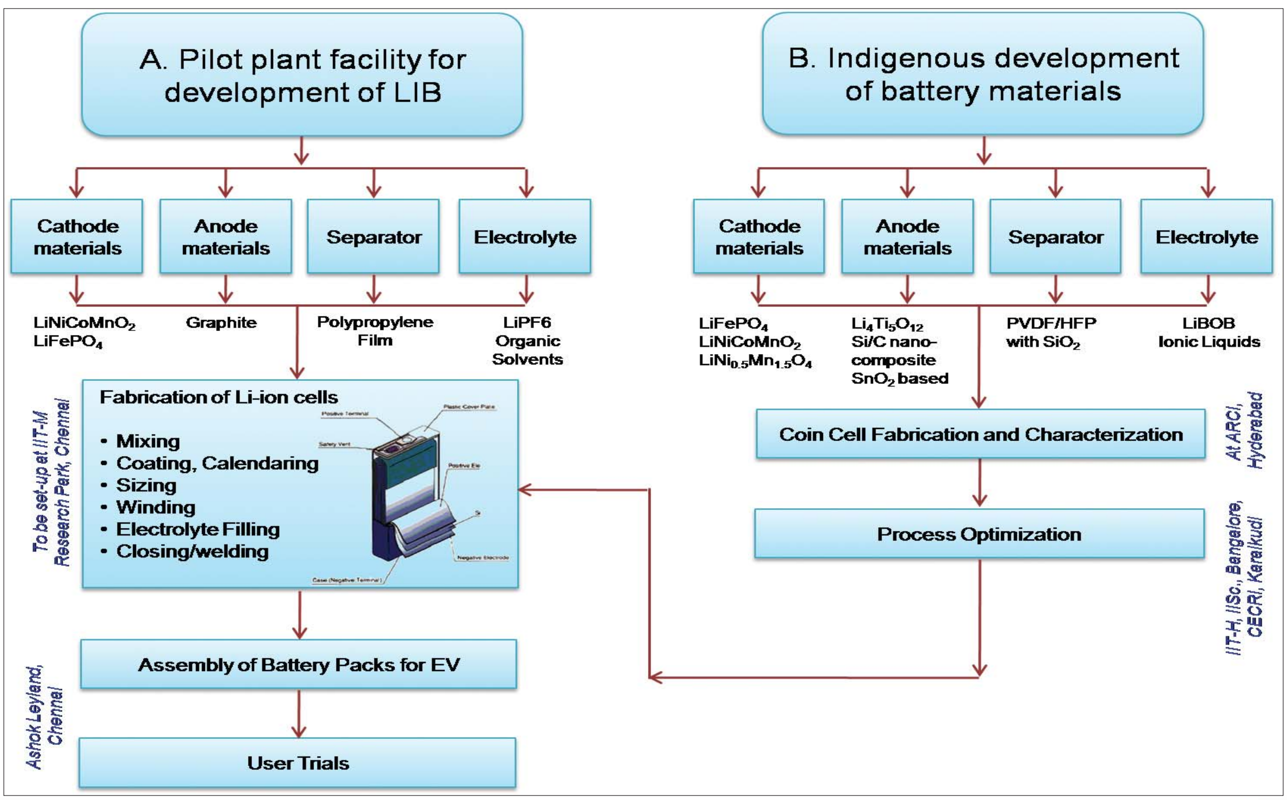
Setting-up a Lithium Ion Battery Research Facility for Electric Vehicle Applications

T Mohan, R Prakash, T Rajappa and R Gopalan, Centre for Automotive Energy Materials

The alarming depletion of fossil energy resources and the rapid growth of the automotive industry demand the need for the development of an alternative energy source for sustainable transportation. Batteries show promise as potential portable power sources for this application. Among the battery technologies known so far, Lithium-Ion Batteries (LIB) are projected as potential alternatives for Electrical Vehicle (EV) and Hybrid Electric Vehicle (HEV) application due to many of their attractive features such as high energy and power density (W/Kg or W/l), high coulombic efficiency, long cyclic and calendar life, wider operational temperature range, low self discharge and fast charging. On the other hand, LIBs are more expensive than the conventional lead-acid batteries. However, the higher cost is compensated by the better performance of LIBs over lead-acid batteries. In addition, the cost is expected to decrease considerably if they are manufactured within the country.

However, there are no LIB manufacturers in India. Hence, ARCI plans to establish a pilot plant facility at the IIT-M Research Park, Chennai to develop the technology indigenously for making large format Lithium-ion cells and batteries for the EV/HEV application. This facility includes state-of–the–art processing equipment and dehumidified rooms. The technology will be optimised initially by importing standard materials. The fabricated cells and batteries will be tested and evaluated for their quality and safety according to the international standards. ARCI will collaborate with an automotive company for testing and eventual usage of ARCI's batteries in e-buses. ARCI will produce HEV batteries according to the specification given by the User agent (200Ah, 320V). Later, large batteries will be designed and assembled according to their requirement, and tested at their end for validating the technology. In addition to the technology development, R&D work will also be carried out to indigenise the raw materials and develop newer materials. Such a technology using indigenously developed materials would be quite cost-effective.

The state-of-the-art plant will be installed at IIT-M Research Park, Chennai. The manufacturing processes need to be carried out in a humidity controlled dry room. Hence, the processing equipments have to be housed in the dry room. Typically, the electrode manufacturing room should have the moisture level of ca. 30% RH and the cell assembly room at 0.5% RH.



A brief description of the processing equipment to be installed at CAEM, IITM Research Park for the fabrication of LIBs:

Mixer: This machine is used for mixing active materials with the binder solution. Typically, polyvinylidene fluoride (PVDF) dissolved in N-Methyl pyrrolidone (NMP) is used as the binder solution. The mixer (Fig.1) is provided with two blades, one for high shear and the other for planetary mixing. The mixer is also provided with a vacuum adapter to deaerate the slurry for better intimacy. The 'mixing' is a very important operation that determines the quality of the electrode. The time of mixing, the mode of addition of the solvents and the rheology of the resulting slurry are fixed by trials. However, a good slurry must have viscosity of about 8000-10000cp.

Fig. 1 Mixer

Coating and drying: The slurry is coated uniformly on both the sides over a thin metal foil (10-25μm) to make the electrode. Typically, Aluminium is used as the substrate for the cathode and copper for the anode. After coating, the electrodes are dried in a hot air oven at 120^{o}C. The coating thickness; the uniformity of the coating and drying temperature are important factors affecting the quality of the electrodes. This machine (Fig. 2) has the provision of pattern/interrupt coating, which can be adjusted depending on the cell configuration and design. For example, if a tab needs to be welded, coating can be avoided using the interrupt provision.

Fig. 2 Coating and drying

Calendering: The dried electrode is calendered by using the roller press (Fig. 3) under a load of ca. 2-5 T/cm^2. The nip gap should be adjusted such that the substrate foil is not distorted. The density of the resulting active material depends on the chemistry of the electrode and method of formulation. A porosity of ca. 30% is desired for optimum electrode.

Fig. 3 Calendering

Slitting: The calendered electrodes are slit using the slitting machine (Fig. 4) according to the cell dimensions. Care must be taken while slitting, such that burrs do not form over the slit edge, as this would cause internal shorting in the cell.

Fig. 4 Slitting

Ultrasonic/Laser welding: Tabs are welded over the uncoated areas of the electrode using the ultrasonic welder (Fig.5). The tabs provide the connection between the terminal and the electrode for current collection. Typically, Aluminium is used for the cathode and Nickel for the anode. The number, length and width of the tabs depend on the cell designs. The welding unit to be procured is capable of welding 128 layers of Al/Cu foil (10μm).

Fig.5 Ultrasonic/laser welding

Winding: The positive and the negative electrodes are wound together with the interposed separator to a jelly roll (Fig. 6). After winding the jelly roll with the positive and the negative tabs separately, the stack is inserted into a cell casing made of Aluminium 3003. The positive and negative tabs are bunched and welded together using ultrasonic welder and again to the GTM terminals, which are pre-welded to a lid made of Aluminium 3003. The lid is welded to the can by laser welding.

Fig. 6 Winding

Electrolyte filling: After drying, calculated amount of electrolyte is filled under vacuum through the fill-port using the filling machine (Fig. 7). This machine has both direct and prefilled filling modes. The behaviour of the cell is evaluated by carrying out a few cycles at different rates. After acceptance, the cell is subjected to battery assembly, life cycle tests, etc.

Fig. 7 Electrolyte filling

The cells and modules of the batteries developed in this project are tested according to the specification of the standards of International Electro-technical Commission (IEC 61960), UL-1642 for the safety tests and the UN Tests for the Transportation Safety for EV/HEV application. After approvable electrochemical performance, the final battery is assembled and mounted in the EV at the user end. Typically, it needs 100 cells of 50Ah to be connected in series and four such strings in parallel. The performance of this battery is monitored continuously for any design modification and validation of the technology.

Trials were conducted on all the equipments at their fabrication site and these equipments will be installed shortly in the proposed dry room at CAEM, Chennai.

Large Scale Synthesis of Li-ion Battery Materials For Electric Vehicle Applications

Tata N Rao, Dinesh Rangappa, K Hembram, B V Sarada and S Anandan, Centre for Nanomaterials

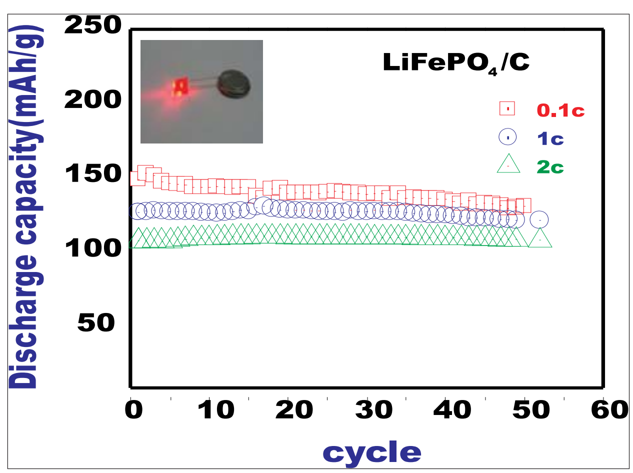
Li-ion battery technology has become the leapfrog technology in the automotive sector to commercialise electric vehicles, especially after Nissan launched its electric car 'LEAF'. The attraction of an electric vehicle is on account of the possibility that it provides to reduce the consumption of gasoline and reduce the dependence on oil imports – especially for countries like India that are heavily dependent on imports and suffer severely from air and noise pollution. Li-ion batteries are best suited for electric vehicle due to their high specific capacity compared to lead acid batteries, and fast charge/discharge capabilities. While carbon is the most reliable anode at present, cathodes based on $LiMnO_4$ and $LiFePO_4$ compounds are already being used in electric vehicles.

The Government of India has recognized the potential of the EV technology, and is providing encouragement for its indigenous development. Indian auto makers like Mahindra and Mahindra are already planning to launch the new electric car, Reva, in the market equipped with Li-ion batteries. Other companies, including two wheelers manufacturers like Hero MotoCorp, are also planning to introduce electric two wheeler products into market. It is important to note that a significant fraction of cost of the EV goes into battery stacks. In this situation, there is an urgent need to indigenize the Li-ion battery technology to reduce the battery cost and make EVs affordable. To make this technology techno-commercially viable in India, an urgent need for production of both anode and cathode materials on a large scale exists and shall be complemented by manufacture of battery assemblies.

ARCI has taken up the challenge of performing both the above activities. ARCI has already demonstrated synthesis of $LiFePO_4$ in kilogram quantities and established its satisfactory performance in the half cell with Li-metal as reference electrode. Specific capacity as high as 100mAh/g even at high C rate of 2C, which is relevant to EV performance, has been achieved. Work is currently ongoing to further improve the performance and confirm batch-to-batch reproducibility.

Apart from up-scaling the production of cathode materials, ARCI is also working on novel, nanostructured and composite high-capacity anode materials. Si and Sn are known to be high-capacity anode materials but they suffer from practical problems such as volume expansion and capacity fading. There have been several attempts to overcome these problems by nanostructuring in the fibre form as well as by dispersion into a porous carbon matrix. Both the above approaches are currently being explored at ARCI.

Fig. 1 Flame spray pyrolysis equipment and $LiFePO_4$ powder (Inset)



Battery performance

Preparation of Cathode Material for Lithium Ion Batteries

V Manimuthu, V Phanikumar, T Mohan and R Gopalan, Centre for Automotive Energy Materials

In recent years, LiFePO4 has been receiving increasing attention as a cathode material for Lithium Ion Batteries (LIB) because of its stability, environmental benignity and low cost. A number of methods have been advanced for the synthesis of the compound viz. conventional solid state reaction, sol-gel methods, carbothermal reduction, hydrothermal reaction, microwave assisted synthesis, spray pyrolysis, combustion synthesis, etc. Among those, hydrothermal reaction – also used by a leading manufacturer from Canada to manufacture LiFePO4 (grade P2) for the EV and other high power application - is considered as one of the best methods to synthesise this compound in sub-micron size with uniform morphology.

The preliminary R&D work on synthesis of electrode materials is being carried out at the Centre for Automotive Energy Materials, ARCI, Chennai. The cathode material $LiFePO_4$/C composite was synthesised according to the scheme.

$$Fe(C_2O_4) + (NH_4)_2HPO_4 + LiOH \xrightarrow{H_2O,\ 170°C,\ 3h} \xrightarrow{EG,\ 600°C,\ Ar/H_2\ 3h} LiFePO_4/C$$

XRD analysis of the as-synthesised material confirms that the existence of a single phase $LiFePO_4$ according to the JCPDS pattern (Fig. 1). SEM and HRSEM images (Fig. 2) display the sub-micron nature of the particle with uniform morphology. Most particles are isolated from each other, however, some agglomerates were also observed. The particle size analysis shows a narrow distribution of the particles with D50 = 20 microns.

Electrochemical experiments were preformed with two electrode coin cells. The positive electrode was fabricated by mixing $LiFePO_4$ (90wt%), 1:1 Super P, KS-6 Timcal (5wt%) and PVDF (5wt%) in NMP to make a slurry that was tape-casted to an aluminium foil (50μm). Electrochemical half cell was made with $LiFePO_4$ cathode, metallic lithium as the anode, $LiPF_6$ (1M in EC:DMC:DEC; 1:1:1 vol. ratios) as the electrolyte and thin polypropylene film (Celgard 2500) as the separator in a Teflon fixture (made in-house). The charge/discharge was carried out using Solatron Work Station at a current rate of ca. C/20. Preliminary results indicated that the material possesses a reversible specific capacity of 130mAh/g. However the charge/discharge coulombic efficiency was found to be 99%. Efforts are currently underway to enhance its specific capacity, cyclic stability and rate capability.

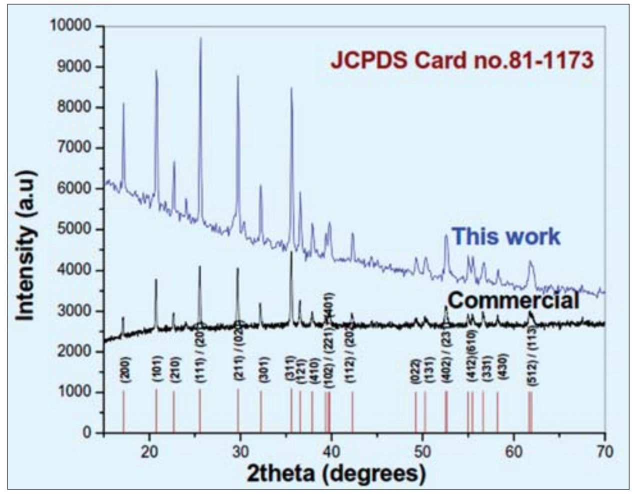


Fig. 1 XRD Pattern of $LiFePO_4$

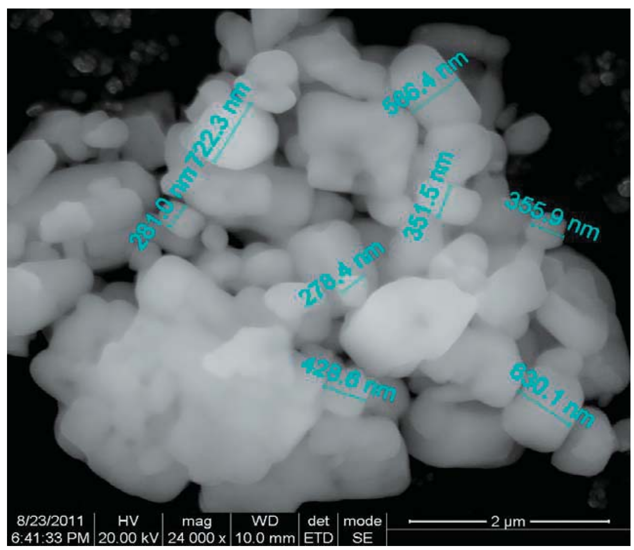
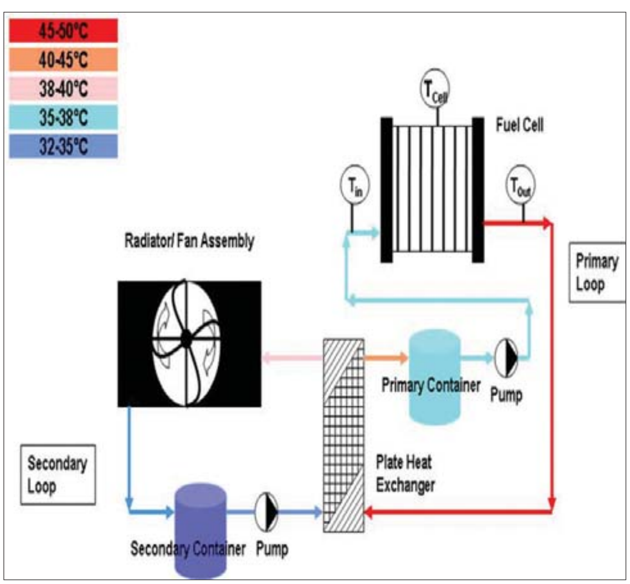


Fig. 2 HRSEM of $LiFePO_4$

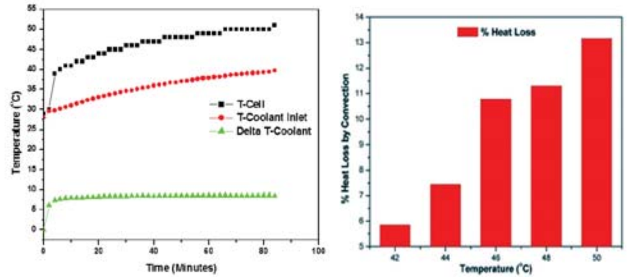
Development of 5 kW Power Pack With Thermal Management Suitable For Transportation Applications

B Sasank Viswanath, N Rajalakshmi and K S Dhathathreyan, Centre for Fuel Cell Technology

One of the applications for PEM fuel cells is in transportation. Based on the success of integration, a 3kW PEMFC in a Mahindra and Mahindra Bijlee electric vehicle where the fuel cell is used as a range extender, the centre has now developed 5kW PEMFC system, incorporating the fuel cell stack, DC-DC converter, power sharer, for use in the Bijlee. Bijlee, operating on lead acid batteries has a range of 75-82 KMs. In the first step the 5kW PEMFC system using a single hydrogen cylinder (140bar) will serve as a range extender. In the next step, the number of batteries will be reduced and the amount of hydrogen carrying capacity increased. Thermal management of the fuel cell system in transportation application is highly challenging as there are volume, weight and parasitic power loss constraints. An issue with a closed-loop system is the heat addition from fuel cell into the cooling loop. This heat can be subdued by the use of heat transfer modules like Plate Heat Exchanger (PHE) and radiators in the loop. We have designed a thermal management system, which can remove heat from the fuel cell to ambient effectively and allow the stack to operate at its conditions for more than 60 minutes. Coolant flow rate optimisation and thermal management configuration design are conducted to increase the heat transfer from fuel cell. The average thermal power removed by the coolant from the cell for all the thermal management configurations is calculated. A relation between the average thermal power, flow rate and thermal management circuit has been established.

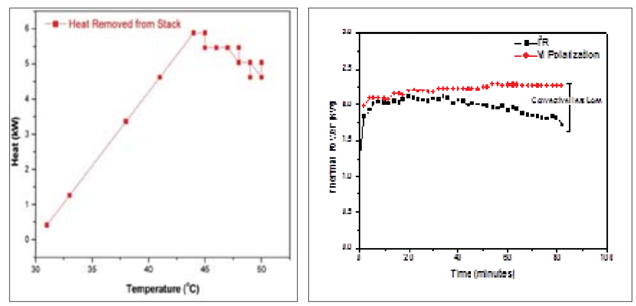


Schematic of the thermal management system



Energy analysis of the thermal management system

Energy analysis has been done for various concepts and the temperature map is shown below.



5 kW stack thermal performance data

The convective heat loss has been evaluated based on the fuel cell thermal data collected during the operation of the stack and found that the heat removal was sufficient to operate the stack continuously for the said period depending on the hydrogen availability. The 5kW module developed for transportation application comes with a power management system using a suitable DC-DC converter that can be integrated with battery pack of the fuel cell vehicle. The system has a control logic circuit to meet the demand of the vehicle in terms of power requirement, from both the battery and fuel cell power pack. The control monitoring system is provided with protection features for the stack module, load following capability and data logging facility for further analysis. The operational data has been collected in terms of continuous and peak power, operational efficiency, balance of plant factors in terms of kWh input and output, runtime details etc. Analysis is being made between battery and FC based power sources by considering factors like fuel cell and battery cost, refuelling cost and time, charging cost and time, infrastructure, maintenance, utility, floor space requirement, life span etc. Integration of this unit in the vehicle and field trials are in progress.

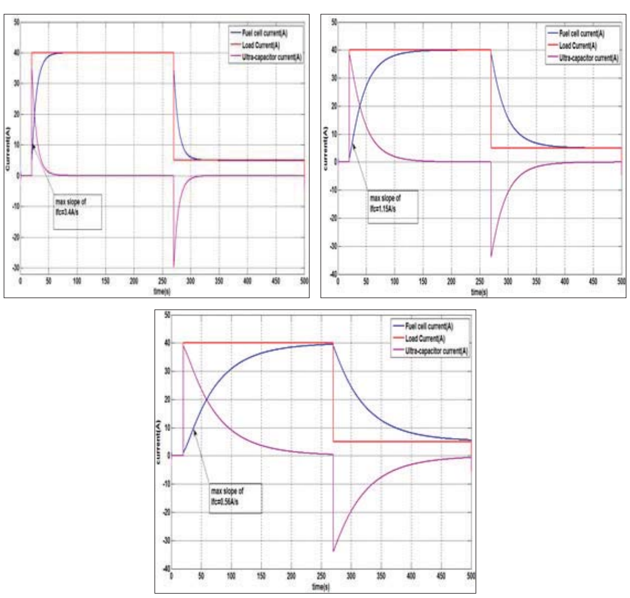
Modelling and Simulation of Fuel Cell - Super Capacitor Hybrid for Stationary and Transportation Applications

Jiflin Das, N Rajalakshmi and K S Dhathathreyan, Centre for Fuel Cell Technology

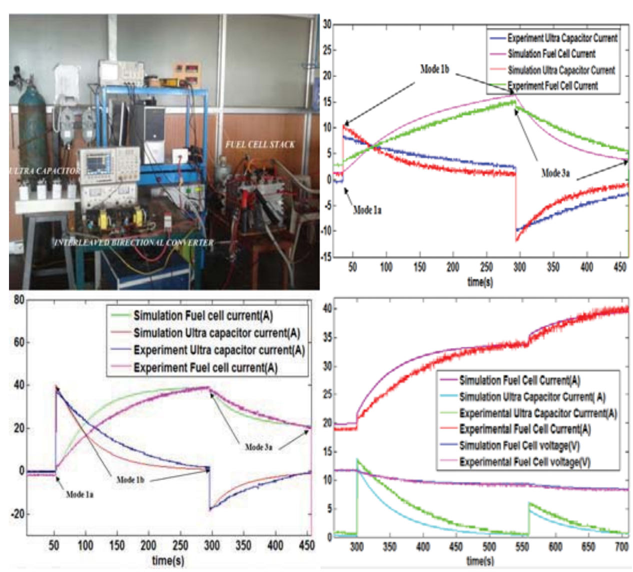
Fuel cells are normally sized to supply the average or steady state power so as to minimise cost. In order to respond to quick changes in load, Fuel Cells (FC) are hybridised with Energy Storage Systems (ESS) such as batteries or super capacitors. The choice of super capacitors or batteries or combination of them depends on the characteristics of the required energy. We have integrated the ESS with FC's to combine the advantage of direct tied configuration with multiple converter configurations. During nominal load demands the converters are interleaved, the FC is operated at Maximum Power Point Tracking (MPPT) with ESS tied directly to FC. Upon prediction/ predefined load demand, the energy requirement of ESS is decided. Isolated or decoupled operation of the converter configuration is chosen whenever the energy requirement of ESS is greater than FC. The fuel cell, ESS units and load are connected to a multi-input interleaved bidirectional converter. The converter provides the necessary connection between FC, ESS and load. A multi-objective controller provides necessary commands based on the status of the FC, ESS and the load demand. The design of hybrid system has a stack of 500W nominal load. PEM FC with 20 cells, 330sq cm, 10-16V, 40A is considered. The ESS used is ultra capacitor (350F, 1200F and 2500F) with a maximum terminal voltage of 2.7V. Eight units of 2500F are connected in series to obtain an Ultra Capacitor bank. Bidirectional converters rated for 500W are connected to fuel cell and ultra capacitor. The switch used was IRF150 for boost and buck switches. Regulated filter capacitance: 128μF. Simulation outputs of the step loading characteristics of the fuel cell coupled with ultra capacitor are shown below . The simulations were carried out for a 600s time frame. A step load of 0A to 40A and then 40A to 5A is applied to the fuel cell coupled with ultra-capacitor.

The simulation is carried out for 600s time. Using higher values of capacitance the slope of the fuel cell current is reduced from 3.4A/s to 0.56 A/s.

The experimental setup of supercapacitor tied fuel cell with interleaved bidirectional converter is shown below. The simulation and experimental waveforms of ultra capacitor and fuel cell currents in various load current step changes are shown for various modes of operation. A multi-objective energy and power management algorithm is proposed on predicted/ predefined load pattern. When the load demand is less than the fuel cell capacity the ESS converters need not be idling and can be directly tied to fuel cell and the converters are interleaved. This helps in restricting the fuel cell slope current for any dynamic changes in the load and the ripple is minimised.



Simulation outputs of the step loading characteristics of the fuel cell coupled with ultra capacitor



Simulation and experimental waveforms of ultra capacitor and fuel cell currents in various load current step changes are shown for various modes of operation

Development of Fe-P Soft Magnetic Alloy for Stator Component in Motor for Automotive Applications

S B Chandrasekhar, V Chandrasekaran, P Venugopal Reddy and R Gopalan,
Centre for Automotive Energy Materials

Soft magnetic materials have a huge potential in motor applications. The use of Brushless DC (BLDC) motor in automotives can improve a vehicle's fuel efficiency and provide a quieter in-car environment. The usage of BLDC motors is estimated to be about 600 million in traditional light vehicles by 2018 (The World Market for Electrical Motors in Automotive Applications - 2011 Edition). For this application, the prerequisites for a good soft magnetic material are high saturation induction and permeability with low coercivity and core loss. Presently Si steel is widely used owing to its high saturation induction (typically 1.7-2.0T). However, the low resistivity of Si steel makes them unsuitable for high frequency applications. Recently though, there is a growing demand in the automotive industry for alternate soft magnetic materials with high induction and relatively low core loss in order to save energy. Fe-P is one of the most promising materials in this regard. Hence a cost-effective synthesis technique combining high saturation induction and low core loss is bound to receive the spotlight. The Centre for Automotive Energy Materials at ARCI has a research programme to develop soft magnetic Fe-P alloy to be used as a stator component in motors for electric/hybrid electric vehicles.

Fe-0.4 wt.%P alloy in the form of ingot was prepared by casting molten Fe with suitable amount of Fe3P. The ingot was forged and rolled at 900°C. The rolled sheet was solution treated at 900°C for 1 hour and was subsequently annealed at 600°C for 30 minutes. The annealed sample exhibited a good combination of soft magnetic properties. The saturation induction (Bs) was as high as 2.1T with a coercivity of 0.67Oe. When a material with such high Bs is used as stator component, the efficiency of the motor is expected to enhance. Detailed microstructure analysis showed that the heat treated sample had fine nano precipitates of Fe3P dispersed in α-Fe(P) matrix. Due to the fine length scale of the precipitates, the two ferromagnetic phases (α-Fe and Fe3P) are exchange coupled, yielding high saturation induction. The relatively large resistivity of 70$\mu\Omega$cm of these materials would be useful in reducing the eddy current losses (Fig. 1).

Owing to the excellent magnetic properties exhibited by the annealed alloy, the material was chosen to make stator for a prototype motor. The stator assembly was fabricated and assembled into a motor in collaboration with M/s. Delta Motors, Secunderabad (Fig. 2). The performance of the motor was tested and was found to be relatively better than the motor with stator component made of conventional Si-steel.

Design and synthesis of new alloys with higher phosphorous content to enhance the soft magnetic properties is being pursued. The suitability of such materials for fabrication of high performance motors in collaboration with the automotive industry will be explored.

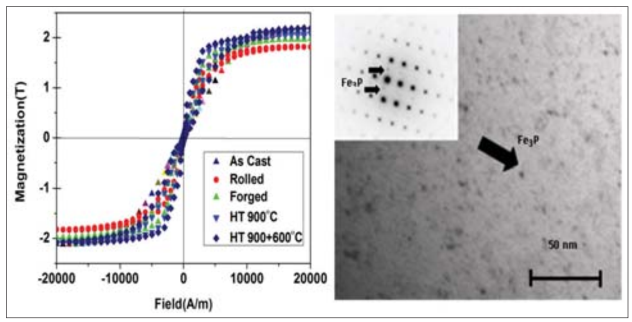


Fig 1: (a) Magnetisation curves of the Fe-0.4 wt.%P at different stages of processing and (b) TEM picture of the annealed sample exhibiting best soft magnetic properties showing the presence of fine precipitates of Fe3P

Fig. 2: A prototype motor assembled using the rotor fabricated from the Fe-P alloy synthesised at ARCI

Fe-based Cerametallic Friction Facings for Automotive Applications

Malobika Karanjai, A Siva Kumar, D Sen and Y Krishnapriya, Centre for Nanomaterials

Cerametallic friction facings for clutch applications primarily consist of tailor-made compositions of (a) Metal powders (b) Ceramics (c) Lubricants and (d) Fillers. Each of the constituents has a specific role to play in the context of the targeted application.

The metallic constituents provide the requisite strength and thermal conductivity while the ceramics act as abrasives and friction stabilizers. The lubricants are meant to control the friction properties and the fillers, being light-weight inorganic minerals, compensate for the weight-volume fraction. Typically, the ingredients selected are metallic powders like Fe, Cu, Sn, bronze, ceramic abrasives like zirconium silicate ($ZrSiO4$) or mullite, friction stabilisers like mica or vermiculite, and lubricants like graphite. The process involves mixing and blending of powders, their compaction and subsequent pressure sintering. The aim of the effort was to develop a cost-effective technology of making Fe-based friction facings having reduced copper content.

ARCI has now developed the technology successfully as part of a major sponsored project. 65-70wt% of metallic powder (Fe, Cu and Sn) was blended with 20wt% zirconium silicate, 8-10% graphite and remaining mica and vermiculite for a total of 6-8 hrs. The blended powders were then compacted at about 550MPa and pressure sintered under hydrogen at 1050°C for 3 hrs at 3-5MPa. The challenge was to process stand-alone friction facings without the use of a steel back plate, such that they can be adhered to the clutch carrier plate directly, using a high-temperature resistant rigid/cushion bonded adhesive. The tolerance required on the thickness was $\pm 50\mu m$ and that in parallelism was $80\mu m$. After establishing the material properties at a laboratory scale, a special-purpose hot-press (Fig. 1) was designed and fabricated indigenously to produce actual-sized, friction facing components with the required tolerance as shown in Fig. 2.

Material properties like density, hardness, microstructure, porosity, phase constitution, thermal conductivity, friction and wear properties were evaluated and optimised. The results obtained were at par with those displayed by imported samples, as shown in Table 1. About 500 samples with properties at par with commercial imported samples used as a benchmark, with the desired tolerance in thickness and parallelism were supplied to a company for validation. A patent application covering the process and the multi-piston hot press has already been filed. A technology transfer document consisting of plant layout and production design of a special-purpose hot press to produce 100,000 pieces of friction-facings per month has also been prepared.

Table 1 Comparison of properties of ARCI sample to that of commercial sample

Properties	Commercial sample	ARCI sample
Density, g/cc	4.54-4.73	4.55-4.75
Hardness	26-34 HB 43-54 HV	24-40 HB 43-66 HV
Thermal properties at 300°C	7.54 W/m^3-K 2.54 mm^2/s	17.6 w/m^3-K 3.55 mm^2/s
Friction coefficient	0.48	0.55
Wear rate, (mm^3/mm)	22 x 10^{-6}	16 x 10^{-6}
Disc wt. loss, (mg)	214	140

Fig. 1 Special purpose hot press

Fig. 2 Cerametallic friction facing

Aluminium Alloy-CNT Composites for Fastener Applications

R Vijay, Y Sumanth and Tata N Rao, Centre for Nanomaterials

Several industries, including automobile, aerospace, defence and medical increasingly demand high-strength, ultra-light, non-ferrous nano-composite materials, which are environmentally friendly, energy saving and economical. Most popular among them are Aluminium-Carbon Nano Tube (Al-CNT) nano-composites due to significant enhancement they afford in the mechanical performance of the final composite because of extremely high strength (150GPa), high elastic modulus (1-5TPa) and low weight of CNT. The use of aluminium is advantageous in reducing the overall vehicle weight, since its density (2.7g/cm^3) is one third of steel. One of the potential applications of Al-CNT composites is in fasteners, replacing the commercially available steel fasteners. The materials for use as fasteners should possess yield strength higher than 500MPa, ultimate tensile strength greater than 550MPa and elongation more than 6%.

ARCI's expertise in the field of synthesising CNTs and in producing nanostructured materials by mechanical alloying/high energy milling makes it possible to produce well dispersed Al-CNT nano-composites. ARCI has initiated a R&D programme to develop Al-CNT based composites that are suitable for high-strength, light-weight fasteners as a substitute for steel fasteners in critical applications.

Al2025 alloy (Al-4.4Cu-0.5Mg) was taken as a base material and CNT (0.5-2.5wt%) (Fig. 1) was dispersed in this material by high-energy milling. The milled powder was filled in a can, degassed and sealed. The sealed can was hot-extruded to get a rod of 12mm diameter and 400mm length. The extruded rods were characterised for microstructure and tensile properties. Typical TEM image of Al alloy-CNT composite showing both $CuAl_2$ precipitates and fragmented CNTs is given in Fig. 2.

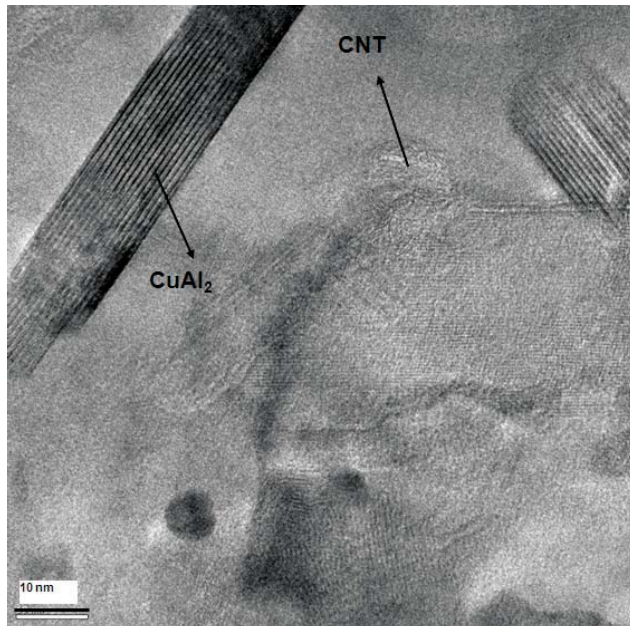


Fig.2 TEM image of Al alloy-2.5%CNT composite

The stress-strain plots of Al alloy-CNT composites with CNT concentration are given Fig. 3. The strength of the composite material increases with CNT content, reaching 638MPa with 2.5wt% CNT. A detailed study on the above composites is in progress to establish their suitability for fastener applications.

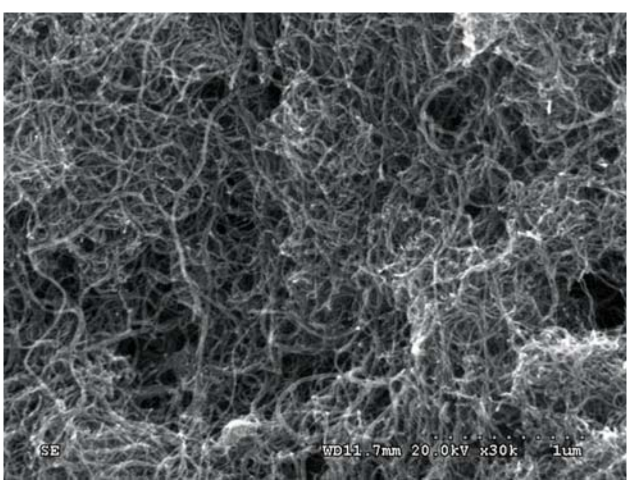


Fig.1 FE-SEM image of MWCNT

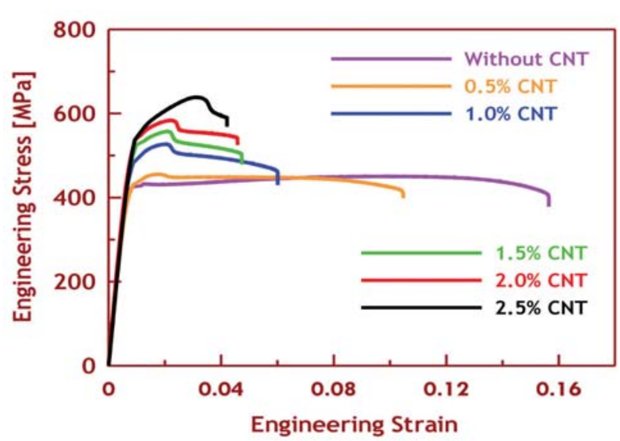


Fig.3 Stress-strain data of Al alloy-CNT composites with varying CNT content

Electrospun Nanofibres For High Performance Automotive Filter Applications

S Sarma and Tata N Rao, Centre for Nanomaterials

Nanofibre filter media has enabled new levels of filtration performance in applications spanning air, water, beverages, chemicals, oils, etc. Polymer nanofibre coatings on standard filtration media have brought about significant improvement in the performance of automotive air filters. Nanofibres with a diameter of less than 500nm have high specific-surface area, adequate porosity and small porosity suitable for high-performance air filters. These coatings improve the filtration efficiency and dust holding capacity of the filter with minimum rise in pressure drop.

Electrospinning is one of the most popular techniques used to produce nanofibre coatings on conventional filtration media. An attempt has been made at ARCI to develop nylon-based polyamide-6 nanofibre coating on commercial air filtration medium using continuous electrospinning equipment. This allows coating of several metres of filter fabric, indicating its potential for commercialisation.

As shown in Fig. 1, a cylindrical electrode rotates in a polymer liquid container, while a filter fabric moves below another cylindrical collector electrode. When high voltage is applied, the droplets on the rotating cylinder expand in the form of nanofibres due to high voltage on the surface of the droplets, which dominates the surface tension. The resulting nanofibres deposit on the moving filter fabric and form a very thin film as shown in Fig. 2. A commercial filtration medium is used as the fabric substrate, which continuously moves below the collecting electrode. The fibre size and morphology depend on the concentration of the polymeric liquid, the electric voltage applied, distance between the electrodes and rotation speed of the electrode.

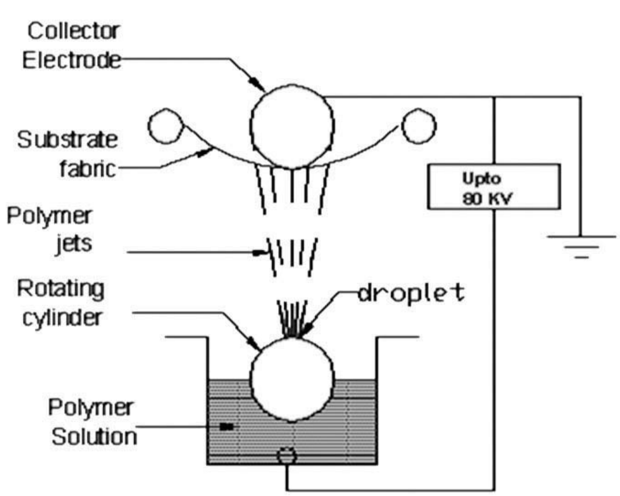


Fig. 1 Schematic of continuous electrospinning unit

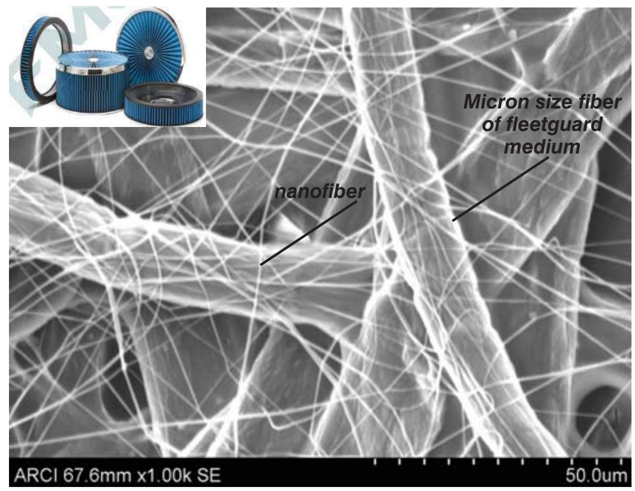


Fig. 2 SEM image showing nanofibres on the conventional filter media. Inset shows commercial filter elements used in automotives

One of India's leading manufacturer of heavy duty air, fuel, lube and hydraulic filters, has shown interest in nanofibre coatings on their filtration medium. Based on their requirements, ARCI has developed PA-6 nanofibre coatings on the filtration medium supplied by the company. Developed composite samples were tested by the company and according to preliminary test results, filtration efficiency increased to particle sizes ranging from 0.4-10 microns, and dust holding capacity of the composite has increased by 18%. These sheets will be transformed to fleeted filter elements to be tested in simulated conditions in automobiles. These electrospun coatings can be applied for oil/ air filtration in the combustion engine as well as for cabin air filtration.

Development of New Grade of TiCN-based Metal/ Intermetallic Matrix Nanocomposites for Machining Inserts

J Joardar, M S Archana and P Chandran, Centre for Nanomaterials

TiCN cermets are widely used for steel machining. The properties of these cermets can be enhanced by incorporating an intermetallic matrix as a partial replacement of the metal binder phase, along with nano or ultrafine grade hard phase(s). It is envisaged that such a structure can be useful in machining 'difficult to machine' materials like Compacted Graphitic Iron (CGI) and other new-generation Advanced High Strength Steels (AHSS) used in the automotive industries.

At ARCI, several new grades of TiCN-based nano/ ultrafine composites have been developed by Spark Plasma Sintering (SPS) techniques and their properties compared with those obtained by conventional sintering (CS). These composites contain nano metal and/or intermetallic matrix comprising of one or more aluminides. Some of these are listed in Table 1, which shows properties at par or better than commercial grade TiCN-based cermets. The advantage of aluminide in the matrix is to improve oxidation resistance of the composite. The nano or ultrafine grade of the hard phase(s) ensures higher rate of diffusion of tungsten and other elements in the TiCN core, which leads to better grain boundary cohesion and improved toughness. Further improvement in the insert properties is underway with the development of new SPS die-punch design using finite element modeling.

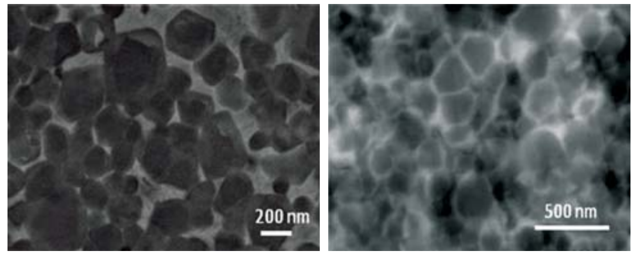


Fig. 1: SEM of (a) CS and (b) SPS TiCN based ultrafine/ nanocomposites with nanocrystalline binder developed at ARCI

Table: TiCN-based ultrafine/nano composites developed at ARCI vs commercial grades

Cermet	Vickers Hardness (GPa)
CS TiCN-WC-nNi*	12
CS TiCN-WC-FeAlNi*	11-12
SPS TiCN-WC-nNi*	24-25
SPS TiCN-WC-FeAlNi*	18-19
TiCN-based+	16.7
TiCN-NbC-based+	14.9
TiCN-WC-NbC-9.4Co**	18
TiCN-WC-TaC-12.9Co**	17.3

* Developed by ARCI +Commercial grade
** Patented by a leading company

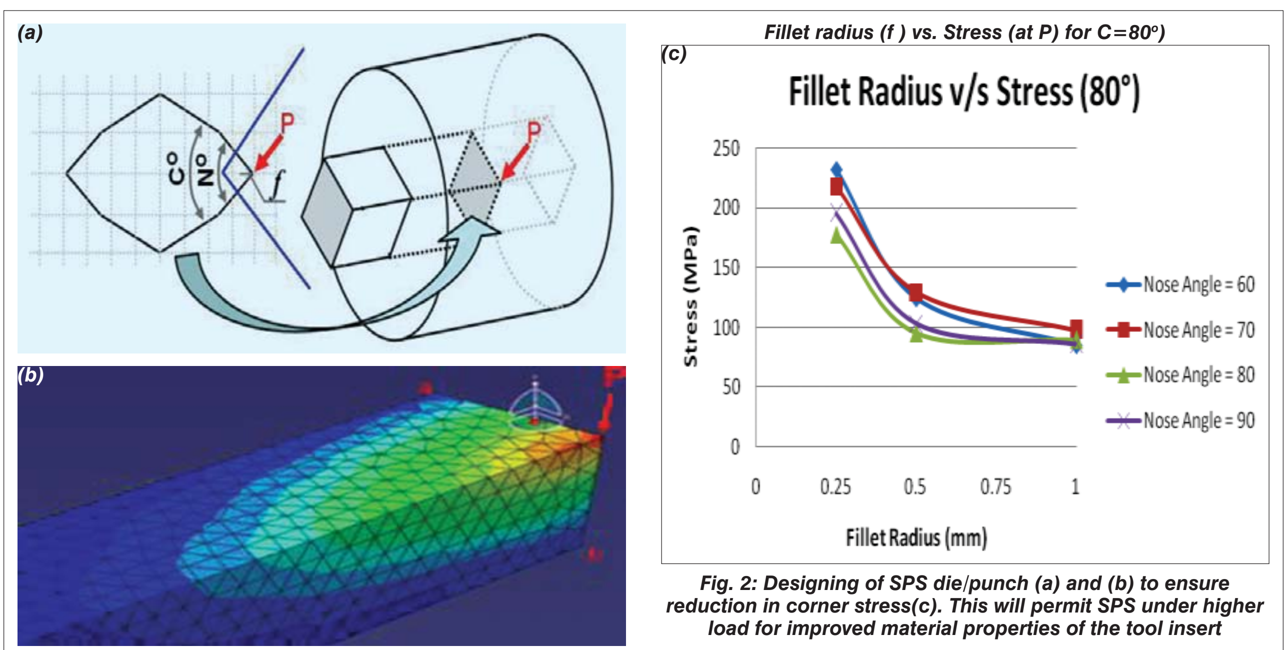


Fig. 2: Designing of SPS die/punch (a) and (b) to ensure reduction in corner stress(c). This will permit SPS under higher load for improved material properties of the tool insert

Laser Hardening of Automotive Components

S M Shariff, Manish Tak and G Padmanabham, Centre for Laser Processing of Materials

Laser Hardening is a solid-state transformation hardening process where steel is heated above its critical temperature by irradiating the surface with laser beam followed by rapid cooling upon self-quenching. The heating above the critical temperature transforms ferrite and carbide phase to Austenite phase of the steel, which converts to martensite upon quenching. The martensite phase is harder than carbide and austenite phase. The martensitic transformation mainly depends upon the chemical composition of the material i.e. more carbon percentage leads to better martensitic transformation. Also, the martensitic transformation not only depends on the temperature rise but also on rate of cooling. The laser hardening technique is ideal for improving the mechanical properties with significant improvement in wear resistance and fatigue life in a localized manner with less heat input and minimal distortion. A few automotive components have been successfully laser transformation hardened to meet the performance requirement of users. Some of them are presented here.

Laser Hardening Process for An Automotive Compressor Crankshaft

Laser hardening process for hardening the wear-contact regions with a case depth and hardness of 200μm and 500–600 HV, respectively was developed using a 6-kW fiber-coupled diode (Fig. 1) laser integrated with a 6-axis robot and turn-tilt table. Initially, the effect of parameters such as laser power (P), scan speed (V) on case-depth, case-width, hardness and microstructure of the hardened case of the steel used for crankshaft were investigated. The effect of parameters on case depth is shown in Fig.1

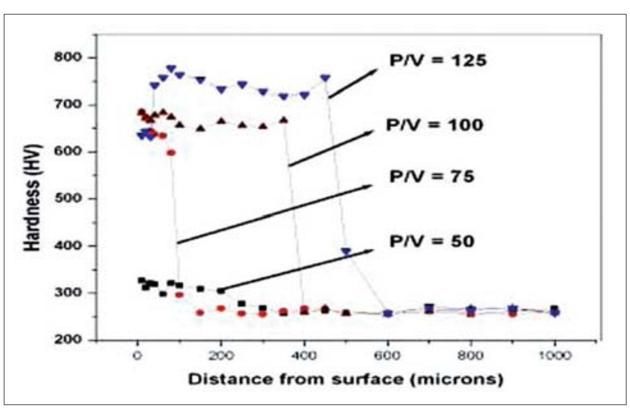


Fig.1 Response of parameters to case depth

Microstructure of treated layers (Fig.2) showed uniform martensite in the hardened layer (HZ) and partially transformed pearlite and matensite in interface region (TZ). Residual stress analysis in hardened region also indicated net compressive stress of about-220MPa with 70% martensitic phase, 20% carbide phase & 10% austenite phase which is expected to improve fatigue life. After optimizing the process parameters, actual crankshaft was processed by developing the robotic program for hardening required five different locations that include contact-pin and bearing faces in a single step. The processing sequence was chosen in such a way that minimum time taken to process as well as avoid pre-heating effect to its neighboring area. Various issues like corner-effects, edge effects and heat-sink effects were addressed by fine tuning parameters like laser power, scanning speed, processing direction, angle of processing and ramping effects. Finally, the hardened layer processed with optimized parameters produced a case depth of 350 micron having a hardness value more than 600 HV with a peak hardness value of 820HV at the surface. The surface roughness of the hardened layer was also as low as 0.4Ra with no distortion. The final process time achieved is 90 seconds with actual laser processing time being 28 sec. The crankshaft processed with optimized parameters was subjected to compressor overload testing wherein compressor speed used was 3600 RPM with a delivery pressure of 19 bar. The crankshaft did not show any signs of deterioration even after 24-hrs indicating the acceptance of the application.

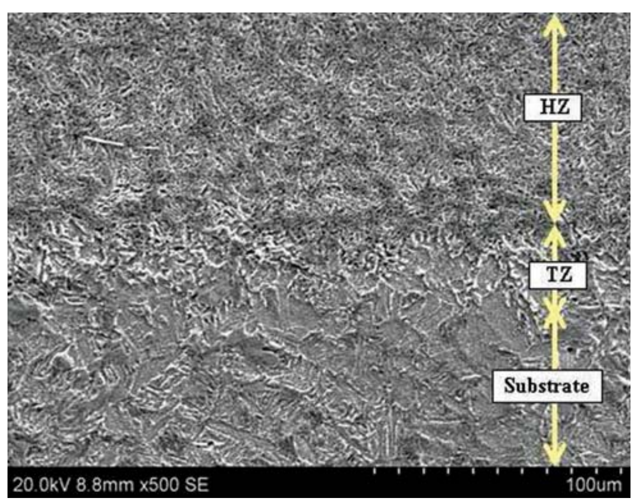


Fig.2 Microstructure of treated layers

Laser Surface Treatment of Automotive Piston Ring

S M Shariff, Manish Tak and G Padmanabham, Centre for Laser Processing of Materials

Piston rings are subjected to wear due to their relative movement with cylinder bore under certain load and environmental conditions. Most automotive piston rings are made of either cast irons or steel with surface modified to provide wear resistance. Various coatings like gas nitriding, chromium coating, PVD coating, carbo-nitriding, molybdenum coating and other thermal treatments are imparted in automotive industry depending upon the service conditions required. With the advent of industrial lasers, application of laser surface hardening techniques involving transformation hardening or re-melting of ductile iron utilized in various automotive components have been investigated and analyzed for hardness, microstructure and wear performance. The effect of laser processing conditions on microstructure and hardness of treated layer of piston ring surface and its influence on sliding wear performance utilizing ring-on-disc tribometer was investigated and compared to the sliding wear performance of chrome plated, PVD coated and untreated counterparts. The sliding wear performance of as-treated laser-processed as well as other coated rings vis-à-vis untreated ring is shown in Fig 2. As evaluation of worn profile is difficult in case of piston ring, weight loss measurement is deemed appropriate for wear resistance assessment. In case of wear evaluation of cast iron discs, both weight loss and wear depth measurements at the end of wear testing have been measured and it was considered that representation of wear depth evaluation is more appropriate owing to uniform semi-circular worn trough formation. All laser hardened rings exhibited a 16-fold reduction in weight loss as compared to untreated ring indicating vast improvement in sliding wear resistance due to hard microstructures in the treated layers. Chrome plated (CRPL) ring exhibited only about 11-fold reduction in weight loss in comparison to untreated ring, whereas carbo nitride (CRBD) ring exhibited similar weight loss comparable to that of laser treated rings. However, comparing the wear on cast iron disc, wear depth was relatively more in discs slid against laser hardened and chromium coated rings. Wear depth of disc slid against CRBD ring was the lowest to the tune of 0.07 mm as against 0.08 mm in case of untreated ring and 0.36 mm in CRPL ring. Discs slid against laser treated rings showed a wear depth in the range of 0.25-0.31 mm. This suggests that laser hardening (LH) of piston ring can enhance performance over chrome plating. The present work demonstrated the effect of diode laser hardening of piston ring on improved hardness, refined microstructure and sliding wear performance. Sliding wear performance under unlubricated condition of laser hardened rings improved manifold as compared to that of untreated and chromium plated rings. Compared to that of PVD coated ring, the laser hardened rings showed similar wear loss but also with high disc wear.

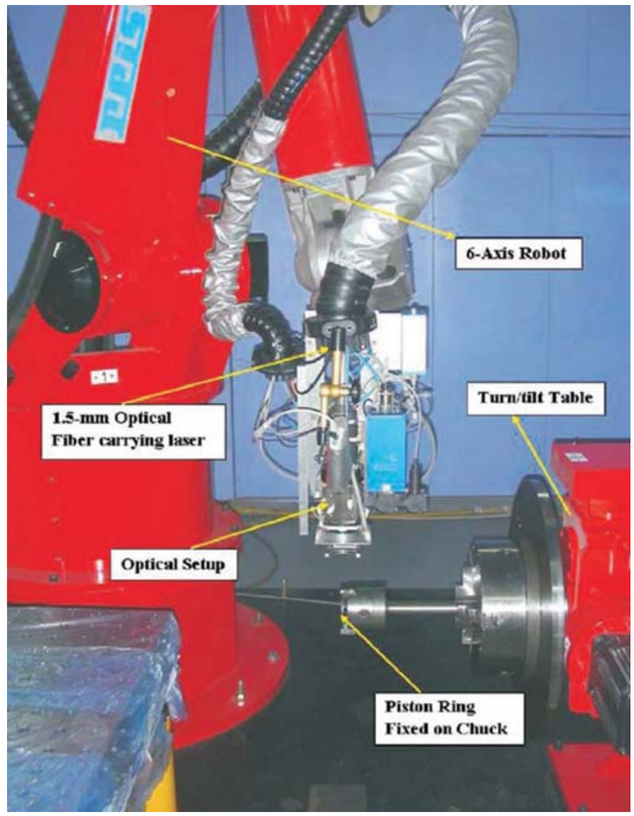


Fig.1 Laser hardening set-up

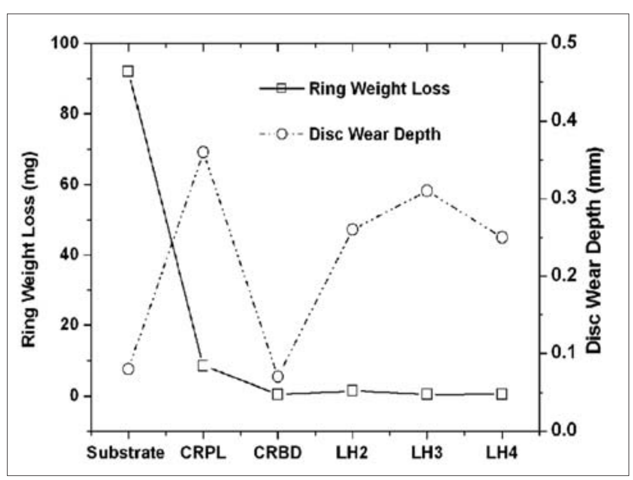


Fig. 2 Sliding wear performance (CRPL,CRBD, LH)

Laser and Laser Hybrid Welding of Automotive Grade Steel Sheets

K V P Prabhakar and G Padmanabham, Centre for Laser Processing of Materials

Dual phase (DP) steels due to their superior crash energy management capability are increasingly being used in automotive applications. The composite microstructure of ferrite and martensite gives them favorable combination of strength, high work hardening rate, ductility & formability over other steels of similar yield strength. Laser and Laser-Metal Inert Gas (MIG) hybrid weldability studies were carried out on 1mm thick similar DP590 steels using 3.5 kW CO_2 laser in conjunction with a pulsed MIG welding system by varying various parameters like laser power, welding speed, shielding arrangement, distance between arc and laser etc., Weld geometries produced by arc, laser and laser- hybrid welding are shown in Fig.1. The arc weld is shallower than both the laser and hybrid welds. The width of the hybrid weld is comparable to that of the arc weld.

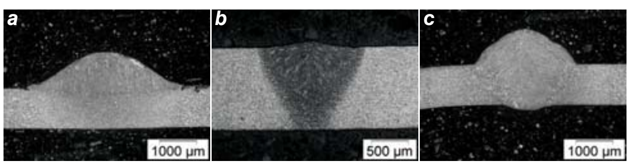


Fig. 1 Weld cross-section of (a) MIG, (b) laser and (c) laser hybrid welded DP 590 steel specimens

The fusion zone (FZ) of the laser welded DP 590 is predominantly martensite (Fig.2a) which is due to rapid cooling of the weld pool during laser welding process. The heat affected zone (HAZ) of the welded joints contained tempered martensite(Fig. 2b). The FZ microstructure of laser hybrid butt welded DP 590 was also found to be martensitic (Fig.3a), but relatively less amount of martensite as compared to laser butt welded specimen. This could be due to low alloying content of filler wire.

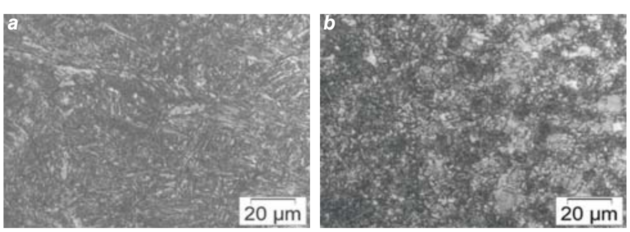


Fig.2 Optical micrographs of laser butt welded joints (a) FZ and (b) HAZ

The microhardness profiles (4 a & b) of laser welded and laser hybrid welded steel joints respectively indicate higher hardness in the FZ compared to base metal in both the cases. Laser welded FZ microhardness is higher than laser hybrid welded joint which is expected due to higher martensitic content. However, a dip in the HAZ hardness was observed. The decrease in microhardness is due to partial disappearance and tempering of pre-existing martensite in case of laser butt welded joints (Fig.2b) and complete disappearance of pre-existing martensite in case of laser hybrid butt welded joints (Fig. 3b). The degree of softening in the laser hybrid welded joints was more severe and the size of the soft zone was also larger than the laser butt joints.

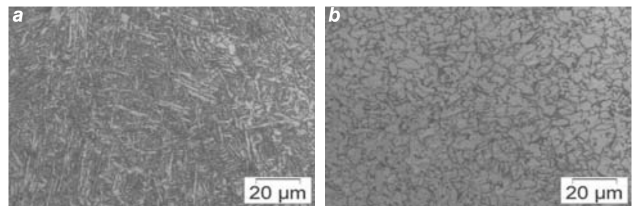


Fig.3 Optical micrographs of laser hybrid butt welded joints (a) FZ and (b) HAZ

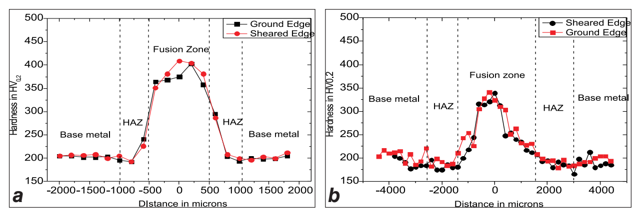


Fig.4 Microhardness profile across the joints (a) laser-welded and (b) laser hybrid welded

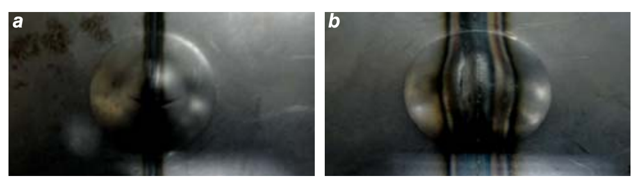


Fig.5 Erichsen cup test specimens a) laser weld; and b) laser hybrid weld

The Erichsen cup test results indicate loss of formability in both the cases compared to base material (Cup height: Base material-11.3 mm; Laser weld-8.1 mm and Laser hybrid weld-8.7 mm). But, the cup height of laser hybrid weld is slightly higher than that of laser weld. The soft zone may be contributing in the deformation process. Further, it has been observed that (Fig.5) the failure in the laser welded specimens occurred across the weld line, while the failure in the laser hybrid butt welded specimens occurred along the weld line in the HAZ. This indicates a weak weld and may not be acceptable for actual use. More optimization of the process is required to get acceptable welds using laser hybrid welds to make use of the good formability achieved in terms of Erichsen cupping test results.

Aluminum – Steel Joining With Cold Metal Transfer Process

K V P Prabhakar and G Padmanabham, Centre for Laser Processing of Materials

Aluminium-steel dissimilar material combination enables multi-material designs useful in automotive light weighting, through selective substitution of heavier steel parts by aluminium alloy parts. Thermal joining of such dissimilar material combination is difficult due to formation of brittle intermetallic compounds (IMC) at the interface that deteriorate the mechanical performance of the joint. Recent reports suggest that if IMC layer is limited to a thickness of less than 10μm, joint strength will not be significantly affected. Low heat input joining processes help in minimizing IMC layer formation.

Cold Metal Transfer (CMT) is a reduced energy process in which nearly zero current metal transfer takes place and can be useful in minimizing IMC layer formation at the interface. CMT is a modified MIG short arc process, wherein, as the filler wire tip makes contact with the molten pool, the digital process control retracts the filler wire promoting droplet detachment with the welding current fast plummeting to near-zero, the wire being fed forward re-igniting the arc. Wire progression/regression operations are executed 70 times every second, with the hot and cold processes being alternately repeated. The CMT process thus provides significant heat input reduction, spatter-free metal transfer with minimal distortion.

Filler metal composition plays a major role in the joint and IMC layer formation. There are reports that addition of Si in filler wire aids in minimizing the IMC layer formation and improving the wetting behavior. In present work 2mm thick A6061 T6 aluminium alloy is brazed to 1.2mm thick galvanized IF steel using 4043 (Al-5%Si) in lap-fillet configuration. Aluminium sheet is placed over the steel sheet and a CMT arc is run along the edge of the aluminum sheet as shown in Fig.1. The molten metal generated by melting of filler wire and base aluminium wets the steel surface to form a joint. Experiments were carried out with varying processing parameters like wire feed rate and processing speed.

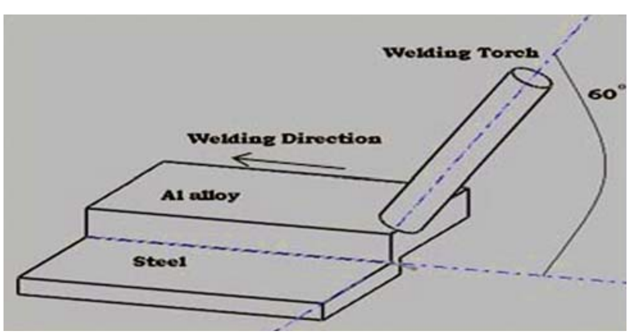


Fig. 1 Schematic plan of the welding process

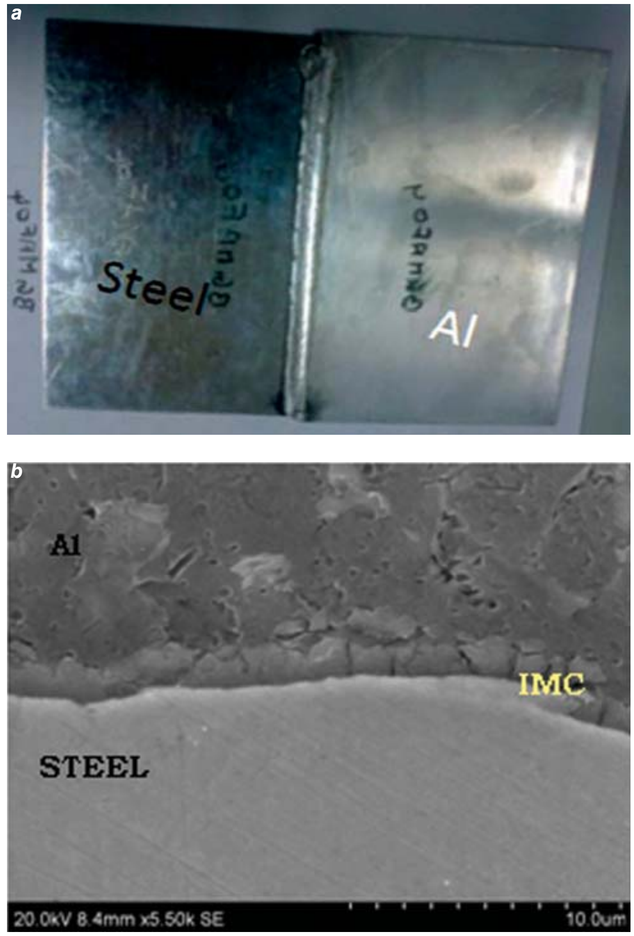


Fig.2 a) CMT weld brazed Al-Steel lap joints and b) SEM micrograph of the interface

Al-Steel joints could be successfully produced (Fig.2a) with very thin intermetallic layer interface (Fig.2b). The joints had a load bearing capacity of 200 N/mm which could be a useful mechanical property for application in automotive body assembly. Further optimization of strength by improving the interface and reducing the porosity in the weld bead is underway.

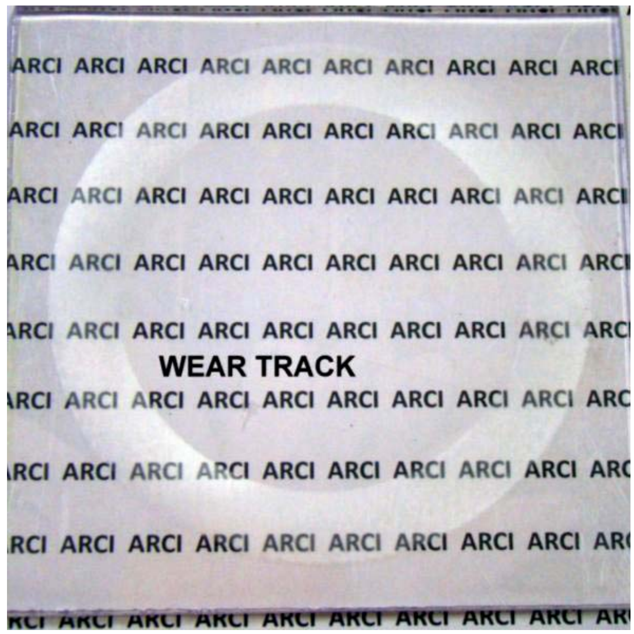
Sol-Gel Functional Coatings for Automotive Applications

R Subasri, K R C Soma Raju, D Sreenivas Reddy and V Uma, Centre for Sol-Gel Coatings

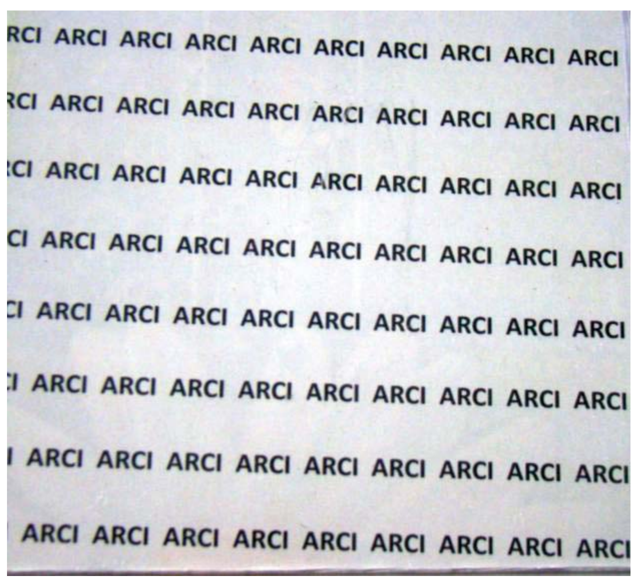
The Sol-Gel coating technology is a versatile surface engineering technique when compared to other vacuum based coating techniques for generating multi-functional coatings on many of the automotive components. Plastics are replacing glasses in automotive industry mainly to achieve light weighting. For example, windshields, window glazings, panoramic rooftops and headlamp bodies, etc. can be made of plastic. However, due to poor mechanical properties of plastics, a transparent, hard and protective coating on the surface is required. Additionally, antireflection property, hydrophobicity, low emissivity, etc. are also sought after for the coated plastic components when used for windscreen applications. Sol-Gel coating curable at low temperature can meet this requirement.

Silica-zirconia nanocomposite sols were synthesised using an appropriate UV polymerisable, organically modified silane and zirconium alkoxide. The sol was dip-coated on polycarbonate flat sheets and cured using UV radiation along with conventional thermal curing at 130°C. The coatings which were 4.0μm thick and showed a pencil scratch hardness of 4H, adhesion rank of 5B and visible light transmittance of 91%, were characterised for abrasion resistance as required by the automotive industry for use as a rear windshield. The percentage change in haze after abrasion testing for 1000 cycles using 2x250g load with CS10F wheels was found to be 0.9% when compared to 11.7% for a bare polycarbonate (PC). The developed coatings were found to qualify the specified requirement of abrasion resistance (change in haze after 1000 cycles <2%) under test conditions. The photographs of coated and uncoated PC after 1000 cycles of abrasion testing are shown in Fig. 1. Dark circles were marked to identify the wear track on coated substrate. As can be seen there is no visible track on the coated substrate while the uncoated PC shows a prominent wear track indicating excellent wear resistance of the coating.

In order that the coatings be applicable to the aerospace industry for aircraft windshields, the coated substrates were subjected to extreme climatic conditions of +50°C with 95% RH and -50°C for an 8hr duration each. All the mechanical and optical properties were found to be the same before and after climatic testing confirming the coatings to be promising for applications in automotive and aerospace industries. Currently, CSOL is exploring the commercial applications of such coatings on aircraft windshields.



(a) Bare PC substrate after taber testing



(b) Coated PC after taber testing

Fig.1 Wear track of (a) bare and (b) coated PC substrates after taber abrasion testing

Knowledge Management of Nanoscience and Technology

H Purushotham, Y R Mahajan and S V Joshi
Centre for Knowledge Management of Nanoscience and Technology

Centre for Knowledge Management of Nanoscience and Technology (CKMNT) was established as one of ARCI's project centres with the aim to offer comprehensive, one-stop, value-added knowledge management services to nanotechnology stakeholders – researchers, industries, policy makers, venture capitalists and funding agencies. CKMNT has been partially funded by the Department of Science and Technology (DST), Govt. of India, in a project mode and would help in fulfilling the objectives of the Nano Mission of DST. The centre is equipped with the required physical infrastructure, hardware/software/ databases, qualified manpower and has been operational since September 2009.

Other Ongoing Activities of CKMNT

Technical Reports

- CNT – Metal Matrix Composites
- Nanofibers in Healthcare
- Nanotechnology in Food & Agriculture
- Nanotechnology in Solar Energy
- Nanosensors for Automobiles

Databases

- Nanoscience & Technology Database
- Indian Nanotechnology Patents Database
- Directory of Indian Nanotechnology Companies and Institutes

Strategic Inputs to Nano Mission

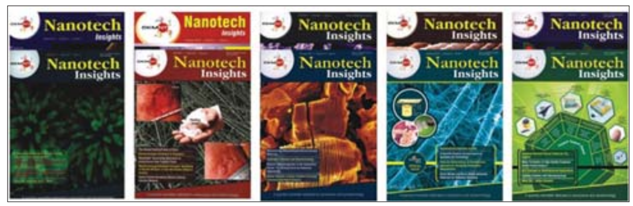
- Review of global regulatory framework
- Global investments and funding
- Guidelines for safe handling of nano materials in research laboratories
- A compendium on nano-enabled sensors in India

Patent Analysis

- CNT composites
- Nano fibres
- Mass production of graphene
- Nanomaterials in solar cells
- Nanomaterials in cancer imaging
- Nanomaterials in lithium-ion batteries
- Curcumin
- Ultra-hard coatings

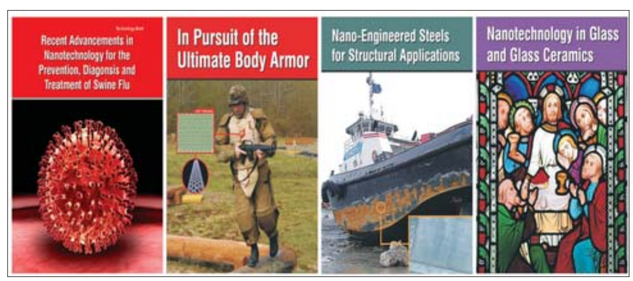
Newsletter

A prominent initiative of CKMNT has been the publication of Nanotech Insights, a quaterly newsletter dedicated to nanoscience and technology. Regularly published since January 2010, the above publication highlights recent advances in the field. CKMNT has published 10 issues of Nanotech Insights so far and about 5000 copies of each issue are being circulated among the nanotechnology stakeholders. Many technical articles covered in Nanotech Insights have been cited in the top 10 accessed articles by Nano Werk (www.nanowerk.com).



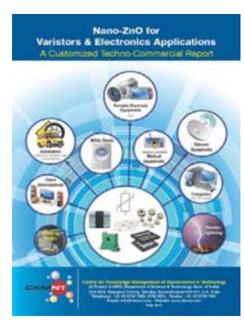
Technology Briefs

CKMNT has also been bringing out technology briefs in select areas of contemporary interest. These reports cover the current technology status, recent R&D developments, new process/product trends, patent analysis, transfer, business/market opportunities etc. Technology briefs have been sent to many concerned industries for their information.



Customized Techno-commercial Reports

CKMNT has also begun to prepare on demand customized techno-commercial reports for its clients. The first such report entitled 'Nano-Zinc for Varistors & Electronics Applications' was prepared for a major multi-national company with a presence in India. Armed with requisite infrastructure and technical resources, CKMNT intends to further expand this service in the near future.



TECHNOLOGY ACQUISITION, TRANSFER AND INTERNATIONAL COOPERATION

Technology Acquisition, Transfer and International Cooperation

The role of Centre for Technology Acquisition, Transfer and International Cooperation is to act as a bridge between the technical centres of ARCI and the external collaborators and technology receivers (prospective and existing). The activities include:

- Formulating engagement models to implement variants of technology collaboration and transfer projects and draft appropriate implementation agreement
- Marketing of technologies
- Preparation of techno-commercial feasibility reports
- IPR management.

Engagement Models being Used by ARCI

ARCI has been continuously evolving its collaborating models to enable involvement of other organisations from R&D, academia and industry to enhance the effectiveness of technology transfer. Following agreements have been signed either to develop technologies and/or to accelerate commercialisation of technologies:

- For know-how transfer of laser cladding processes to refurbish used diesel engine cylinder heads for an engine manufacturing company
- For jointly demonstrating the utility of technology to manufacture receiver tubes, and their further processing, including applying solar absorber coatings, joining of receiver tubes with other materials for Concentrated Solar Power (CSP) applications
- For designing and developing a Progressive Reactive Hot Press (PRHP) to produce complicated iron based Powder Metallurgy (PM) components (like automotive transmission components and air craft brake discs from metallic, ceramic and composite compositions), which particularly require multi-component hot pressing
- For providing options to explore applications of sol-gel technology and nano-silver technology to private sector companies so that they can explore different possible applications of a technology for which the basic scientific and technical concepts have already been understood reasonably well by ARCI. In these cases, associated companies presumably possess good understanding of targeted markets.
- For development of know-how for surface re-engineering of different grades of cold rolled, close annealed steels for automotive applications
- For joining and compatibility of aluminium with steel and plastic with partners from academia, R&D and industry in consortium mode to develop a pre-competitive technology that can be potentially useful for the industry as a whole

Marketing of Technologies

Channels like participation in exhibitions, presentations in seminars and workshops and personalised communication to carefully identified companies have been used during last year to popularise ARCI knowledge-base, skills and technologies. During the year 2011-12, ARCI participated in a number of exhibitions by putting up a stall to showcase its technologies, processes, products, expertise and achievements to a variety of audience such as entrepreneurs, scientists, R&D institutes and consulting companies. The following table depict the exhibitions participated by ARCI during the year 2011-12.

Table 1: ARCI participation in exhibitions during the year 2011-12

S.No	Name of the Exhibition and Place	Date
1.	Utilisation of Laser Technology in Industry and Medicine, Indore	April 28-29, 2011
2.	IIM-NMD-ATM 2011, Hyderabad	August 13-16, 2011
3.	Bharat Utsav-2011, Hyderabad	August 18-24, 2011
4.	31st India International Trade Fair- 2011, New Delhi	November 14-27, 2011
5.	National Workshop on Drinking Water Quality	November 15-16, 2011
6.	Laser India, Bangalore	December 6-9, 2011
7.	Bangalore Nano 2011, Bangalore	December 8-9, 2011
8.	Energy Efficient Materials, Manufacturing, Methods & Machineries for Ceramic Industries, Agra	December 20-22, 2011
9.	ICONSAT 2012	January 20-23, 2012

Several presentations and invited lectures made during conferences, seminars and workshops by ARCI officials are used to generate awareness about ARCI technologies and services.

Through a systematic process, the Centre identifies companies that can potentially benefit from commercialising ARCI technologies. Personalised communication is used to interact with them and to initiate discussions for possible transfer of ARCI technology.

Organisations initiating discussions with ARCI, including the ones looking forward to a collaborative technology development or to commercialise ARCI technologies, need to sign a confidentiality and Non-Disclosure Agreements (NDA). Fig. 1 depicts the NDAs signed by ARCI compared to the year 2010-11.

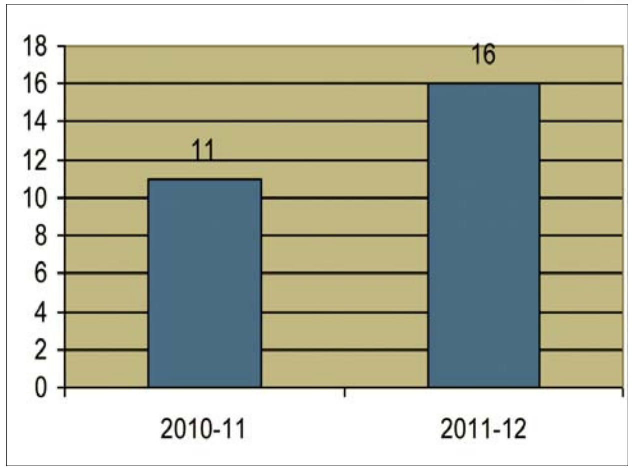


Fig. 1: NDAs signed by ARCI during 2011-12 compared to 2010-11

Preparation of Techno-commercial Feasibility Reports

Techno-commercial feasibility reports are prepared for technologies that are ready for transfer. Such reports contain useful information on technology features, proven and potential applications, preliminary financial analysis, and provide critical inputs to a prospective technology recipient company for technology commercialisation decisions. A techno-commercial feasibility report on Cerametallic Cookies for clutch applications was prepared during last year.

Portfolio of ARCI Technologies

Technology Transfers Undertaken

Sr. No	Technology	Application areas	Transfer status
1-8.	Electro Spark Coating (ESC) equipment	Hard, wear resistant coatings	Transferred to 8 companies on nonexclusive basis
9.	Magnesia Aluminate Spinel (MAS) technology	Steel, cement and power plants	Transferred on exclusive basis
10.	Ceramic crucibles for C&S analysis	Import substitute product	Transferred on exclusive basis
11.	Energy efficient air heaters from ceramic honeycombs	Industrial heating	Transferred on exclusive basis
12-15	Detonation spray coating	Wear and corrosion resistant coating for various components	Transferred to 4 companies on region-exclusive basis
16.	Reinforced graphite sheets and seals	Automotive sector	Transferred on exclusive basis
17.	Heat pipes heat sinks	Waste heat recovery systems, solar energy applications, power electronics	Transferred on exclusive basis
18.	Evaporation boats	Metallisation industry	Transferred on exclusive basis
19.	Ceramic honeycomb molten metal filters	Molten metal filtration	Transferred on exclusive basis
20.	Calcium aluminate cements and furnace sealants	In refractory castables	Transferred on exclusive basis
21-24	Micro Arc Oxidation (MAO) technology	Hard(1800 VHN) wear resistant coatings on aluminum and titanium alloys	Transferred to 3 companies on region-exclusive basis. Ongoing with one company
25.	ESC equipment manufacturing technology	Diverse industry segments	Knowledge transfer completed but not commercialised
26.	Nanosilver impregnation of ceramic water filter candles to impart anti-bacterial function	Water purification	Transferred
27.	Nano silver based textile finishes for anti-bacterial applications	Anti-bacterial applications	Transferred
28.	Technology to manufacture silica aerogel ceramic fibre based sheets or granules	Thermal insulation	Ongoing

Portfolio of ARCI Technologies

Technology Transfers Undertaken

Sr. No	Technology and Related Issues	Key Features and Possible Applications
1.	**Decorative, corrosion resistant, easy-to-clean (ETC) coatings** Scale of validation achieved-pilot scale; related intellectual property-Indian patent application number 620/DEL/2010 filed on 17/03/2010	Good corrosion resistance (withstands salt spray test of > 720 hrs.); Coloured/decorative coatings possible; ETC coatings with surface properties comparable to those offered by per fluorinated polymers (hydrophobic surface) ***Possible Applications: Blades of ceiling and exhaust fans***
2.	**Hard coatings on plastics** Scale of validation achieved-pilot scale; related intellectual property-Indian patent application number 2427/DEL/2010 filed on 12/10/2010	Optically transparent coatings with excellent adhesion on polymer surfaces which can be increased by plasma surface pretreatment; high scratch and abrasion resistance; superior hardness; application possible by conventional coating techniques like spraying, dipping, spinning etc; thermal and radiation curing possible ***Possible Applications: Helmet visors and road markers***
3.	**Hydrophobic abrasion resistant coatings on carbon epoxy composites** Scale of validation achieved-lab scale; related intellectual property-Indian patent application number 1278/DEL/2011 filed on 02/05/2011	Retention of hydrophobicity was found even after 1000 cycles of abrasion under 1kg load; low temperature curing conditions were optimised to yield maximum hydrophobicity and abrasion resistance of coatings; used new technologies like ultraviolet radiation curing and plasma surface pretreatment to obtain enhanced coating functionalities; entire coating technology amenable to scale-up ***Possible Application: Aerospace sector***
4.	**Nano silver impregnated ceramic candle filter** Scale of validation achieved-real life scale; related intellectual property-Indian patent application number 2786/DEL/2005 filed on 19/10/2005	Uses a simple wet chemical method to impregnate nano silver particles (avg. size 50nm) throughout the porosity of the ceramic drinking water filter; successfully field tested at various villages in Andhra Pradesh with a Non Governmental Organization (NGO); no electrical power and pressurised water required; ease of maintenance; commercially attractive {very low amount of silver used (0.2wt%), cost increase: candle (30-50%) and filter assembly (3-5%), replacement needed once in six months}; technology is ready for transfer to industry on non-exclusive basis for commercialisation in any state of India ***Possible Application: Ceramic candles for drinking water purification***
5.	**Nanocrystalline zinc oxide (ZnO) based varistors** Scale of validation achieved-pilot scale; related intellectual property-Indian patent application number 1669/DEL/2006 filed on 20/07/2006	Novel method to make Nanocrystalline ZnO powders; Breakdown voltage (5 times), coefficient of non-linearity (3-4 times); lower current leakage compared to that of commercial varistors; scale up using high energy milling and flame spray pyrolysis ***Possible Application: Surge voltage protection in electrical and electronics industry***
6.	**Silica aerogel based flexible thermal insulation sheets** Scale of validation achieved-pilot scale	Light weight efficient insulation, stable from cryo (-500C) to 10000C, thermal conductivity (0.03W/mK), fire resistant, chemically inert, easily cut, hydrophobic, thickness range from 5-25mm can be produced ***Possible Applications: Thermal insulation in automotives, architecture, heat cold storages, aerospace, thermal clothing etc.***
7.	**Laser welding and laser-MIG hybrid welding** Scale of validation achieved-real life scale	High power density; can weld a wide variety of materials and thicknesses; controlled heat input welding with precision; no vacuum requirement and can weld magnetic materials unlike electron beam welding ***Possible Applications: Laser welding process can be developed for tailor welded blanks for automotive applications etc.***

Sr. No	Technology and Related Issues	Key Features and Possible Applications
8.	**Laser surface hardening treatment** Scale of validation achieved-real life scale	Selective localised area processing; moderate to rapid cooling rates resulting in refined homogenous microstructures; no quenchant requirement; negligible post process machining requirement; high process flexibility, excellent reproducibility with ease of automation, faster production rates; controlled case depth, minimal distortion, and chemical cleanliness ***Possible Applications: The process can be developed for hardening of various auto components etc.***
9.	**Laser surface coating (alloying and cladding)** Scale of validation achieved-real life scale	Moderate to rapid cooling rates resulting in fine homogenous structures. Other properties are same as laser surface hardening treatment ***Possible Applications: The process can be developed for various components used in automotive, engineering etc.***
10.	**Laser drilling** Scale of validation achieved-real life scale	Non-contact drilling method; holes of large aspect ratio and very small diameter can be drilled; precise control of heat input; holes can be drilled at shallow angles to the surface; a wide variety of materials such as superalloys, diamond etc. can be drilled; due to its flexibility, the process can be automated easily with CNC motion; optical fibre delivery possible ***Possible Applications: The process can be used for specific applications such as drilling of fine holes on high pressure nozzle guided vanes and combustion liners for aero-engine applications***
11.	**Micro arc oxidation (MAO)** Scale of validation achieved-real life scale; related intellectual property-Indian patent number-209817 granted on 06/09/2007; US patent number 6893551 granted on: 17/05/2005	Eco-friendly and economically viable; uniform, dense, hard and thick coatings; superior coating properties and performance compared to other conventional acid-based processes like anodising and hard anodising; excellent tribological properties and corrosion resistance; 5-40 times service life enhancement; ability to coat Al, Ti, Mg and Zr metals and their alloys; ease to coat complex shapes and difficult to access regions; technology is available for export and for states in India other than Andhra Pradesh, Tamilnadu and Karnataka ***Possible Applications: For a wide array of applications in industries such as textile, automobile etc.***
12.	**Detonation spray coating (DSC)** Scale of validation achieved-real life scale	Attractively priced compared to imported HVOF units; extreme versatility; capable of depositing a vast range of metals, alloys, cermet, ceramic and composite coatings for varied functional applications; technology is available for all Indian states (except for Delhi, Haryana, Punjab, Uttar Pradesh, Uttaranchal, Bihar, Jammu & Kashmir, and Himachal Pradesh) and for export ***Possible Applications: Coatings for applications such as wear and corrosion resistance etc. for various Indian industries***
13.	**Exfoliated graphite and its value added products** Scale of validation achieved-real life scale; related intellectual property-Indian patent number-187654 granted on 07/06/1995	Impermeable to fluids; can withstand temperature range from -200 to +500°C in oxidising and up to 3000°C in inert atmosphere; excellent thermal shock resistance; does not age or creep; cannot be wetted by molten glass, metal etc., self-lubricating, easily cut and punched, and resistant to all chemicals; leak proof sealing under low turning torque ***Possible Applications: In automotive, oil refineries, petrochemical industries etc.***

IPR Management

The Centre for Technology Acquisition, Transfer and International Cooperation conducts patents' analysis to provide useful information for research and technology development programmes. The following table shows reports prepared last year:

Topic	No. of cases
Prior Art for novelty/patentability etc.	14
R & D planning	10
Market research and others	6

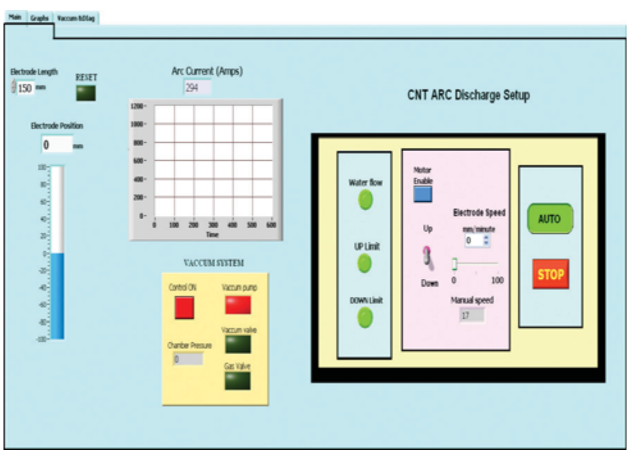
SUPPORT GROUPS

Electronics and Instrumentation

To facilitate constant support to the Centres of Excellence (CoE's) in developing new technologies, ARCI is not only adding modern systems and equipment to its infrastructure but also upgrading the already existing systems using latest technologies and software. The Electronics and Instrumentation Group (E&IG) is continuously striving to support ARCI in the installation and commissioning, maintenance, trouble shooting, system interfacing, fabrication etc. of the equipments at various CoE's. The following are some of the important tasks undertaken by E&IG during the year 2011-12:

Upgradation and Trouble Shooting of Existing Equipment

- The Centre for Carbon Nanotubes was frequently facing maintenance problems of its arc discharge set-up used for production of carbon nanotubes. In order to overcome this problem, the E&IG automated the complete set-up by replacing the electronic systems such as servo-drive, vacuum measuring gauge, etc. with indigenously developed units and also developed a program called LabVIEW so as to manually operate the system in semi and fully automatic modes.



Front panel display developed using LabVIEW program for arc discharge set-up

  Important process parameters like current, electrode traversal could also be logged on a real time basis using this program.

- In order to evaluate the breakdown potential of coatings generated by the Detonation Spray Coating and Plasma spray processes, a High Voltage Breakdown Measuring unit was developed in-house. This breakdown potential is an important parameter, especially when the mentioned coatings are used for various applications in Railway locomotives.

- The 4 axes CNC system at the Centre for Laser Processing of Materials had become obsolete as the software and hardware of the system were slow and had limited scope. In order to upgrade this system, E&IG procured a new controller replacing the existing controller and PC. During commissioning, it was noticed that there were inaccuracies such as, instability and insufficient torque, in the movement of the axes. This affected the combined movement of multiple axes, where interpolation inaccuracies were very prominent e.g. a programmed circular movement practically appeared as an elliptical one. In order to overcome this problem, a Proportional Integral Derivative (PID) circuit was fabricated in-house and added to each axes at minimum expenditure.

- E&IG developed a general data acquisition system, using inexpensive modules, for monitoring different parameters like voltage, current, temperature, etc., which also permits logging of data into Excel compatible files.

- E&IG has also undertaken trouble shooting for major equipments such as Flame Spray Pyrolysis, Electron Beam Physical Vapour Deposition, Powder Feeders of Diode Laser and Solution Precursor Plasma Spray, Detonation Spray Coating System etc.

Management of Telecommunication Systems

- A new digital EPABX system with adde d features along with a Primary Rate Interface line was installed and commissioned.

- In order to overcome communication problems such as poor signal strength, false messaging, non-receipt of calls etc. while using mobile phones, a BSNL tower was installed in ARCI premises.

Electrical and Civil Maintenance

The Electrical and Civil Maintenance (ECM) division provides infrastructural support and essential utilities to the entire ARCI campus. ECM carries out crucial activities in four broad categories namely electrical, civil, water and air conditioning. During the year 2011-12, the following are the infrastructure development, operation and maintenance activities carried out by ECM:

Infrastructure Development Activities

- Redesigned and renovated the building (which was previously used as a guest house) to house the newly initiated Centre for Solar Energy Materials, on an area of 1084 sq mts (shown below), to include facilities such as power supply, telephone/LAN, illumination and air conditioning.

- Provided civil infrastructure support like improving the front elevation of buildings such as Met. Lab. etc. and also modified the internal civil infrastructure at Centres of Excellence as per their requirements for various research programs.
- Monitored external painting work of buildings (more than 18 years old) such as pump house, motor transport, old cycle stand & main step down substation building covering an area of more than 1250 sq mts.

Operation and Maintenance Activities

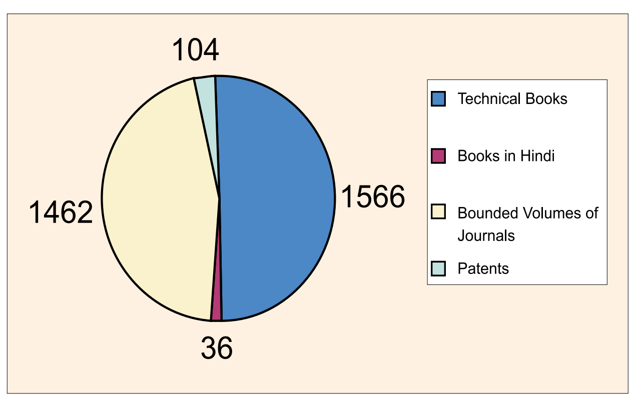
- Carried out round-the-clock operation and maintenance and achieved zero down-time of the following major electrical system at ARCI:
  - 3200 kVA, 11/0.415 kV LTSS- II Power Station
  - 2000 kVA, 11/0.415 kV LTSS-I Power Station
  - 8 MVA, 33/11KV HT Power Station
  - 2500 kVA, LT DG Captive Power Plant
- Coordinated painting work (external area) of various buildings on the campus covering an area of around 2500sq. mts.
- Undertook modification of civil infrastructure facilities (internal area) in various building as required by end users
- Maintained air conditioners of different types and capacities (approximately 520 tones) across the ARCI campus.
- Liaised with different Government external agencies like Central Electricity Authority - Chennai, CPDC Ltd. of AP, HMWSSB, APTRANSCO, HPC Ltd. District Magistrate-Ranga Reddy District, DG of Fire Safety, PESO-Chennai etc. to get statutory approvals.

Center for solar energy materials building

Technical Information Centre

The Technical Information Centre plays an active role in effectively disseminating scientific & technical information to its users by providing vital scientific information through published scientific and technical information sources and based services. During the year 2011-12, TIC continued its efforts to support R&D activities at ARCI by being a focal information centre for scientific knowledge and undertaking the following activities:

- TIC has created a strong collection base by adding 24 new books and 163 bound volumes of journals to its already increasing collection base. Overall, the centre has collected over 3100 documents consisting of books (technical books and books in Hindi), bound volume of journals and patents (as shown below).
- TIC subscribes to 60 scientific journals from internationally reputed publishers and also to databases such as Scopus, Web of Science etc. to cater important scientific information to the scientific and technical personnel at ARCI.
- Being a member of National Knowledge Resources Consortium (NKRC), TIC continued to get full text access to around 3500 e-journals from 19 different publishers such as Maney, Elsevier science, ACS, AIP etc.
- In particular, obtained full text access to the complete collection of journals such as Materials Science and Materials Science and Engineering of Elsevier Science and Maney Publishers respectively.
- Further, TIC fulfilled about 50 Inter Library Loan (ILL) requests originated from other participating labs of NKRC.
- Physical stock verification of the entire collection and also binding of various issues of journals was carried out.



Collection of books, bound volumes of journals and patents at TIC

EVENTS, DATA AND STATISTICS

Major Events

Jayanthi Celebrations

ARCI celebrated Dr. B. R. Ambedkar Jayanthi and Dr. Babu Jagjivan Ram Jayanthi on April 14, 2011.

Technology Day

ARCI celebrated the National Technology Day on May 11, 2011. Dr. D. Yogeswara Rao, Scientist G, Indian Institute of Chemical Technology (IICT), Hyderabad delivered a lecture titled “Essentials of Technology Transfer and IP Issues” on this occasion.

Annual Medical Check-up and Health Talk

The Annual Medical Check-up programme for ARCI employees was organized during July 20-21, 2011. Employees were categorized into two age groups i.e. below and above 45 years of age and special medical tests such as TMT etc. were undertaken for employees above 45 years of age.

Annual medical check-up in progress

In order to create awareness regarding various health issues among its employees, ARCI organized the following lectures related to health management:

- On July 15, 2011, Dr. E. Ravi Sankar, Consultant in Diabetes and Endocrinologist of Kamineni Hospitals, Hyderabad delivered a lecture on ‘Management of Emergencies’
- On March 21, 2012, Dr. Vijay Anand Reddy Palkonda, Director, Apollo Cancer Hospital, Hyderabad delivered a lecture on ‘Cancer-Prevention, Detection and Treatment’

Independence Day

ARCI celebrated Independence Day on August 15, 2011. Dr. S. V. Joshi, Associate Director hoisted the National Flag and addressed the gathering on the occasion.

Business Opportunity Workshop

A business opportunity workshop on ‘Sol-Gel Nanocomposite Coatings for Diverse Applications’ was organized at ARCI, Hyderabad on September 16, 2011 to sensitize the Indian market on versatility and applications of sol-gel coating technology. 28 participants from about 20 companies took part in the workshop. The workshop involved technical lectures, live demonstration of all processes involved in the sol-gel coating technology and one-on-one discussion with interested end-users.

Dr. G. Sundararajan, Director-ARCI with the participants of the workshop

Official Language (Hindi) Implementation at ARCI

The Official Language Implementation Committee (OLIC) under the chairmanship of Dr. G. Sundararajan, Director, ARCI has been successful in the implementation and progressive use of the Official Language in ARCI. During the year 2011-12, ARCI issued more than 3000 letters in bilingual form and surpassed the target set by the Dept. of Official Language, Ministry of Home Affairs, Govt. of India. Achievement was appreciated by DST during a review. To propagate the use of Hindi during work, ARCI conducted Hindi workshops on a quarterly basis for its employees. ARCI has also been imparting Training in Hindi to its Employees under the Hindi Teaching Scheme and has trained a number of employees in Prabodh, Praveen and Pragya levels. ARCI also convenes OLIC meetings on a quarterly basis to review the progress in the implementation of Official Language (O.L.) in ARCI.

Dr. G. Sundararajan addressing the gathering during Hindi Diwas Celebrations

Shri V. V. Lakshmi Narayana with Dr. G. Sundararajan and other ARCI personnel during the lecture organized on the occasion of Vigilance Awareness Week

ARCI celebrated Hindi Diwas on September 29, 2011. Various programmes and competitions like Quiz, Elocution, Noting and Drafting in Hindi were conducted, and the winners were given prizes. Lectures on the 'Application, Use and Utility of Hindi' & 'O.L Policy and Rules' were delivered by Shri Narahar Dev, DGM (Retd.), Bharat Dynamics Limited, Hyderabad and Dr. S. Devi Das, Consultant (O.L.), ARCI respectively.

ARCI along with DRDO jointly organized the "7th Joint Scientific and Technical Raj Bhasha Sammelan" on "Self Reliance in Defence Research" held at DRDL, Hyderabad on February 09 and 10, 2012. Dr. P.K. Jain, Shri Sanjay Bhardwaj and Shri R. Vijay Chander delivered lectures on different technical subjects and Shri N.K. Bhakta, delivered a lecture on "Problems & Solutions of Raj Bhasha" in Hindi. Dr. P.K. Jain and Shri R. Prabhakara Rao also chaired a session in the Sammelan.

Vigilance Awareness Week

ARCI observed Vigilance Awareness Week from October 31, 2011 to November 05, 2011. As a part of this occasion, Shri D. Srinivasa Rao, Vigilance Officer-ARCI administered the pledge in the presence of Dr. G. Padmanabham, Associate Director and other ARCI personnel from Administration, Stores, Finance & Accounts, Computer Centre, and Centre for Technology Acquisition, Transfer and International Coordination. Dr. G. Padmanabham, Associate Director also delivered a message on vigilance awareness on the occasion. The Team Leaders from other centres of excellence administered the pledge at their respective centres in presence of their team. During the week, ARCI also organized a lecture titled 'Probity in Public Life', which was delivered by Shri V. V. Lakshmi Narayana, Joint Director, Central Bureau of Investigation (CBI), Hyderabad. An exhibition displaying posters on different aspects of vigilance awareness was also organized.

Annual Day

ARCI celebrated its 15th Annual Day on December 29, 2011.

Dr. G. Sundararajan giving away prize to a tiny tot who participated in the cultural event during Annual Day Celebrations

On this occasion, Dr. G. Sundararajan – Director - ARCI delivered a speech detailing various achievements during the year. Associate Directors, Dr. S.V. Joshi and Dr. G. Padmanabham also addressed the gathering. As a part of these celebrations, various cultural events with participations from employees and their family were organized, and prizes were distributed to the participants.

International Conference on Nanoscience and Technology

The International Conference on Nanoscience and Technology (ICONSAT-2012) was organized by ARCI at Hyderabad during January 20-23, 2012. The Conference, a regular biennial event under the Govt. of India's Nano Mission initiative, had an overwhelming response. About 930 participants from 15 countries registered at the Conference, making it one of the biggest events dedicated to the field of nanoscience and technology to be held in this part of the world. The ICONSAT-2012 Distinguished Lecture titled "Graphene, Graphene Mimics and Their Unusual Properties" was delivered by Prof.CNR Rao, Linus Pauling Research Professor and Honorary President, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore and Chairman, Scientific Advisory Council to Prime Minister of India. Apart from the above, the Conference also featured an impressive line-up of 8 Plenary Lectures, 22 Keynote Lectures and 19 Invited Lectures by world renowned scientists. The technical program comprised a total of 42 technical sessions addressing diverse aspects of nanoscience & technology which provided an opportunity for over 180 contributory oral papers to be presented. A special feature of the Conference was expense-free participation of more than 175 young researchers, who were selected based on merit from among a large number of applicants and provided a slot to present their research in the form of posters. A Technical Exhibition held concurrently during the conference also attracted widespread interest and nearly 40 leading companies from India and abroad associated with the field of nanoscience and technology participated. Dr. T. Ramasami, Secretary – DST, inaugurated the exhibition. Prof. Arup Raychaudhuri of SN Bose National Centre for Basic Science, Kolkata was conferred the "National Research Award in Nanoscience & Technology".

Dr. T Ramasami, Secretary-DST, at the Technical Exhibition held during ICONSAT-2012

The Conference also included a satellite program "Nano for the Young", which was attended by nearly 250 first year students pursuing courses in science and engineering, along with their mentors from about 40 colleges from in and around Hyderabad. This effort, supported by the Government of India's NanoMission, was intended to inspire young talent to take up a career in science by providing them an unparalleled opportunity to interact with leading scientists, besides making them aware of the vast promise of the exciting field of nanotechnology. The program was conducted by Prof. C.N.R. Rao.

Expert panel interacting with the students during 'Nano for the Young'

Dr. G. Sundararajan, Director-ARC, addressing the gathering at ICONSAT-2012

Republic Day

ARCI celebrated Republic Day on January 26, 2012. Dr. G. Padmanabham, Associate Director hoisted the National Flag and addressed the gathering on the occasion.

Sports

ARCI constituted a sports committee to conduct sports and games for the year 2011-12. Sports and Games 2011-12 was inaugurated on

February 22, 2012 by Associate Directors, Dr. S. V. Joshi and Dr. G. Padmanabham. About 20 events were conducted and more than 100 employees participated in games such as Volleyball, Cricket, Badminton, Football, Carom, Athletics etc. Prizes were distributed to the winners and runners-up by Associate Directors, Dr. S. V. Joshi and Dr. G. Padmanabham as well as by Shri R. Prabhakara Rao, Admin and Personnel Officer.

National Science Day

National Science Day was celebrated on March 02, 2012 at ARCI. Dr. S V Joshi, Associate Director welcomed the audience comprising of Scientists, Officers, Research Fellows, Project and Trainee Students and briefed about the importance of National Science Day Celebrations. The focal theme selected for the occasion was "Clean Energy Options and Nuclear Safety". Ms. Meena Nair, Deputy General Manager, Nuclear Fuel Complex, Hyderabad delivered a lecture on "Uranium: From Mine to Fuel" on this occasion.

Ms. Meera Nair delivering a lecture as part of National Science Day celebrations

Safety Day

ARCI observed Safety Day on March 05, 2012. Shri S Jagan Mohan Reddy, Security and Fire Officer arranged a demo on the usage of fire extinguishers kept handy at all major locations in ARCI. He explained in detail the operation of various fire extinguishers in case of emergencies.

Shri S Jagan Mohan Reddy explaining the importance of fire extinguishers

Shri S Jagan Mohan Reddy demonstrating the operation of fire extinguishers

Women Welfare

ARCI celebrated International Women's Day in March, 2012. As a part of this occasion, Dr. (Mrs.) M. Lakshmi Kantham, Deputy Director, IICT, Hyderabad was invited as Chief Guest to deliver a lecture.

Dr. (Mrs.) M. Lakshmi Kantham delivering the lecture during International Women's Day celebrations

Human Resource Development

ARCI-IIT Fellowship Programme

ARCI continues to sponsor fellowship programmes at Indian Institute of Technology (IIT) - Bombay and IIT-Hyderabad. As a part of these ARCI – IIT Fellowships, ARCI supports the doctoral study of talented students selected as ARCI Fellows to work in areas of immediate interest to ARCI under the expert guidance of an identified Faculty member. The ARCI support includes stipend, procurement of consumables and essential equipment. After successful completion of the programme, the ARCI Fellow is awarded a Ph.D. degree by the respective academic institution.

The status of projects being undertaken is as follows:

Project	Collaborating Institute	Name of the Fellow	Status
Study of multi ferroic composite thin films	IIT – Bombay	Tarun	Ongoing
Synthesis of cathode material for lithium ion batteries	IIT – Hyderabad	A. Bhaskar	Ongoing

Research Scholars, Senior/Junior Fellows, Post Graduate/Graduate Trainees and M.Tech/B.Tech Project Students at ARCI

Research Scholars	2
Senior ARCI Fellows (SAF)	14
Junior ARCI Fellows (JAF)	14
Post Graduate Trainees	7
Graduate Trainees	26
M. Tech./B. Tech. Project Students	26

Recognition of ARCI as an External Centre for Carrying Out Ph.D. Research

- University of Hyderabad (UoH) has recognized ARCI as an external centre for carrying out Ph.D. research. In view of this, interested ARCI employees and ARCI Fellows can register for Ph.D. (as per university norms) at the University.

Following students are registered at UoH for their Ph.D. studies:

Topic	Name of the Student	Status
Development of nanostructured 8YSZ electrolytes with enhanced ionic conductivity for SOFC applications	K Rajeswari	Ongoing
Joining of aluminium and steel by thermal joining techniques	Y Krishna Priya	Ongoing
Evaluation of structure property correlation in nanostructured copper and copper foils prepared by pulse and pulse-reverse electrodeposition	Ch. Leela Pydi Pavithra	Ongoing
Development of TiCN metal/intermetallic based nanocomposites for cutting tool applications	M S Archana	Ongoing
Structure property correlation in cathodic arc deposited coatings	P Sai V Pramod Kumar	Ongoing
Structure property correlation in ODS 18 Cr steels	M. Nagini	Ongoing
Development of Micro Arc Oxidation coatings for enhancing fatigue strength of Al alloys	G. Sailaja	Ongoing
To stabilize cadmium chalcogenide based phto anode for phto electro chemical hydrogen production using solar light	Alka Pareek	Ongoing
A comparative evaluation of extrusion and pressure slip casting processing parameters on thermo mechanical properties of low thermal expanding ceramics	R. Papitha	Ongoing

- Following student is registered at Osmania University for her Ph.D. studies:

Topic	Name of the Student	Status
Synthesis and characteristics of ferrite photocatalysts	D Rekha	Ongoing

- Anna University Chennai has recognized ARCI's Centre for Fuel Cell (CFCT, Chennai as a centre to conduct collaborative research for the purpose of pursuing Ph.D./M.S. (by research) programmes by the regular employees of CFCT, Chennai upto March 31, 2012.

Following student is registered at Anna University Chennai for her Ph.D. studies:

Topic	Name of the Student	Status
Graphene as catalyst support for Polymer Electrolyte Membrane Fuel Cell (PEMFC) electrodes	P. Karthika	Ongoing
Development of alternative and durable electro catalyst support for PEMFC	Maidhily	Ongoing
Aspect of Hydrogen generation by electrolysis of water	S. Seetharaman	Ongoing

- Indian Institute of Technology- Hyderabad (IIT-H) has recognized ARCI as an external centre for carrying out Ph.D. research and has signed a Memorandum of Understanding with ARCI in this regard.

Following are the students registered at IIT-H for their Ph.D studies:

Topic	Name of the Student	Status
Electrochemical synthesis and characterization of CIS and CIGS materials for solar cell applications	Mandati Sreekanth	Ongoing
Electrospinning of organic and inorganic nanofibers for health and energy applications	K. H. Anulekha	Ongoing
Spherical indentation behaviour of porous copper and cold sprayed cracked copper coatings	Bolla Reddy	Ongoing

- Andhra University has recognized ARCI to carry out Extra - Mural Research (EMR) in the fields of Physics, Chemistry, Metallurgy, Chemical Engineering and Mechanical Engineering. With such recognition in place, ARCI can undertake research programmes leading to M.Phil. and Ph.D. degrees at Andhra University under EMR category.

Appointments

ARCI has added the following employees to its fold to take up varied responsibilities:

Empoyee Name	Designation	Date of Joining
Dr. Sanjay R. Dhage	Scientist “D”	September 30, 2011
Dr. Easwaramoorthi Ramasamy	Scientist “C”	September 30, 2011
Dr. Raju Prakash	Senior Scientist (Contract)	January 02, 2012
Dr. Rajappa Tadepalli	Senior Scientist (Contract)	February 01, 2012

Promotions

ARCI has been following its existing assessment and promotion policy since the year 2000-01. As per the policy, assessments were carried out for all eligible employees and the following were promoted during 2011-12:

Name of the Promotee	Effective Date	Promotion for the Post	
		From	To
Md. Sadiq	October 01, 2010	Driver “B”	Driver “C”
K. Satyanarayana Reddy	October 01, 2010	Driver “B”	Driver “C”
D. Srinivasa Rao	October 01, 2011	Scientist “E”	Scientist “F”
Sanjay Bhardwaj	October 01, 2011	Scientist “D”	Scientist “E”
Dr. I. Ganesh	October 01, 2011	Scientist “D”	Scientist “E”
Dr. Joydip Joardar	October 01, 2011	Scientist “D”	Scientist “E”
Nitin P. Wasekar	October 01, 2011	Scientist “C”	Scientist “D”
Dibyendu Chakravarty	October 01, 2011	Scientist “C”	Scientist “D”
Dr. Neha Yeshwanta Hebalkar	October 01, 2011	Scientist “C”	Scientist “D”
R. Vijay Chandar	October 01, 2011	Scientist “B”	Scientist “C”
Anirban Bhattacharjee	October 01, 2011	Officer “A”	Officer “B”
G.M. Rajkumar	October 01, 2011	Officer “A”	Officer “B”

Name of the Promotee	Effective Date	Promotion for the Post	
		From	To
A. Srinivas	October 01, 2011	Officer "A"	Officer "B"
K. Ramesh Reddy	October 01, 2011	Technical Assistant "A"	Technical Assistant "B"
A. JayaKumaran Thampi	October 01, 2011	Technician "B"	Technician "C"
D. Kutumba Rao	October 01, 2011	Technician "B"	Technician "C"
B. Subramanyeswara Rao	October 01, 2011	Technician "B"	Technician "C"
K. Vigneswara Rao	October 01, 2011	Technician "B"	Technician "C"
G. Venkat Reddy	October 01, 2011	Technician "B"	Technician "C"
G. Anjan Babu	October 01, 2011	Technician "A"	Technician "B"

Resignations/Retirements

Employee Name	Designation Held	Date of Resignation
Dr. Sanjay R. Dhage (Resigned from Contract)	Scientist	September 29, 2011
Dr. Easwaramoorthi Ramasamy (Resigned from Contract)	Scientist	September 29, 2011
Dr. U. S. Hareesh	Scientist "D"	November 04, 2011
Dr. N. Thiyagarajan	Scientist "E"	February 29, 2012

Reservations and Concessions

The Reservations and Concessions for SCs/STs/OBCs and persons with disabilities are followed as per Government of India orders from time to time. At ARCI, the representation of employees under SC is 16.56%, ST is 3.68%, OBC is 24.53% and that of persons with disabilities is 2.45% as on March 31, 2012.

Obituary

Mr. Kattekola Venkata Ramana, Lab. Assistant "B" passed away on April 23, 2011.

Visit by Students and Others to ARCI

1. 28 Scientists from various National Laboratories who participated in ASCI's "General Management Programme" visited ARCI on May 11, 2011.
2. 18 Engineers from various Government Organizations who participated in ESCI's "Professional Development Programme" visited ARCI on July 08, 2011.
3. 23 Scientists from various National Laboratories who participated in ASCI's "Advanced Techno Management Programme" visited ARCI on July 21, 2011.
4. 30 Scientists/Engineers of ISRO who participated in ASCI's "Management Development Programme" visited ARCI on July 27, 2011.
5. 20 Lecturers from various Degree Colleges who participated in JNTUH's UGC sponsored refresher course "in Recent Trends in Chemical Engineering" visited ARCI on September 14, 2011.
6. 28 Scientists from various National Laboratories who participated in ASCI's "General Management Programme" visited ARCI on September 21, 2011.
7. 28 Scientists from various National Laboratories who participated in ASCI's "Public Private Partnership for Science & Technology Sector" visited ARCI on September 27, 2011.
8. 70 M.S and B.Tech (Nanoscience and Nano Technology) students from SRM University Chennai visited ARCI on September 29, 2011.
9. 25 Woman Scientists from various National Laboratories who participated in ASCI's "General Management Programme for Woman Scientists" visited ARCI on November 24, 2011.
10. 30 Scientists from various National Laboratories who participated in ASCI's "Advanced Techno-Management Programme" visited ARCI on January 25, 2012.
11. 34 M.Sc, M.Phil and Ph.D (Physics) students and faculty from Karunya University, Coimbatore visited ARCI on February 13, 2012.
12. 68 B.E (Metallurgical Engineering) students and faculty from PSG College of Technology, Coimbatore visited ARCI on February 16, 2012.

13. 20 M.Tech (Nano Technology) students and faculty from Periyar Maniammai University, Thanjavur visited ARCI on February 22, 2012.
14. 30 B.Tech (Mechanical Engineering) students and faculty from VIT University, Vellore visited ARCI on March 07, 2012.

Summer Training Programme for Students 2011

As in the previous year, this year too students from universities such as IITs, NITs, Banaras Hindu University and various other universities from all over the country were short-listed for availing Summer Training Programme at ARCI. 28 students were selected for the summer training programme, which was held during May 18 to June 30, 2011. The selected students initially underwent a week long orientation course so as to get familiarity with the activities being carried of at ARCI. Each student was guided by a scientist to carry out a mini project. The students were issued certificates on completion of the programme. The feedback received from the students was encouraging.

Dr. SV Joshi, Associate Director with summer training students

Indian/Foreign Visitors

1. Dr. S. G. Sankar, President and Chief Executive Officer (CEO), Advanced Materials Corporation (AMC), USA visited on April 12, 2011.
2. Dr. Suwas Nikumb, Senior Researcher and Scientific Advisor, Industrial Materials Institute of National Research Council of Canada (NRC-IMI), Canada visited during May 09-11, 2011.
3. Dr. R. Ranganathan, Director-Business Development, Saskatchewan Research Council, Canada visited on May 31, 2011.
4. Dr. Appajosula S. Rao, Materials Engineer, Office of Nuclear Regulatory Research, US Nuclear Regulatory Commission, USA visited on June 20, 2011.
5. Mr. Dinesh Khandagale, Director, C.G. Motors, Mumbai visited on June 27, 2011.
6. Team from Ohio State University, USA visited on June 28, 2011.
7. Mr. Ravi Subramanian, Hydrogen Energy System-India Lead of Prodair Airproducts India Pvt. Ltd, Pune visited on July 18, 2011.
8. Dr. Mathew Abraham, Senior General Manager, Mahindra & Mahindra (M&M), Chennai and team visited on July 22, 2011.
9. Prof. Pravansu Mohanty, University of Michigan, USA visited on August 12 and August 16, 2011.
10. Mr. Mohit Uberoi, President and CEO, MEGTEC Systems Inc, USA and Mr. Madhav Athalye, General Manager, MEGTEC Systems India Pvt. Ltd, Pune visited on August 19, 2011.
11. Mr. Shivam Tiwari, Director, Easter Electrolysers, New Delhi visited on August 23, 2011.
12. Dr. Bhujanga Rao, President R&D and Mr. Roopesh Battepati, Director, Natco Pharma Ltd, Hyderabad visited on September 02, 2011.
13. Prof. Mahesh Kumar and Dr. Lakshmi Narasamma, Assistant Professor, Indian Institute of Technology (IIT) Madras, Chennai visited on October 14, 2011.
14. Prof. R. Mahendran, National University of Singapore (NUS), Singapore visited on November 02, 2011.
15. Mr. Mark Denys, Chief of R&D and Scientific Services, Tata Steel, Jamshedpur and Mr. C. Mc Donald, Department Manager of Steel Making and Continuous Casting, Tata Steel, Jamshedpur/ Teesside Tech Centre United Kingdom (UK) visited on November 16, 2011.
16. Dr. Bernhard Koegl, Manager, Rofin Laser Tech, Germany visited on November 23, 2011.
17. Dr. William Clark, President & CEO, Clark-MXR Inc, USA visited on December 02, 2011.
18. Mr. Yury Zlobinsky, Harris Environmental Systems, USA visited on December 08, 2011.
19. Mr. Nayan Shah, Proprietor and Mr. Kaushik Shah, Partner, Madhuchitt Industries, Mumbai visited on December 14, 2011.
20. Mr. Eiichi Hachisu, Manager- JX Energy, Japan visited on December 15, 2011.
21. Mr. Ramesh Balasubramanian, Managing partner and Mr. K. Rajasekar, Sales Engineer, Nordson EFD

Business (Snap Solutions), Bangalore visited on January 05, 2012.

22. Prof. Narendra B. Dahotre, University of North Texas, USA visited during January 12-19, 2012.

23. Dr. Eckhardt Schneider and Dr. Kurzenhauser Sven, Fraunhofer NDT Institute (IZFP), Germany visited during January 16-17, 2012.

24. Dr. Hans Soderjheim, Vice President, Hoganas AB, Sweden visited on January 17 and January 19, 2012.

25. Dr. S. Ashok, Director-Technology, Hoganas India Pvt. Ltd, Pune visited on January 19, 2012.

26. Prof. Akira Fujishima, President of Tokyo Science University, Japan visited on January 19, 2012.

27. Prof. S. Ramakrishna, Vice President (Research Strategy), NUS, Singapore visited on January 24, 2012.

28. Prof. Stanislav Veprek, Technical University Munich, Germany visited on January 24, 2012.

29. Mr. Carlos Trindade, Industry Advisor, McGill University, Canada and Prof. Arun Misra, McGill University, Canada visited on February 02, 2012.

30. Dr. Ashok Joshi, President-Ceramatec Inc, USA and Mr. Douglas Coors, CEO-Ceramatec Inc., USA visited on March 05, 2012.

31. Dr. T. Jayakumar, Director-Metallurgical and Materials Group, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam and Dr. M.D. Mathew, Head-Creep Studies Section, IGCAR, Kalpakkam visited on March 09, 2012.

32. Prof. A. Suzuki, Prof. Junichi Tatami and Dr. Mitsuaki Matsupka, Yokohama National University, Japan visited on March 12, 2012.

Seminars by Indian/Foreign Visitors

1. Dr. D. Yogeswara Rao, Scientist-G, Indian Institute of Chemical Technology (IICT), Hyderabad delivered a lecture on “Essentials of Technology Transfer and Intellectual Property (IP) Issues” on May 11, 2011.

2. Dr. Sivakumar Pasupathi, Programme Manager, University of the Western Cape, South Africa delivered a lecture on “Hydrogen and Fuel Cell Research Activities in South Africa” on July 06, 2011.

3. Dr. Alok Singh, Chief Researcher, Research Centre for Strategic Materials, National Institute of Materials Science (NIMS), Japan delivered a lecture on “Challenges in the Development of Magnesium Alloys and Some Solutions” on July 08,2011.

4. Prof. Ing.Uwe Fussel, University of Technology, Dresden, Germany delivered a lecture on “Physics of Materials Joining Processes” on July 21, 2011.

5. Dr. D. Bommi Bommannan, CEO, Maxval IP Services Pvt. Ltd, Chennai and Dr. V. Shankar, Vice President, Maxval IP Services Pvt. Ltd, Chennai delivered lectures on “Introduction to Patents and Patent Search” and “Patent Filing in India” respectively on July 26, 2011.

6. Mr. Phillip Allnatt, Director, Wall Colmonoy Limited, UK and Mr. Bal Ginde, Director Business Development, India and Gulf, Wall Colmonoy Ltd, UK delivered a lecture on “Coating Materials for High Temperature Erosion, Dry Wear and Nuclear Components” on August 01, 2011.

7. Dr. Saptarshi Basu, Assistant Professor, Indian Institute of Sciences (IISc), Bangalore delivered a lecture on “Droplets with Nano-Additives: Vaporization, Precipitation and Combustion” on August 17, 2011.

8. Prof. Yogeswar Sahai, Ohio State University, USA delivered a lecture on “Development of a Cost-Effective and More Efficient Direct Borohydride Fuel Cell” on August 19, 2011.

9. Dr. Indranil Lahiri, PhD Scholar, Florida International University, USA delivered a lecture on “High Efficiency Anode for Li-Ion Batteries:Application of Interface Engineered Carbon Nanotubes” on September 08, 2011.

10. Dr. Shekhar D. Bhame, Post Doctoral Fellow, LCIS - GreenMAT, University of Liege, Belgium delivered a lecture on “Magnetostriction Studies on Cobalt Ferrite and Thermoelectric Studies on Indium Oxide based Materials” on September 08,2011.

11. Dr. Pinaki Prasad Bhattacharjee, Assistant Professor, IIT, Hyderabad delivered a lecture on “Evolution of Microstructure and Crystallographic Texture during Cold Rolling and Annealing of a Highly Cube Textured ({001}<100>) Polycrystalline Nickel Sheet” on September 09, 2011.

12. Dr. Guruvenket Srinivasan, Post Doctoral Fellow, North Dakota State University, USA delivered a lecture on “Non-Equilibrium Atmospheric Pressure Plasma Synthesis of Materials for Energy Related Applications” on September 20, 2011.

13. Mr. Matthew Powers, Director-International Sales, Perma Pure LLC, USA delivered a lecture on

"Permapure Products for Fuel Cell Application" on September 21, 2011.

14. Dr. Ashok Joshi, President, Ceramatec, USA delivered a lecture on "Devices for Energy and Environmental Applications" on September 26-27, 2011.

15. Mr. S. Jeong Soo Kim, Principal Scientist, Battery R&D, SK Innovation, South Korea delivered a lecture on "Advance Battery Developments at SK Energy" on October 03, 2011.

16. Dr. Terry Turney, Chief Technical Officer, Micronisers Australia Pty Ltd, Australia delivered a lecture on "Drivers for Nanomaterials Development: Managing Expectations from Lab to Market" on October 12, 20111

17. Dr. Mainak Majumder, Lecturer, Monash University, Australia delivered a lecture on "Functional Materials from Carbon Nanotube and Graphene" on October 21, 2011.

18. Dr. D. Prabhu, Post Doctoral Research Associate, NIMS, Japan delivered a lecture on "High Performance Soft and Hard Magnetic Materials" on November 17, 2011.

19. Mr. Sanket Bhatia, Sales Manager, Axetris Ltd, Switzerland delivered a lecture on "Flow Controls using MEMS Technology" on December 05, 2011.

20. Prof. Christian Boller, Director, IZFP, Germany delivered a lecture on "Recent Advances in NDT Methods and their Applications" on December 05, 2011.

21. Mr. Hiroshi Takami, Senior Manager, JX Energy, Japan delivered a lecture on "Fuel Cell Activities at JX Nippon Oil and Energy Corporation" on December 15, 2011.

22. Dr. Srinivasan Anandan, JSPS Post Doctoral Researcher, Tokyo Institute of Technology, Japan delivered a lecture on "Photocatalysis in Modified Nano-Metal Oxide and its Applications" on January 03, 2012.

23. Dr. Ramana Reddy, ACIPCO Endowed Chair Professor, University of Alabama, USA delivered a lecture on "Solar Energy - A Sustainable Alternative Energy Source" on January 06, 2012.

24. Prof. U.V. Varadaraju, IIT Madras, Chennai delivered a lecture on "Introduction to Thermoelectric Materials" on January 16, 2012.

25. Prof. Kan-Lin Hsueh, National United University, Taiwan delivered a lecture on "Development of Fuel Cell and Energy Storage Systems" on February 02, 2012.

26. Prof. Chung-Jen Tseng, National Central University, Taiwan delivered a lecture on "Solar Cells and Hydrogen Generation" on February 02, 2012.

27. Prof. Chin-Hsiang Cheng, National Cheng Kung University (NCKU), Taiwan delivered a lecture on "Modeling Fuel Cells and Micro Reactors for Hydrogen Generation" on February 02, 2012.

28. Prof. Christopher Charles Berndt, President, ASM International and Professor Swinburne University of Technology, Australia delivered a lecture on "Nanostructures via Thermal Spray: Processing, Properties and Modeling" on February 13, 2012.

29. Dr. Anjaneyulu Krothapalli, Don Fuqua Eminent Scholar Chair of Engineering at Florida State University, USA and Founder CEO, Sujana Energy Ltd, Hyderabad delivered a lecture on "Multi Generation Concentrating Solar-Hydrogen Power System for Sustainable Rural Development" on March 06, 2012.

Visits Abroad

1. Dr. Y.S. Rao and Mr. V. Mahender visited SAMA Maschinebau GmbH, Germany for pre dispatch inspection and training on Pressure Slip Casting Machine during April 11-15, 2011.

2. Dr. G. Sundararajan participated in the 'Indo-Dutch Meet on Water Management' held at The Netherlands during April 18-21, 2011 and delivered an invited lecture on "Indian Strategies for Water Management: An Overview".

3. Dr. G. Padmanabham and Dr. Ravi N. Bathe visited Industrial Materials Institute of National Research Council of Canada (NRC-IMI), Canada for technical discussion during April 24- May 01, 2011.

4. Dr. K.S. Dhathathreyan participated in the 'Indo-Korean Workshop on Energy and Environment' held at Seoul, South Korea during May 02-05, 2011 and delivered an invited lecture on "Fuel Cell Activities in India".

5. Dr. T. N. Rao participated in the 'Indo-Korean Workshop on Energy and Environment' held at Seoul, South Korea during May 02-05, 2011 and delivered an invited lecture on "Clean Technologies based on Nanosilver and Nanotitania".

6. Dr. G. Sundararajan attended the 'Scientific Council Meeting and Industrial Research Committee Meeting of the Indo-French Centre' held at Paris, France during May 17-25, 2011.

7. Dr. S.V. Joshi visited USA during June 05-13, 2011 to i) participate in the 'Spring 2011 Consortium Meeting on Thermal Spray Technology' and ii) visit University of Central Florida for technical discussion.

8. Dr. S.V. Joshi visited Australia during July 06-16,

2011 to i) participate in the '9th International Meeting of Pacific Rim Ceramic Societies (PAC RIM 9)' held at Cairns, Australia and delivered an invited lecture on "Correlating Particle Formation, Splat Morphology and Coating Microstructure in SPPS Deposition" ii) deliver an invited lecture on "Nanomaterials and Surface Engineering Activities at ARCI: Translating Research to Applications" at Monash University, Melbourne and iii) visit University of Swinburne, Melbourne for technical discussion.

9. Mr. Dibyendu Chakravarty participated in the '9th International Meeting of Pacific Rim Ceramic Societies (PAC RIM 9)' held at Cairns, Australia during July 10-14, 2011 and presented a paper on "Optimization of Mechanical Properties of Spark Plasma Sintered ZTA using Genetic Algorithm".

10. Dr. N. Rajalakshmi visited Netzsch-Geratebau GmbH, Germany for training on 'Simultaneous Thermal Analyser with MS' during July 10-14, 2011.

11. Dr. N. Thiyagarajan visited Ohio Carbon Industries, USA to overlook the grinding operation process of the CVD coated substrates during July 16-23, 2011.

12. Dr. M. Buchi Suresh visited IZFP, Germany for pre-dispatch inspection and training on 'NDT Microwave System' during August 08-12, 2011.

13. Dr. G. Padmanabham participated in the 'International Conference on Harnessing the Potentials of New and Advanced Materials for Developing Economies' held at Abuja, Nigeria during August 09-12, 2011 and delivered an invited lecture on "Trends in Advanced Materials Research in India".

14. Dr. D. Sivaprahasam delivered a lecture on "Can Copper Melt at 450°C at the Size of Few Nanometers?" and made a poster presentation on "Sintering of Fe-Cu Nanopowder" at the 'Asia Nanotech Camp 2011' held in South Korea during August 16-27, 2011.

15. Mr. Dibyendu Chakravarty delivered a lecture on "Nanotechnology for World Energy Problems" and made a poster presentation on "Spark Plasma Sintering of Ceramic and Metallic Materials for various Structural and Functional Applications" at the 'Asia Nanotech Camp 2011' held in South Korea during August 16-27, 2011.

16. Dr. K. Murugan delivered a lecture on "Sustainable Nanotechnology for Saving Water" and made a poster presentation on "Nanosilver and Nanotitania for Environmental Application" at the 'Asia Nanotech Camp 2011' held in South Korea during August 16-27, 2011.

17. Dr. R. Subasri participated in the '16th International Sol-Gel Conference' held at Hangzhou, PR. China during August 28- September 02, 2011 and presented papers on "Effect of Heat Treatment on Mechanical and Corrosion Properties of Low Temperature Curable Sol-Gel Silica-Zirconia Nanocomposite Coatings" and "Hybrid Sol-Gel Coatings for Corrosion Protection of Low Cost Stainless Steels".

18. Dr. L. Ramakrishna participated in 'EUROMAT 2011 Congress - An International Conference' held at Montpellier, France during September12-15, 2011 and presented a paper on "Influence of Magnesium Alloy Composition on the Process, Properties and Performance of Micro Arc Oxidation Coatings".

19. Dr. R. Vijay and Mr. K.V.B. Vasantha Rayudu visited Phoenix Scientific Industries Ltd, United Kingdom for pre-dispatch inspection of 'Inert Gas Atomizer' during September 19-24, 2011.

20. Mr. Naveen M. Chavan participated in INTERRA-11 held at Novosibirsk, Russia during September 22-24, 2011 and made a presentation on "Cold Gas Dynamic Spray - A Unique Surface Engineering Tool".

21. Dr. Neha Y. Hebalkar visited General Motors, USA to carry out testing on samples and for technical discussion during October 03-07, 2011.

22. Dr. R. Vijay and Dr. K. Suresh visited Indian Beamline of KEK Photon Factory, Japan to carry out synchrotron X-Ray Diffraction (XRD) experiments on various samples during October 09-20, 2011.

23. Dr. G. Sundararajan visited USA during October 11-23, 2011 to i) participate in the 'Materials Science and Technology 2011 (MST11)' held at Columbus, USA and delivered invited lectures on "Migration of Nanotechnology based Technologies from Laboratory to Market Place-ARCI's Experience" and "Understanding the Dynamic Indentation Behaviour of Metallic Materials", ii) have technical discussion and deliver an invited lecture on "Migration of Nanotechnology based Technologies from Laboratory to Market Place - ARCI's Experience" at General Motors R&D, Michigan, USA and iii) visit Megtec Systems Inc-Wisconsin, Argonee National Laboratory-Argonne, Illinois and Centre for Automotive Research-Ohio State University, Ohio.

24. Dr. T.N. Rao participated in the '2nd Meeting of the Indo-German (DST-DFG) Joint Scientific Advisory Committee' held at Berlin, Germany during October 30-November 03, 2011.

25. Dr. N. Rajalakshmi and Mr. Arvindvivek Ravichandran

visited Votsch Industrietechnik GmbH, Germany for training on 'Environmental Test Chamber' during November 02-05, 2011.

26. Dr. G. Sundararajan participated in the 'MRS Trilateral Conference on Advances in Nanoscience-Energy, Water and Healthcare' held at Shanghai, China during November 08-13, 2011 and delivered an invited lecture on "Status of Nanoscience and Technology in India: An Overview".

27. Dr. T.N. Rao, as a member of the '5th Committee on Standardization of Photocatalytic Material and Products (CASD) in Asia' visited Tokyo, Japan during November 29-30, 2011 and made a presentation on "Recent Trends in Photocatalytic Applications: An Indian Perspective".

28. Dr. G. Sundararajan and Dr. S.V. Joshi visited Russia during December 13-17, 2011 to i) participate in the 'First Meeting of Russian-Indian Scientific and Technological Centre Joint Board' and ii) attend the inauguration of the centre as a members of the joint board.

29. Dr. K. S. Dhathathreyan visited Taiwan during December16-23, 2011 for i) technical discussion on 'Indo-Taiwan Joint Research Programme on Fuel Cell and Redox Battery for Energy Storage' ii) technical discussion at various places like Institute of Nuclear Energy Research (INER), National United University, Noveltek Industrial Manufacturing Inc, Asia Pacific Fuel Cell Technologies Ltd, Taiwan Power Company (Tai Power), Toplus Energy Corporation-Fuel Cell Power and iii) delivering an invited lecture on "Latest Development in Hydrogen Research at Centre for Fuel Cell Technology, ARCI" at the Industrial Technology Research Institute (ITRI), Taiwan.

30. Dr. G. Sundararajan, as a member of the SEDY Programme of Saha Institute of Nuclear Physics (SINP), Kolkata visited Hamburg, Germany during December 21-22, 2011.

31. Dr. G. Sundararajan visited Japan during February 27-March 04, 2012 to i) participate in the '8th International Hydrogen and Fuel Cell Expo 2012' held at Tokyo, Japan ii) deliver invited lectures on "Indian and ARCI Initiatives in Nano Science and Technology" on the eve of National Science Day at Indian Embassy, Tokyo, Japan and iii) have technical discussion and deliver an invited lecture on "Alternative Energy Programmes at ARCI" at Yokohama National University, Japan.

32. Dr. K.S. Dhathathreyan participated in the '8th International Hydrogen and Fuel Cell Expo 2012' held at Tokyo Japan during February 28-March 04, 2012.

33. Dr. L. Rama Krishna participated in the '4th Indo-American Frontiers of Engineering Symposium' held at Maryland, USA during February 29-March 03, 2012.

34. Dr. N. Rajalakshmi visited Advanced Materials Corporation, USA for training on 'Sieverts Apparatus' during March 06-13, 2012 and also delivered lectures on "Fuel Cell Activities at CFCT-ARCI" and "Recent Developments in Hydrogen Storage Materials" at Carnegie Mellon University, Pittsburgh, USA and Advanced Materials Corporation, Pittsburgh, USA respectively.

35. Dr. T.N. Rao participated in the 'Research and Innovation Week' held at University of South Africa (UNISA), Pretoria, South Africa during March 12-15, 2012 and delivered a plenary lecture on "Technology innovation on Healthcare: A Case Study on Nanosilver" and an invited lecture on "Application of Nanomaterials in Energy, Health and Environment" at the 'Indo-South African Symposium on Nanotechnology and Innovation' conducted as a part of the Research Innovation Week.

Invited Lectures/Presentations by ARCI Personnel in India

1. Dr. K. Ramya presented a paper on "Ionic Conducting Materials - Solid Polymer Electrolytes" at a two day programme on 'Fuel Cell Education and Training' organized by TIFAC-CORE in Automotive Infotronics and Vellore Institute of Technology (VIT) at Vellore during April 04-05, 2011.

2. Dr. K. S. Dhathathreyan delivered an invited lecture on "Renewable Energy in India" and "Renewable Energy and Nanotechnology" at the 'National Conference on Renewable Energy Technologies (RET-2011)' organized by Velammal Engineering College at Chennai during April 07-08, 2011.

3. Ms. B. Yamini Sarada presented a paper on "Synergetic Effect of Hydrothermally Synthesised α-MnO_2 Nanorods in PEM Fuel Cells" at the 'National Conference on Renewable Energy Technologies (RET-2011)' organized by Velammal Engineering College at Chennai during April 07-08, 2011.

4. Dr. G. Sundararajan delivered an invited lecture on "Commercialization of Materials based Technologies - ARCI's Experience" at the 'Innovation Educators Conference' held at Indian School of Business, Hyderabad on April 30, 2011.

5. Dr. K. Suresh delivered a lecture on "Small Angle X-Ray Scattering (SAXS) for Microstructural Studies" at ARCI, Hyderabad on May 18, 2011.

6. Dr. Joydip Joardar conducted a 'Workshop on Rietveld Refinement' and delivered a series of lectures during the event at IIT Madras, Chennai during May 26-28, 2011.

7. Dr. K. S. Dhathathreyan delivered an invited lecture on "Nanotechnology in Renewable Energy" at the 'AICTE Staff Development Programme on Nano Technology' held at Vivekanandha College of Engineering for Women, Thiruchengode during June 01-02, 2011.

8. Dr. N. Rajalakshmi delivered an invited lecture on "Nanomaterials for Energy Devices" at the 'AICTE Staff Development Programme on Nano Technology' held at Vivekanandha College of Engineering for Women, Thiruchengode during June 01-02, 2011.

9. Mr. Sanjay Bhardwaj delivered invited lectures on "Managing Post-Ideation Phase in Technology Development Projects" and "Enterprise Creation in Advanced Materials Sector" at the 'Faculty Development Programme' held at Osmania University, Hyderabad on June 14, 2011.

10. Dr. K.S. Dhathathreyan delivered an invited lecture on "Sustainable Hydrogen Energy - Role of Wind Power" at 'Global Wind Day-2011' held at Centre for Wind Energy Technology (C-WET), Chennai on June 15, 2011.

11. Dr. T.N. Rao delivered an invited lecture on "Nanomaterials-based Functional Textiles" at the '3rd Indo-German Frontiers of Engineering Symposium' held at Khandala during June 16-19, 2011.

12. Dr. G. Sundararajan delivered an invited lecture on "Development & Commercialization of MAO Coating Technology: ARCI's Experience" at the 'RC Meeting of AMPRI, Bhopal' held at Bhopal on June 20, 2011.

13. Dr. S.V. Joshi delivered an invited lecture on "Advances in Surface Engineering for Tribological Applications" at the '3rd Summer School in Tribology' organized by Tribology Society of India at New Delhi on June 23, 2011.

14. Dr. R. Subasri delivered an invited lecture on "Sol-Gel Derived Nanocomposite Coatings for Commercial Applications" at the 'National Conference on NanoScience and Engineering for Better Ceramics (NanoSEC 2011)' held at Bangalore during June 23-24,2011.

15. Ms. Rekha Dom (Dr. P.H. Borse) presented a paper on "Microwave Synthesis of Solar Active Nano Crystalline Ferrite Photocatalysis of MFe_2O_4 (M: Ca, Zn and Mg)" at 'NanoSEC 2011' held at Bangalore during June 23-24, 2011.

16. Dr. R. Gopalan delivered an invited lecture on "Multi Scale Microstructural Characterization of Magnetic Materials" at the 'International Conference on Electron Nanoscopy and XXXII Annual Meeting of Electron Microscopic Society of India (EMSI)' held at Hyderabad during July 06-08 2011.

17. Dr. G. Ravi Chandra presented a paper on "SEM based Micro Diffraction for Characterization of Coatings" at the 'International Conference on Electron Nanoscopy and XXXII Annual Meeting of Electron Microscopic Society of India (EMSI)' held at Hyderabad during July 06-08 2011.

18. Dr. B.V. Sarada made a poster presentation on "Characterization of Electrochemically Synthesized Graphene by Electron Microscopy" at the 'International Conference on Electron Nanoscopy and XXXII Annual Meeting of Electron Microscopic Society of India (EMSI)' held at Hyderabad during July 06-08 2011.

19. Dr. Neha Y. Hebalkar presented a paper on "Investigation of Bi-Functional SiO_2 @TiO_2, Ag Core Shell Nanocomposites using Electron Microscopy" at the 'International Conference on Electron Nanoscopy and XXXII Annual Meeting of Electron Microscopic Society of India (EMSI)' held at Hyderabad during July 06-08 2011.

20. Dr. D. Siva Prahasam made a poster presentation on "TEM Investigation of Pure ZnO Nanorods Grown by Flame Spray Pyrolysis Technique" at the 'International Conference on Electron Nanoscopy and XXXII Annual Meeting of Electron Microscopic Society of India (EMSI)' held at Hyderabad during July 06-08 2011.

21. Mr. P. Sai Venkata Pramod (Dr. G. Ravi Chandra) made a poster presentation on "Dual Beam FIB and Transmission Electron Microscopy Studies on a Multilayer Coatings" at the 'International Conference on Electron Nanoscopy and XXXII Annual Meeting of Electron Microscopic Society of India (EMSI)' held at Hyderabad during July 06-08 2011.

22. Dr. G. Padmanabham delivered an invited lecture on "Laser Material Processing for Automotive Applications" at TVS Motors, Hosur on July 11, 2011.

23. Dr. G. Padmanabham delivered an invited lecture on "Application of Lasers in Manufacturing" at Hindustan Aeronautics Limited (HAL), Bangalore on July 12, 2011.

24. Dr. G. Padmanabham delivered an invited lecture on "Comparison of Laser-MIG Hybrid Welding of Mild Steel and Modified 9CrlMo(P91) Steel" at the '64th Annual Assembly and International Conference of the International Institute of Welding (IIW)' held at Chennai during July 17-21, 2011.

25. Ms. Y. Krishna Priya (Dr. G. Padmanabham) presented a paper on "Joining of Aluminium Alloy to Steel using Pulsed-MIG Welding" at the '64th Annual Assembly and International Conference of the IIW' held at Chennai during July 17-21, 2011.

26. Mr. S.M. Shariff delivered an invited lecture on "Laser Hardening of Steels : Process and Applications" at the two-day course programme on 'Heat Treatment of Industrial Components' jointly organized by Indian Institute of Metals (IIM) and IIT Madras at Chennai during July 29-30, 2011.

27. Dr. G. Sundararajan delivered an invited lecture on "The Relevance and Importance of Materials Development to Product Design and Development" at the 'Young Scientists Colloquium-2011' sponsored by Materials Research Society of India (MRSI)-Kolkata Chapter at Indian Association for Cultivation of Science (IACS), Kolkata on August 04, 2011.

28. Dr. D. Sivaprahasam delivered a lecture on "Studies on Synthesizing Fe and Fe-Cu Nanopowders by Levitational Gas Condensation Process and their Consolidation Characteristics" at ARCI, Hyderabad on August 05, 2011.

29. Dr. G. Sundararajan delivered the T.R. Anantharaman Memorial Lecture on "New Generation Oxide Dispersion Strengthened (ODS) Steels" at Banaras Hindu University (BHU), Varanasi on August 06, 2011.

30. Dr. S.V. Joshi delivered an invited lecture on "Advanced Surface Engineering Technologies for Aerospace Applications" at Defence Research Development Laboratory (DRDL), Hyderabad on August 09, 2011

31. Mr. S. M. Shariff delivered an invited lecture on "Laser Surface Modification by Cladding and Alloying", at a 'Workshop on Metal Additive Processes' held at Bangalore on August 10, 2011.

32. Dr. N. Rajalakshmi delivered an invited lecture on "Microbial Fuel Cells for Clean Energy Generation" at a 'Workshop on Nanobiotechnology - The Force of the Future' held at Women's Christian College, Chennai during August 10-12, 2011.

33. Ms. L. S. Ranjani presented a paper on "Polymer Electrolyte Membrane based Humidity Sensors for Fuel Cells" at 'National Symposium on Electrochemical Science and Technology (NSEST-2011)' held at IISc, Bangalore during August 19-20, 2011.

34. Ms. P. Karthika (Dr. N. Rajalakshmi) presented a paper on "Phosphorus Doped Graphene for Supercapacitors" at 'NSEST-2011' held at IISc, Bangalore during August 19-20, 2011.

35. Dr. R. Vijay delivered an invited lecture on "Applications of Nanomaterials in Health, Energy and Environment: An Indian Perspective" at 'National Seminar on Finite Element Formulations on Nanostructures' held at Sidhartha Engineering College, Vijayawada during August 19-20, 2011.

36. Dr. G. Sundararajan delivered the Prof. Brahm Prakash Memorial lecture on "Commercialization of Materials based Technologies at ARCI: An Overview" at IISc, Bangalore on August 21, 2011.

37. Dr. K. S. Dhathathreyan delivered an invited lecture on "Integration of Wind Energy with Other Energy Sources-The Hydrogen Option" at the 'International Training Course (ITC-2011)' held at C-WET, Chennai on August 23, 2011.

38. Dr. G. Sundararajan delivered an invited lecture on "Automotive Sector Related R&D at ARCI: Present and Future" at the 'National Conference on Design, Materials & Constructions (NCDMC 11)' held at Veltech Technical University, Chennai on August 25, 2011.

39. Dr. G. Sundararajan delivered an invited lecture on "Tribological Properties of Conventional and Nanostructured Detonation Sprayed WC-12Co Coatings" at the 'National Conference on Tribology and Materials' held at IIT Madras, Chennai on August 26, 2011.

40. Dr. P.K. Jain delivered an invited lecture on "Development of Carbon Nanotubes and their Field Emission Applications" at the 'National Workshop on Carbon' organized by Sardar Patel University, Gujarat and Indian Carbon Society at Vallabh Vidyanagar, Gujarat on August 26, 2011.

41. Dr. R. Vijay delivered an invited lecture on "Nano Dispersion Strengthened Steels for Supercritical Thermal Plants, Fusion Reactors and Fast Breeder Reactor Applications" at the 'National Seminar on Nanotechnology - Its Future and Applications in Energy Sector' held at Hyderabad during August 26-27, 2011.

42. Dr. S. Sakthivel delivered an invited lecture "Development of High Absorption and Low

Emissivity Coatings for Solar Thermal Applications" at the 'National Seminar on Nanotechnology – Its future and Applications in Energy Sector' held at Hyderabad during August 26-27, 2011.

43. Mr. Sanjay Bhardwaj delivered invited lectures on "Entrepreneurship in Materials Technology Domain" and "Growth Strategies for Technology-based Businesses" at the 'Seminar on Student Options-Employment or Entrepreneurship' organized by the Alluri Institute of Management Sciences, Warangal with the support of All India Council of Technical Education (AICTE), New Delhi at Warangal on August 30, 2011.

44. Mr. Raman Vedarajan delivered an invited lecture on "Fuel Cell Technology: Challenges and Opportunities for Material Researchers" at Anna University, Coimbatore on September 07, 2011.

45. Dr. S.V. Joshi delivered an invited lecture on "Surface Engineering: Emerging Frontiers and Commercial Prospects" at SASTRA University, Thanjavur on September 09, 2011.

46. Dr. G. Ravi Chandra delivered an invited lecture on "Nanoscience and Nanotechnology - The Role of Engineers" at SR International Institute of Technology, Hyderabad on September 12, 2011.

47. Dr. T.N. Rao delivered an inaugural lecture on "Nanomaterials for Energy, Health and Environment: An Indian Perspective" at the 'National Conference on Applications of Nanomaterials in Manufacturing' held at Chennai on September 14, 2011.

48. Dr. S.V. Joshi delivered an invited lecture on "Thermal Barrier Coatings: Status, Challenges and Opportunities" at the 'Workshop on Thermal Barrier Coatings' organized by TATA Steel at Jamshedpur on September 16, 2011.

49. Dr. P.K. Jain delivered an invited lecture on "Field Emission Properties of Aligned Carbon Nanotubes" at the 'National Workshop on Different Aspects of Field Emission' organized by Microwave Tube Research and Development Centre (MTRDC) - Defense Research Development Organization (DRDO) at Bangalore on September 17, 2011.

50. Dr. G. Ravi Chandra presented a paper on "Studies on Ti-Al-N Multilayer Coatings" at the workshop on 'Mechanical Behaviour of Systems at Small Length Scales' held at Trivandrum during September 18-21, 2011.

51. Dr. G. Padmanabham delivered an invited lecture on "Surface Engineering using Lasers" at 'Recon Technology Workshop' organized by Cummins India Limited at Pune on September 20, 2011.

52. Dr. P.K. Jain delivered an invited lecture on "Synthesis of Carbon Nanotubes and their Various Applications" at a 'Workshop on Nanomaterials' organized by Barhitar University at Coimbatore during September 21, 2011.

53. Dr. G. Sundararajan delivered an invited lecture on "Characterization of Thermal Spray Coatings" at the 'Asia Pacific Seminar on Characterization' held at Anna University, Chennai during September 22-24, 2011.

54. Dr. K. S. Dhathathreyan delivered an invited lecture on "Characterizing PEM Fuel Cell Electrodes" at the 'Asia Pacific Seminar on Characterization' held at Anna University, Chennai during September 22-24, 2011.

55. Dr. N. Rajalakshmi delivered an invited lecture on "Fuel Cells Materials Characterization-Beyond" at the 'Asia Pacific Seminar on Characterization' held at Anna University, Chennai during September 22-24, 2011.

56. Dr. G. Padmanabham delivered an invited lecture on "Application of Laser in Welding and Manufacturing Processes" at the 'Seminar on Advance Manufacturing Technologies (MetEx India 2011)' organized by IIM-Bangalore on September 23, 2011.

57. Mr. Raman Vedarajan presented a paper on "Recent Trends in Energy Materials" at Vivekananda College, Thiruchungode on October 03, 2011.

58. Dr. K. S. Dhathathreyan delivered the inaugural address on "Importance of Solar Radiation Measurement" at the training programme on 'Functioning and Maintenance of the Solar Radiation Resource Assessment' held at C-WET, Chennai on October 10, 2011.

59. Dr. S.V. Joshi delivered an invited lecture on "Translating Nanotechnology Research to Applications: Challenges and Opportunities" at the 'Nanocellulose Training Programme' held at Central Institute for Research on Cotton Technology(CIRCOT), Mumbai during October 10-24, 2011.

60. Dr. P.K. Jain delivered an invited lecture on "Fundamental Aspects of Carbon Nano-Materials and their Various Applications" at a 'Workshop on Materials' organized by RCMA (Materials)-DRDO at Hyderabad on October 12, 2011.

61. Dr. G. Sundararajan delivered a special lecture on "Nanotechnology and NBIC Convergence" at the '6th Nanotechnology Conclave 2011' held at Chennai on November 03, 2011.

62. Dr. G. Sundararajan delivered an invited lecture on "Micro Arc Oxidation Coating Technology for Aluminium Alloys" at the 'IIM-49th National Metallurgists Day-65th Annual Technical Meeting (IIM-NMD-ATM 2011)' held at Hyderabad during November 13-16, 2011.

63. Dr. K. S. Dhathathreyan delivered an invited lecture on "Supported Catalysts to Mesoporous Metal Catalysts: A Journey in the Advance of Catalysts for Hydrogen Energy" at 'IIM-NMD-ATM 2011' held at Hyderabad during November 13-16, 2011.

64. Dr. R. Gopalan delivered an invited lecture on "Permanent Magnets & other Magnetic Alloys for High Performance Applications" at 'IIM-NMD-ATM 2011' held at Hyderabad during November 13-16, 2011.

65. Dr. G. Ravi Chandra presented a paper on "Microstructural Study of Al-Fe Welds' at 'IIM-NMD-ATM 2011' held at Hyderabad during November 13-16, 2011.

66. Dr. K. Suresh presented a paper on "Probing Nano-Scale Structures in ODS Steel by Small Angle X-Ray Scattering (SAXS)" at 'IIM-NMD-ATM 2011' held at Hyderabad during November 13-16, 2011.

67. Dr. P. Suresh Babu presented a paper on "Microstructure, Mechanical and Tribological Properties of Detonation Sprayed WC-12Co Coatings" at 'IIM-NMD-ATM 2011' held at Hyderabad during November 13-16, 2011.

68. Mr. K.V.P. Prabhakar presented a paper on "Formability of Laser Welded and Laser Hybrid Welded Dual Phase Steels for Automotive Applications" at 'IIM-NMD-ATM 2011' held at Hyderabad during November 13-16, 2011.

69. Mr. Sanjay Bhardwaj delivered an invited lecture on "Nano-Silver Coated Ceramic Filter Candles for Water Purification" at the 'National Workshop cum Exhibition on Drinking Water Quality' organized by the Government of India's Ministry of Drinking Water and Sanitation at New Delhi during November 15-16, 2011.

70. Dr. G. Sundararajan delivered an invited lecture on "Nanoscience and Technology: An Overview" at the 'National Workshop on Nanotechnology for Defense Applications' held at Solid State Physics Laboratory, DRDO, Delhi on November 16, 2011.

71. Dr. G. Padmanabham delivered an invited lecture on "Laser based Repair Technologies", at the 'International Conference on Emerging Trends in Repair / Reclamation Technologies on Aero Engine Parts' organized by the Aeronautical Society and the Indian Air Force 3BRD at Chandigarh on November 18, 2011.

72. Dr. N. Rajalakshmi delivered an invited lecture on "Nano Electrocatalysts for PEM Fuel Cells" at a refresher course on 'Nanoscience and Nanotechnology' organized by Madras University at Chennai on November 18, 2011.

73. Dr. G. Ravi Chandra delivered an invited lecture on "Introduction to Electron Backscatter Diffraction" at the 'Workshop on Electron Microscopy (WEM-2011)' held at Bhubaneswar during November 23-25, 2011.

74. Mr. Sai Venkata Pramod (Dr. G. Ravi Chandra) presented a paper on "Characterization of Multilayer Coatings by Electron Beam Backscatter Diffraction, Focused Ion Beam Milling and Transmission Electron Microscopy" at 'WEM-2011' held at Bhubaneswar during November 23-25, 2011.

75. Ms. Y. Krishna Priya (Dr. G. Padmanabham) presented a paper on "Characterization of MIG-Brazed Aluminium-Steel Joint Interface" at 'WEM-2011' held at Bhubaneswar during November 23-25, 2011.

76. Dr. B. V. Sarada presented a paper on "Plasmon Resonance Enhanced Photo Electrochemical Response at Au-Modified TiO_2 Nanotube Array Electrodes" at the International Conference on TAPSUN 2011 held at IICT, Hyderabad during November 25-26, 2011.

77. Mr. K.R.C. Soma Raju, presented a paper on "Effect of Plasma Pre-Treatment on Adhesion and Mechanical Properties of Sol-Gel Nanocomposite Coatings on Plastics" at the '1st International Conference on Plasma Processing of Organic Materials and Polymers (PPOMP 2011)' organized by Institute of Macromolecular Science and Engineering (IMSE) at Kottayam, during November 25-27, 2011.

78. Dr. B.V. Sarada presented a paper on "Electrochemical Synthesis and Characterization of Nanostructured Materials for Photonic and Solar Energy Applications" at the Workshop on 'Recent Advances in Photonic Applications' held at Sri Sathya Sai Institute of Higher Learning, Prashanthinilayam during November 28-29, 2011.

79. Dr. G. Sundararajan delivered a keynote lecture on "Nanomaterials at ARCI" at the 'International Conference on Nanoscience Engineering and Technology (ICONSET 2011)' held at Sathyabama University, Chennai during November 28-30, 2011.

80. Mr. H. Purushotham presented paper on "Knowledge Management and Regulatory Issues-Key for Sustainable Development of Nanoscience and Technology in India " at 'ICONSET 2011' held at Sathyabama University, Chennai during November 28 -30, 2011.

81. Dr. G. Sundararajan delivered a keynote lecture on "Nanocomposites at ARCI" at the 'Indo-French Seminar on High Performance Composites for Aeronautics and Space Application and Extreme Environments' held at Bangalore on November 30, 2011.

82. Dr. K. S. Dhathathreyan delivered an invited lecture on "Status of Fuel Cell Research in India and the Way Forward" at the 'Hydrogen Association of India Workshop on Hydrogen Production, Storage, Safety and Application' held at New Delhi during December 01-02, 2011.

83. Dr. G. Padmanabham delivered an invited lecture on "Application of Laser Surface Engineering and Welding" at the 'Laser Forum on Role of Lasers in Manufacturing' organized by Hannover Milano Fairs of India Limited at Bangalore on December 06, 2011.

84. Dr. G. Sundararajan delivered an invited lecture on "Automotive Research under the CAR Programme" at the '6th International Conference on Aluminium (INCAL-11)' held at Hyderabad International Convention Centre (HICC), Hyderabad on December 07, 2011.

85. Dr. T.N. Rao delivered an invited lecture on "Applications of Nanomaterials: From Laboratory to Market" at the 'Pre-Conference Tutorials' held on the occasion of '4th Bangalore Nano 2011' at Bangalore on December 07, 2011.

86. Dr. G. Sundararajan delivered an invited lecture on "Nanosilver for Anti Microbial Textiles: Laboratory to Market Place" at '4th Bangalore Nano 2011' held at Bangalore on December 08, 2011.

87. Dr. S. Kumar delivered an invited lecture on "Cold Spray Coatings" at the 'International Symposium on Surface Coatings Technology' held at Bangalore on December 08, 2011.

88. Dr. S.V. Joshi delivered an invited lecture on "Advances in Surface Engineering to Combat Components Wear" at the 'National Tribology Conference (NTC-2011)' held at IIT, Roorkee during December 08-10, 2011.

89. Mr. H. Purushotham presented a paper on "Framework for Knowledge Management of Nanoscience and Technology in India" at the 'International Conference on Nanoscience and Technology and Societal Implications' held at Bhubaneswar during December 08-10, 2011.

90. Mr. Balaji Padya presented a paper on "Self Organized Growth of Bamboo like Carbon Nanotubes Arrays for Field Emission Properties" at the '2nd International Conference on Advanced Nanomaterials and Nanotechnology (ICANN 2011)' held at Guwahati during December 08-10,2011.

91. Dr. K. S. Dhathathreyan delivered an invited lecture on "Fuel Cell Catalysts-Should We Revert to Unsupported Catalysts for Low Temperature Fuel Cells?" at the 'National Workshop on Catalysis – NCCR' held at Chennai during December 11-13, 2011.

92. Dr. R. Gopalan delivered an invited lecture on "Functional Materials for Sustainable Transportation Energy" at the 'International Conference on Advanced Materials (ICAM 2012)' held at Coimbatore during December 12-16, 2011.

93. Dr. G. Ravi Chandra presented a paper on "Characterization of Coatings by SEM based Micro Diffraction" at the '16th International Conference on Textures of Materials (ICOTOM)' held at Mumbai during December 12-17, 2011.

94. Mr. L. Venkatesh presented a paper on "Process Parameters Impact on Microstructure of Laser Clad Inconel-Chromium Carbide Layers" at 'ICOTOM' held at Mumbai during December 12-17, 2011.

95. Mr. P. Sai Venkata Pramod (Dr. G. Ravi Chandra) made a poster presentation on "Structure-Property Correlations in Cathodic Arc Deposited TiAlN Coatings" at the 'ICOTOM' held at Mumbai during December 12-17, 2011.

96. Dr. S.V. Joshi delivered an invited lecture on "Technology Commercialization: ARCI's Experience" at the DST sponsored training programme on 'Innovation Management and Technology Valorization' held at Administrative Staff College of India (ASCI), Hyderabad during December 12-23, 2011.

97. Dr. G. Sundararajan delivered an invited lecture on

"Technology Development and Commercialization: ARCI's Experience" at the course on 'Paradigm Shift in Science and Technology' held at National Institute of Advanced Studies (NIAS), Bangalore on December 13, 2011.

98. Dr. K. S. Dhathathreyan delivered an invited lecture on "PEM Fuel Cell Development – from Materials to System"at the 'Indo-Norwegian Workshop on Materials for Hydrogen Storage and Fuel Cells' held at PSG College of Technology, Coimbatore during December 13-15, 2011.

99. Dr. K. S. Dhathathreyan delivered an invited lecture on "The Importance of Nano Technology in Electronics and Energy Conversion Devices" at the 'AICTE Faculty Development Programme on Fundamentals of Nanoscience and Technology' held at Anna University, Chennai on December 16, 2011.

100. Dr. G. Sundararajan delivered an invited lecture on "Advanced Manufacturing Technologies for State-of-the-Art Systems" at the 'International Conference on Advanced Materials and Processing (ICAMP-2011)' held at RMK Engineering College, Chennai on December 19, 2011.

101. Dr. Roy Johnson delivered an invited lecture on "Advanced Ceramic Materials in Energy Sector: Current Status and Future Scenario" at the 'International Conference on Energy Efficient Materials and Manufacturing Methods and Machineries of Ceramic Industries (IC2E4MCI-11) and The Platinum Jubilee Session of the Indian Ceramic Society' held at Agra during December 19-22,2011.

102. Dr. B.P. Saha presented a paper on "Extrusion Processing of NiO-8YSZ Honeycombs for SOFC Applications" at 'IC2E4MCI-11 and The Platinum Jubilee Session of the Indian Ceramic Society' held at Agra during December 19-22, 2011.

103. Dr. M. Buchi Suresh presented a paper on "Development of a Novel Cathode Material for IT SOFC Applications" and made a poster presentation on "Microstrcuture and Ionic Conductivity Correlation of Nanostructured 8Y Zirconia Ceramics Sintered through Spark Plasma Sintering" at 'IC2E4MCI-11 and The Platinum Jubilee Session of the Indian Ceramic Society' held at Agra during December 19-22, 2011.

104. Mr. Pandu Ramavath presented a paper on "Estimation of Cohesion Index of Spray Dried Alumina Granules using Powder Flow Analyzer" at the 'IC2E4MCI-11 and The Platinum Jubilee Session of the Indian Ceramic Society' held at Agra during December 19-22, 2011.

105. Ms. Papiya Biswas presented a paper on "Methyl Cellulose based Gel Casting: An Energy Efficient and Environmentally Benign Process for the Shaping of Alumina" at the 'IC2E4MCI-11 and The Platinum Jubilee Session of the Indian Ceramic Society' held at Agra during December 19-22, 2011.

106. Ms. K. Rajeshwari (Dr. Roy Johnson) presented a paper on "Studies of Sintering Kinetics and Correlation with Sinterability of 8Y Zirconia based on Dilatometric Shrinkage Curves" at 'IC2E4MCI-11 and The Platinum Jubilee Session of the Indian Ceramic Society' held at Agra during December 19-22,2011.

107. Dr. S. Sakthivel delivered an invited lecture on "Importance of Solar Energy Conversion Technology and Challenges of Producing Solar Receiver Tubes for High Temperature Concentrated Solar Power Plant Applications" at a 'One Day Seminar on New Frontiers in Heterogeneous Catalysis' held at Chennai on December 21, 2011.

108. Dr. Y.S. Rao delivered an invited lecture on "Bulk Synthesis on Nano ZnO/LSM Powders by Spray Pyrolysis and Characterization" at SKDS Mahila Kalasala, Tanuku on December 23, 2011.

109. Dr. B. V. Sarada presented a paper on "New Directions in Electrochemical Synthesis of Nanostructured Materials" at the 'Annual Convention of Andhra Pradesh Akademi of Science' held at Hyderabad during December 23-24, 2011.

110. Mr. R. Balaji delivered an invited lecture on "Hydrogen Energy Technology" at Mahendra Engineering College, Salem on December 24, 2011.

111. Dr. G. Sundararajan delivered a keynote lecture on "Sustainable Energy Programmes at ARCI" at Thermax Limited, Pune on December 30, 2011.

112. Dr. R. Gopalan delivered an invited lecture on "High Performance Materials for Automotive Applications" at the 'Indian National Science Congress (INSC-2012)' held at Bhuvaneshwar during January 03-07, 2012.

113. Dr. G. Sundararajan delivered an invited lecture on "Automotive Research and Technology Development at ARCI" at the 'Indo-French Seminar on Automotive R&D' held at Trident Hotel, Chennai on January 04, 2012.

114. Mr. M. Srikanth (Dr. P.K. Jain) presented a paper on "Development of Flexible Conductive Paper using Carbon Nanotubes for Energy Storage Applications" at the 'International Conference on Nano Technology and Functional Materials' held at Sreenidhi Institute of Science and Technology, Hyderabad during January 04-07, 2012.

115. Mr. S. Raghuram Reddy (Dr. P.K. Jain) presented a paper on "A Facile Method for High Yield of Graphene Nanosheets from Exfoliated Graphite" at the 'International Conference on Nano Technology and Functional Materials' held at Sreenidhi Institute of Science and Technology, Hyderabad during January 04-07, 2012.

116. Dr. R. Gopalan delivered an invited lecture on "Characterization of Hard Magnetic Materials by 3-Dimensional Atom Probe" at a 'Conference on Atom Probe Technique (APT)' held at Chennai on January 09, 2012.

117. Dr. S.V. Joshi delivered an invited lecture on "Growing Prospects of Laser Processing in Industrial Manufacturing" at the '2nd International Conference on Advances in Mechanical Manufacturing and Building Sciences (ICAMB 2012)' held at Vellore during January 09-11, 2012.

118. Dr. K. Radha presented a paper on "Sol-Gel Coated Stainless Steel Filters" at the 'International Conference on Frontiers in Materials Science for Energy and Environment (ICFMS 2012)' held at Chennai during January 11-13, 2012.

119. Dr. N. Rajalakshmi delivered an invited lecture on "Green Power Initiative-Challenges" at the 'CSIR CPYLS Programme' held at Central Leather Research Institute (CLRI), Chennai during January 12, 2012.

120. Dr. G. Sundararajan delivered an invited lecture on "Advanced Ceramics Programmes at ARCI" at the 'International Workshop on Advanced Ceramics for the Future (ACF-2012)' held at IIT Madras, Chennai on January 16, 2012.

121. Mr. Sanjay Bhardwaj delivered invited lectures on "Essentials of Indian Patent System" and "Creating Material Technologies-based Sustainable Enterprises" at the 'Entrepreneurship Development Programme' held at Osmania University, Hyderabad on January 18, 2012.

122. Dr. G. Padmanabham delivered an invited lecture on "Recent Developments in Laser based Joining Techniques" at the 'International Symposium on Joining of Materials (SOJOM-2012)' organized by the Indian Welding Society and the Welding Research Institute, Trichy during January 19-22, 2012.

123. Mr. K.V.P. Prabhakar presented a paper on "Laser and Laser Hybrid Welding of Automotive Grade Steel Thin Sheets" at 'SOJOM-2012' organized by the Indian Welding Society and the Welding Research Institute, Trichy during January 19-22, 2012.

124. Ms. Krishna Priya (Dr. G. Padmanabham) presented a paper on "Effect of Torch Orientation on Pulsed-MIG Brazed Aluminium Steel Joints" at 'SOJOM-2012' organized by the Indian Welding Society and the Welding Research Institute, Trichy during January 19-22, 2012.

125. Dr. T.N. Rao delivered a keynote lecture on "Applications of Nanomaterials: From Laboratory to Market" at the 'International Conference on Nanoscience and Technology (ICONSAT-2012)' organized by ARCI, Hyderabad during January 20-23, 2012.

126. Dr. R. Subasri presented a paper on "Sol-Gel Nanocomposite Coatings on Plastics for Improved Mechanical Properties" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

127. Dr. D. Sivaprahasam presented a paper on "Effect of Surface Segregation on the Sintering Behavior of Binary Fe-Cu and Fe-Co Alloy Nanopowders" at 'ICONSAT-2012'organized by ARCI, Hyderabad during January 20-23,2012.

128. Mr. Dibyendu Chakravarty presented a paper "Mechanical Properties and Microstructure Evaluation of Spark Plasma Sintered Al_2O_3-ZrO_2-TiCN Nanocomposites" at ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

129. Dr. S. Sakthivel presented a paper on "Ag-TiO_2 Nanocomposite Selective Solar Absorber Coatings for Solar Thermal Application" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

130. Dr. B.V. Sarada presented a paper on "Photoelectrochemical Properties of Metal and Semiconductor Modified TiO_2 Nanotube Array Electrodes" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

131. Dr. P.K. Jain presented a paper on "Vertically Aligned

Carbon Nanotubes Arrays for Field Emission Applications" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

132. Dr. I. Ganesh presented a paper on "Li-Doped ZnO Nano Powder: An Efficient and Re-Generable Photocatalyst" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

133. Dr. Neha Y. Hebalkar presented a paper on "Enhancing the Photocatalytic Activity of Anatase Nano Titania Particles & a Novel Method to Test Self Cleaning Property" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

134. Mr. K. Hembram presented paper on "Synthesis and Characterization of Catalyst Free Bulk Pure ZnO Nanorods by Flame Spray Pyrolysis" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

135. Dr. R. Dinesh presented a paper on "Preparation of $LiMn_2O_4$/Graphene Hybrid Nanocrystals as Cathode for Lithium-Ion Battery" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

136. Mr. Balaji Padya presented a paper on "Influence of Nitrogen Content on Microstructure and Raman Spectrum of Bamboo Shaped Multiwalled Carbon Nanotube Arrays" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

137. Dr. P.H. Borse presented a paper on "Efficient Photoelectrochemical Activity of Spinel Mixed Ferrite Film for H_2 Generation: An Approach by Solution Precursor Plasma Spray Optimization" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

138. Mr. Sreekanth Mandati (Dr. B.V. Sarada) made a poster presentation on "Electrochemical Synthesis and Characterization of $CuInSe_2$ Thin Films for Solar Cell Applications" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

139. Ms. M.S. Archana (Dr. Joydip Joardar) made a poster presentation on "Synthesis of Nanocrystalline FeAl and its Role as a Binder in Ti(C, N) based Nanocomposites" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

140. Mr. Sai Pramod (Dr. G. Ravi Chandra) made a poster presentation on "Nanostructured Nitride Coatings for Improved Wear and Corrosion Resistance" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

141. Mr. M. Sylvester (Dr. Joydip Joardar) made a poster presentation on "Carbon-Doped Nanostructured WO_3 by Mechanically Activated Processing" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

142. Ms. Swapna Challagulla (Dr. Neha Y. Hebalkar) made a poster presentation on "Novel Synthesis of Silica Aerogel Granules" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

143. Ms. K. Anulekha (Dr. T.N. Rao) made a poster presentation on "Functionalized Electrospun Nanofibers of Polystyrene for Biomedical Applications" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23, 2012.

144. Ms. Rekha Dom (Dr. P.H. Borse) made a poster presentation on "Deposition of Nanostructure Metal Oxide Photo-Electrode Film using Solution Precursor Plasma Spray Technique for Green Energy Generation" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

145. Ms. Alka Pareek (Dr. P.H. Borse) made a poster presentation on "Nanostructuring of Efficient Cadmium Sulfide Film by Simple Spray Pyrolysis for Energy Application" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

146. Ms. Ch.L.P. Pavithra (Dr. B.V. Sarada) made a poster presentation on "Electrochemical Synthesis and Characterization of Copper-Graphene Nanocomposite Foils" at 'ICONSAT-2012' organized by ARCI at Taj Krishna, Hyderabad during January 20-23,2012.

147. Ms. L. Sowntharya (Dr. R. Subasri) made a poster presentation on "Investigations on the Mechanical Properties of Sol-Gel Hybrid Nanocomposite Hard Coatings on Polycarbonate" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

148. Ms. M. Nagini (Dr. R. Vijay) made a poster presentation on "Crystallite Size Effects in Oxide Dispersion Strengthened Iron Powders" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

149. Mr. Murali Krishna (Dr. Krishna Valleti) made a poster presentation on "Implementation of C-CAPVD Grown Refractory Metal Nitride Coatings for Solar Thermal Applications" at 'ICONSAT-2012' organized by ARCI, Hyderabad during January 20-23,2012.

150. Dr. Malobika Karanjai presented a paper on

"Multipiston Hot Press (MPHP) for Bonded Cerametallic Friction Pads in Clutches" at the 'International Conference and Exhibition on New Vistas in Particulate Materials Technology and 38th Annual Technical Meeting of Powder Metallurgy Association of India (PMAI)' held at Mumbai during February 02-04, 2012.

151. Mr. Sanjay Bhardwaj presented a paper on "Innovation Paradigms: Contractual Models for Research and Technology Organizations (RTO)" at the '1st International Conference on Management of Intellectual Property and Strategy (MIPS 2012)' held at Mumbai during February 02-05, 2012.

152. Dr. G. Sundararajan delivered a keynote lecture on "Use of Nanopowders to Develop Products and Composites at ARCI" at PMAI, Mumbai on February 03, 2012.

153. Dr. P.H. Borse delivered an invited lecture on "Photocatalytic and Photochemical (PEC) Investigations of Fe/Sn/Nb Containing Oxides for Energy Applications" at the 'International Conference on Recent Trends in Physics (ICRTP 2012)' held at Devi Ahilya University, Indore during February 04-05, 2012.

154. Dr. N. Rajalakshmi delivered an invited lecture on "Studies on Fuel Cell Electrocatalysts and Hydrogen Storage using TGA and MS" at a seminar on 'Material Characterization by Thermal Analysis Techniques' held at Chennai on February 08, 2012

155. Dr. P.K. Jain delivered an invited lecture on "Carbon Nanotubes and their Field Emission Applications" at the '7th All India Joint Scientific and Technical Official Language Seminar' held at Defence Research Development Laboratory (DRDL) at Hyderabad during February 09-10, 2012.

156. Mr. Sanjay Bhardwaj presented a paper on "Managing Intellectual Property Rights at Research and Technology Organizations (RTOs)" at the '7th All India Joint Scientific and Technical Official Language Seminar' held at DRDL, Hyderabad during February 09-10, 2012.

157. Mr. R. Vijaya Chander presented a paper on "Global Nanoscience and Technology Research during 2007-2011: A Literature Analysis" at the '7th All India Joint Scientific and Technical Official Language Seminar' held at DRDL, Hyderabad during February 09-10, 2012.

158. Mr. Narendra K. Bhaktha presented a paper on "Problem and Importance of Hindi Software in Implementation of Official Language" at the '7th All India Joint Scientific and Technical Official Language Seminar' held at DRDL, Hyderabad during February 09-10, 2012.

159. Dr. G. Sundararajan delivered a plenary lecture on "Surface Engineering Activities at ARCI: An Overview" at the 'National Conference on Engineering Coatings: Process Controls and Applications (ENGGCOAT-2012)' held at IIT-Bombay, Mumbai during February 09-11, 2012.

160. Dr. S.V. Joshi delivered an invited lecture on "Solution Precursor Plasma Spraying (SPPS) - A Versatile Technique for Depositing Diverse Functional Coatings" at 'ENGGCOAT-2012', held at IIT-Bombay, Mumbai during February 09-11, 2012.

161. Dr. G. Padmanabham delivered an invited lecture on "Laser based Surface Engineering Techniques and their Applications" at 'ENGGCOAT-2012' held at IIT-Bombay, Mumbai during February 09-11, 2012.

162. Dr. S. Sakthivel delivered an invited lecture on "Importance of Solar Energy Conversion Technologies in India" at Yogi Vemana University, Cudappah on February 10, 2012.

163. Dr. S. Sakthivel delivered an invited lecture on "A Role of Nanotechnology in the Fields of Environment and Energy" at the 'National Seminar on Role of Nanotechnology in Environmental Protection' held at Jawaharlal Nehru Technological University (JNTU), Ananthapur on February 11-12, 2012.

164. Dr. Roy Johnson delivered the MRSI medal lecture on "Polycrystalline Transparent Ceramics: Processing, Properties and Products" at the 'MRSI-Annual Generalbody Meeting' held at Patiala on February 14, 2012.

165. Mr. R. Balaji delivered an invited lecture on "Green Electrolytes for Electrodeposition" at KSR Engineering College, Tiruchencode on February 16,2012.

166. Dr. Vivek Dhand delivered an invited lecture on "Synthesis of Carbon Nanomaterials - Process Development-Case Study" at the 'National Workshop on Recent Trends in Nanotechnology' held at MVGR College of Engineering, Vijayanagaram on February 17, 2012.

167. Dr. N. Rajalakshmi delivered invited lectures on "PEM for Scientists " and "PEM for Engineers" at National Institute of Technical Teachers Training and Research (NITTTR), Chennai on February 22, 2012.

168. Dr. G. Sundararajan delivered an invited lecture on "Solar Energy Related Programmes at ARCI" at the 'Workshop on NANOSOLAR-2012' held at Amrita University, Cochin on February 24, 2012.

169. Dr. T.N. Rao delivered an invited lecture on "Nanomaterials: Laboratory to Market" at a 'Two-Day Workshop on Nanotechnology Applications' held at Chaitanya Bharati Institute of Technology (CBIT), Hyderabad during February 27-28, 2012.

170. Dr. S.V. Joshi delivered an invited lecture on "Solution Precursor Plasma Spraying (SPPS)-Opening Vistas for Exciting Research and Niche Applications" at the 'International Workshop on Surface Engineering of Metals and Alloys' held at Bengal Engineering and Science University (BESU), Howrah during March 01-02, 2012.

171. Dr. P. K. Jain delivered an invited lecture on "Carbon Nanotubes Synthesis and their Electronics Applications" at the 'National Workshop on Applications of Nanomaterials' held at SSJ Engineering College, Hyderabad on March 02, 2012.

172. Dr. N. Rajalakshmi delivered an invited lecture on "Electrochemical Aspects in Energy Storage Devices-Fuel Cell" at the 'Workshop on Realms of Electrochemistry' held at SSN College, Chennai on March 03, 2012.

173. Dr. M. Buchi Suresh presented a paper on "Structure-Property Correlation on Mixed Ionic and Electronic Conducting Nanocomposite SOFC Cathodes" at the 'International Conference and Workshop on Nanostructured Ceramics and Other Nanomaterials (ICWNCN-12)' held at New Delhi during March13-16, 2012.

174. Mr. Sanjay Bhardwaj delivered invited lectures on "Technology-based Products: Development and Launch Strategies" and "Materials Technologies-based Businesses : Case Studies" at a 'Workshop on Entrepreneurship Opportunities for Professional Students" organized by Alluri Institute of Management Sciences (AIMS)'s Entrepreneurship Development Cell in association with National Bank for Agriculture and Rural Development (NABARD) at Warangal on March 14, 2012.

175. Mr. T.K. Gireesh Kumar presented a paper on "Electronic Thesis and Dissertations (ETD) Initiatives to Provide Open Access to Public Funded Research in India", at the 'National Conference on (NCALUC-2012) of Agricultural Libraries and User Community-2012 on Role of Agriculture Libraries in Knowledge Management' held at Hyderabad during March 15-16, 2012.

Participation in Indian Conferences/ Symposia/Seminars/Workshops/ Exhibitions

1. Dr. R. Gopalan attended the 'Workshop on Hybrid and Electric Vehicle Technologies' held at New Delhi during April 04-05, 2011.

2. Mr. P. Vasanth attended the 'Solid Edge Software Training' conducted by Empower Technologies at Chennai during April 22-23, 2011.

3. Mr. Manish Tak attended an 'Interactive Meet on Utilization of Laser Technology in Industry and Medicine' organized by Indian Laser Association at Raja Ramanna Centre for Advanced Technology (RRCAT) at Indore during April 28-29, 2011.

4. Mr. V. Senthil Velan attended the 'Workshop on Rheological Characterization of Liquids, Powders and Gel' conducted by Brookefield Corporation at Chennai during June 23, 2011.

5. Mr. P. Dharma Rao attended the 'Condensed Translation Training Course' held at Hyderabad during July 04-08, 2011.

6. Mr. S. Arun attended the 'Bharat Utsav Exhibition' held at Hyderabad during August 18-24, 2011.

7. Mr. S.P. Mishra attended the 'National Training Programme on IPR and WTO Issues' held at New Delhi during August 22-26, 2011.

8. Dr. Sanjay R. Dhage and Dr. Easwaramoorthi Ramasamy attended the 'National Seminar on Nanotechnology-Its Future and Applications in Energy Sector' held at Hyderabad during August 26-27, 2011.

9. Mr. K.V.P. Prabhakar attended the 'Proficiency Improvement Programme on Welding Technology and Advances' held at Pune during September 12-16, 2011.

10. Dr. T. Mohan attended the '14th Asian Battery Conference' held at Hyderabad during September 13 -16, 2011.

11. Mr. H. Purushotham attended the 'Workshop on Nanosensors' conducted by Confederation of Indian Industry (CII), DST and National Manufacturing Competitiveness Council at India Habitat Centre, New Delhi during September 19-20, 2011.

12. Ms. S. Nirmala, Mr. Ch. Sambasiva Rao and Ms. N. Aruna attended the 'Seminar on Fluke Test Tools (Measurements/ Verification/ Calibration)' held at Hyderabad on September 20, 2011.

13. Mr. K. Naresh Kumar and Mr. M.R. Renju attended the 'Seminar on the Latest Technologies and its Applications' conducted by Microsoft Corporation at Hyderabad on September 27, 2011.

14. Mr. Md. Sadiq attended a 'Course on Repair and Maintenance of Latest Petrol Engines' held at Hyderabad during October 10-21, 2011.

15. Mr. K. Satyanarayana Reddy attended a 'Course on Repair and Maintenance of Latest Petrol Engines' held at Hyderabad during October 10-21, 2011.

16. Mr. P. Dharma Rao attended a 'Training Programme on Administrative and Technical Terminology' held at Hyderabad during November 01-02, 2011.

17. Dr. P. Suresh Babu attended the 'Pre-SMiRT Conference on Miniature Specimens for Evaluation of Mechanical Properties of Structural Materials' held at Mumbai during November 04-05, 2011.

18. Dr. B. P. Saha, Dr. Sanjay R. Dhage and Dr. Easwaramoorthi Ramasamy attended the 'SOLARCON India 2011 Conference' held at Hyderabad during November 09-11, 2011.

19. Mr. Nitin P. Wasekar attended the 'IIM-NMD-ATM 2011' held at Hyderabad during November 13-16, 2011.

20. Mr. Sanjay Bhardwaj, Mr. S.P. Mishra, Mr. S. Arun, Mr. Aan Singh and Mr. Gaje Singh attended the 'India International Trade Fair' held at New Delhi during November 14-17, 2011.

21. Mr. P. Vasanth and Mr. Sashank Viswanath attended the 'Hydrogen Safety Workshop' conducted by Air Products at IIT, Delhi on November 15, 2011.

22. Dr. K. Madhuri attended the 'National Workshop on Nanotechnology for Defence Applications (NWNDA 2011)' held at Solid State Physics Laboratory (SSPL), Delhi during November 16-17, 2011.

23. Mr. Sanjay Bhardwaj attended the 'Management Development Programme (MDP) on Marketing Scientific Research and Innovation in International Business' organized by Indian Institute of Foreign Trade in association with DST at New Delhi during November 28-December 02, 2011.

24. Dr. G. Padmanabham and Mr. Gururaj Telesang attended the 'International Trade Fair for Laser Systems and Laser Technology for Manufacturing-Laser India 2011' held at Bangalore International Exhibition Centre, Bangalore during December 06-09, 2011.

25. Dr. Vivek Dhand and Mr. Ratnesh Kumar Gaur attended the '4th Bangalore Nano 2011 Exhibition' held at Bangalore during December 07-09, 2011.

26. Ms. S. Nirmala and Ms. N. Aruna attended the 'National Instruments Technical Symposium 2011' held at Hyderabad on December 09, 2011.

27. Ms. S. Nirmala attended the '99th Indian Science Congress-DST Programme on Special Discussion Sessions on Issues Related to Women in Science' held at Bhuwaneswar January 03-07, 2012.

28. Ms. Priya A. Mathews attended the 'National Training Programme on IPR and WTO Issues' held at Bhabha Atomic Research Centre (BARC), Mumbai during January 09-13, 2012.

29. Dr. K. Murugan attended the 'Basic and Advanced Course of Spectroscopic Ellipsometry' held at Mumbai and Pune during January 22-25, 2012.

30. Dr. R. Vijay attended the '6th International Conference on Creep Fatigue-Creep Fatigue Interaction (CF6)' held at Chennai during January 22-25, 2012.

31. Mr. K. V. P. Prabhakar attended the 'IMTEX Exhibition' held at Bangalore International Exhibition Centre, Bangalore during January 23-24, 2012.

32. Mr. A. Rajashekar Reddy attended a 'Training Programme on Thermal Analyzer System' held at Netszch India Pvt. Ltd, Chennai on February 07, 2012.

33. Mr. R. Prabhakara Rao, Mr. N. Srinivas, Mr. S. Arun, Mr. K. Srinivas Rao, Mr. Anirban Bhattacharjee, Mr. A. Srinivas, Mr. Y. Krishna Sarma, Mr. P.V. Ramana, Mr. K. Naresh Kumar, Ms. K. Shakuntala, Mr. A. Satya Narayana, Mr. J. Bansilal and Mr. Ch. Jangaiah attended the '7th All India Joint Scientific and Technical Official Language Seminar' held at DRDL, Hyderabad during February 09-10, 2012.

34. Dr. T. Rajappa attended the 'National Conference on Magnetism, Magnetic Materials and Applications (MAgMA 2012)' held at IIT-Madras, Chennai on March 12, 2012.

35. Mr. Sanjay Bhardwaj attended the 'Workshop on Commercial Contracts' organized by Achromic Point, AZB and Partners, and KPMG's Contract Compliance Services Division at Chennai on March 21, 2012.

Patents' Portfolio

Discontinued Indian Patents

Title	Patent Number with Date of Grant	Remarks
A Solar Cooker	184675 -25/05/2001	Discontinued from 11th year
An Indirect Heated Catalytic Converter for use with Vehicles	185433-10/08/2001	Discontinued from 9th Year
A Process for the Preparation of Short Ceramic Fibres	186751-07/06/2002	Discontinued from 11th year
A Process of Producing Chemically Treated Expanded Graphite and a Device having Such Graphite	187654 -05/12/2002	Discontinued from 11th Year

Indian Patents Granted

Title of Patent	Patent Application Number	Date of filing	Patent Number	Date of Grant
A Solar Drier	487/MAS/1994	08/06/1994	184674	23/09/2000
A Process for Preparation of Reaction Bonded Silicon Carbide Components	1886/MAS/1996	28/10/1996	195429	31/08/2006
	28/10/1996	195429	31/08/2006	02/05/2006
New Composite Material Having Good Shock Attenuating Properties and a process for the Preparation of Said Material	976/MAS/1998	06/05/1998	194524	02/01/2006
Improved Process for the Preparation of Magnesium Aluminate Spinel Grains	29/MAS/1999	07/01/1999	200272	02/05/2006
Ceramic Honey Comb Based Energy Efficient Air Heater	30/MAS/1999	07/01/1999	200787	02/06/2006
A Method and a Device for Applying a Protective Carbon Coating on Metallic Surfaces	719/MAS/1999	08/07/1999	211922	13/11/2007
A Process for the Preparation of Improved Alumina Based Abrasive Material, an Additive Composition and a Process for the Preparation of the Composition	122/MAS/2000	18/02/2000	198068	16/02/2006
A Process for the Production of Dense Magnesium Aluminate Spinel Grains	520/MAS/2000	06/07/2000	198208	16/02/2006
A Process for Preparing Ceramic Crucibles	806/MAS/2000	26/09/2000	207700	20/06/2007
An Improved Method for Making Honeycomb Extrusion Die and a Process for Producing Ceramic Honeycomb Structure using the Said Die	538/MAS/2001	03/07/2001	198045	13/01/2006
Device for Gas Dynamic Deposition of Powder Materials	944/MAS/2001	22/11/2001	198651	25/01/2006
A Process for Forming Coatings on Metallic Bodies and an Apparatus for Carrying out the Process	945/MAS/2001	22/11/2001	209817	06/09/2007
An Improved Boronizing Composition	289/MAS/2001	03/04/2001	220370	27/05/2008
Process for Carbothermic Reduction of Iron Oxide in an Immiscible Flow with Constant Descent in Vertical Retort of Silicon Carbide	546/CHE/2003	01/07/2003	205728	29/06/2007 (Dt. of Publication of Grant)
An Evaporation Boat useful for Metallization and a Process for the Preparation of Such Boats	882/CHE/2003	31/10/2003	201511	01/03/2007
Titanium Based Biocomposite Material useful for Orthopaedic and other Implants and a Process for its Preparation	2490/DEL/2005	14/09/2005	228353	03/02/2009
An Improved Method of Forming Holes on a Substrate using Laser Beams	3205/DEL/2005	29/11/2005	239647	29/03/2010
A Method of and an Apparatus for Continuous Humidification of Hydrogen Delivered to Fuel Cells	670/CHE/2007	30/03/2007	247547	22/04/2011 (Dt. of Publication of Grant)

Indian Patents Filed

Title of Patent	Patent Application No.	Date of filing
A Device for Controlling the On & Off Time of the Metal Oxide Semi Conductor Field Effect Transistor (MOSFET), A Device for Spark Coating the Surfaces of Metal Workpiece Incorporating the said Control Device and a Method of Coating Metal Surfaces using the said Device	1610/DEL/2005	21/06/2005
A Process for the Preparation of Nanosilver and Nanosilver-Coated Ceramic Powders	2786/DEL/2005	19/10/2005
Novel Ceramic Materials Having Improved Mechanical Properties and Process for their Preparation	3396/DEL/2005	19/12/2005
An Improved Process for the Preparation of Exfoliated Graphite Separator Plates useful in Fuel Cells, The Plates Prepared by the Process and a Fuel Cell Incorporating the Said Plates	1206/DEL/2006	17/05/2006
An Improved Hydrophilic Membrane Useful for Humidification of Gases in Fuel Cells and a Process for its Preparation	1207/DEL/2006	17/05/2006
An Improved Process for the Preparation of Doped Zinc Oxide Nanopowder useful for the Preparation of Varistors and an Improved Process for the Preparation of Varistors Employing the said Nano Powder	1669/DEL/2006	20/07/2006
An Improved Test Control System Useful for Fuel Cell Stack Monitoring and Controlling	1989/DEL/2006	06/09/2006
An Improved Process for Preparing Nano Tungsten Carbide Powder useful for Fuel Cells	81/DEL/2007	12/01/2007
A Hydrophilic Membrane Based Humidifier useful for Fuel Cells	95/DEL/2007	16/01/2007
Improved Fuel Cell having Enhanced Performance	606/DEL/2007	21/03/2007
An Improved Method for the Generation of hydrogen from a Metal Borohydride and a Device Therefor	1106/DEL/2007	23/05/2007
Improved Cylindrical Magnetron Cathode and a Process for Depositing Thin Films on Surfaces using the said Cathode	21/DEL/2008	03/01/2008
Improved Electrode Membrane Assembly and a Method of Making the assembly	631/DEL/2008	13/03/2008
An Improved Catalyst Ink useful for Preparing Gas Diffusion Electrode and an Improved PEM Fuel Cell	680/DEL/2008	18/03/2008
A Process for Continuous Coating Deposition and an Apparatus for Carrying out the Process	1829/DEL/2008	01/08/2008
An Improved Gas Flow Field Plate for use in Polymer Electrolyte Membrane Fuel Cells	2339/DEL/2008	13/10/2008
Improved Method of Producing Highly Stable Aqueous Nano Titania Suspension	730/DEL/2009	09/04/2009
Novel Copper Foils having High Hardness and Conductivity and a Pulse Reverse Electrodeposition Method for their Preparation	1028/DEL/2009	20/05/2009
An Improved method for preparing Nickel Electrodeposit having Predetermined Hardness Gradient	1455/DEL/2009	15/07/2009
An Improved Composition for Coating Metallic Surfaces, and a Process for Coating Such Surfaces using the Composition	620/DEL/2010	17/03/2010
An Improved Gas and Coolant Flow Field Plate for use in Polymer Electrolyte Membrane Fuel Cells	1449/DEL/2010	22/06/2010
Improved Process for the Preparation of Stable Suspension of Nano Silver Particles having Antibacterial Activity	1835/DEL/2010	04/08/2010
Improved Method for Producing Carbon Containing Silica Aerogel Granules	2406/DEL/2010	08/10/2010
Improved Scratch and Abrasion Resistant Compositions for Coating Plastic Surfaces, a Process for their Preparation and a Process for Coating using the Compositions	2427/DEL/2010	12/10/2010
An Improved Method for Producing ZnO Nanorods	2759/DEL/2010	19/11/2010
Improved Process for the Preparation of Bi-Functional Silica Particles useful for Antibacterial and Self Cleaning Surfaces	3071/DEL/2010	22/12/2010

Title of Patent	Patent Application No.	Date of filing
An Improved Method of Preparing Porous Silicon Compacts	912/DEL/2011	31/03/2011
An Improved Process for the Preparation of Nano Silver Coated Ceramic Candle Filters	1249/DEL/2011	28/04/2011
An Improved Abrasion Resistant and Hydrophobic Composition for Coating Plastic Surfaces and a Process for its Preparation	1278/DEL/2011	02/05/2011
An Improved Method for Making Sintered Polycrystalline Transparent Submicron Alumina Article	1358/DEL/2011	10/05/2011
An Improved Hybrid Methodology for Producing Composite Multi-Layered and Graded Coatings by Plasma Spraying Utilizing Powder and Solution Precursor Feedstock	2965/DEL/2011	17/10/2011
An Improved Composition for Solar Selective Coatings on Metallic Surfaces and a Process for its Preparation and a Process for Coating using the Compositions	3324/DEL/2011	22/11/ 2011
A Process and a Multi-Piston Hot Press for Producing Powder Metallurgy Components, such as Cerametallic Friction Composites	3844/DEL/2011	28/12/ 2011
A Novel Process for Producing IR Transparent Polycrystalline Alumina Articles and the Articles so Produced	365/DEL/2012	08/02/2012
A Process for Preparing Nano-Crystalline Olivine Structure Transition Metal Phosphate Materials	405/DEL/2012	14/02/2012

International Patents Granted

Title of Patent	Country	Patent Number	Date of Grant	Year of filing	Indian Patent Details
Process for Forming Coatings on Metallic Bodies and an Apparatus for Carrying out the Process	USA	US6893551B2	17/05/2005	2001	209817
A Process for the Preparation of Nano Silver and Nano Silver-Coated Ceramic Powders	South Africa	2006/8591	30/04/2008	2006	2786/ DEL/2005
	Sri Lanka	14258	02/11/2011	2006	
A Process for Continuous Coating Deposition and an Apparatus for Carrying out the Process	South Africa	2009/06786	26/05/2010	2009	1829/ DEL/2008
A Device for Controlling the On & Off Time of the Metal Oxide Semi Conductor Field Effect Transistor (MOSFET), A Device for Spark Coating the Surfaces of Metal Workpiece Incorporating the said Control Device and a Method of Coating Metal Surfaces using the said Device	USA	US8143550B2	27/03/2012	2006	1610/ DEL/2005

International Patents Filed

Title of Patent	Country	Patent Application No.	Year & Date of filing	Indian Patent Details
A Process for the Preparation of Nano Silver and Nano Silver-Coated Ceramic Powders	Indonesia	P-00200600616	2006	2786/DEL/2005
	Bangladesh	233/2006	2006	
A process for continuous coating deposition and an apparatus for carrying out the process	Germany	DE102009044256A1	2009	1829/DEL/2008
	United Kingdom	GB0917306.3	2009	
	USA	US20090579002	2009	
	France	FR0957102	2009	
	Japan	JP20090237921	2009	
	Brazil	BR2009PI04232A2	2009	
Improved Process for the Preparation of Stable Suspension of Nano Silver Particles having Antibacterial Activity	Under consideration	PCT/IN2011/000474	19/07/2011	1835/DEL/2010

Journal Publications by ARCI Personnel

1. B.M. Girish, K.R. Prakash, B.M. Satish, P.K. Jain and K. Devi, "Need for Optimization of Graphite Particle Reinforcement in ZA-27 Alloy Composites for Tribological Applications", Materials Science and Engineering A-Structural Materials Properties Microstructure And Processing, Vol. 530, p382-388, 2011.
2. M. Swathi, R. Papitha, U.S. Hareesh, B.P. Saha, R. Johnson and M. Vijayakumar, "Rheological Studies on Aqueous Alumina Extrusion Mixes", Transactions of the Indian Institute of Metals, Vol. 64(6), p 541-547, 2011.
3. G. Sivakumar, R. O. Dusane and S.V. Joshi, "In-Situ Particle Generation and Splat Formation during Solution Precursor Plasma Spraying of Yttria-Stabilized Zirconia Coatings", Journal of the American Ceramic Society, Vol. 94 (12), p 4191-4199, 2011.
4. E.D. Jeong, J.S. Jin, H.J. Kim, T.E. Hong, C.R. Cho, K.T. Lim, H.G. Kim and P.H. Borse, "Metal-Ion Dependent Band Energetics in $SrM_{0.5}Ti_{0.5}O_3$ (M=Ru, Rh, Ir, Pt, Pd) like Structures for Solar Applications", Journal of Ceramic Processing Research, Vol.12 (6), p 712-715, 2011.
5. S. Nirmala, Nitin. P. Wasekar, A.S. Joshi and G. Sundararajan, "A Virtual Instrument for Pulsed Electrodeposition: A Novel Technique for Obtaining Graded Coatings", Journal of Scientific and Industrial Research, Vol. 70(12), p 1026-1028, 2011.
6. N.D. Kumar, T. Rajasekharan, R.C. Gundakaram and V. Seshubai, "Extensive Nanotwinning: Origin of High Current Density to High Fields in Preform-Optimized Infiltration-Growth-Processed $YBa_2Cu_3O_7$-Delta Superconductor", IEEE Transactions on Applied Superconductivity, Vol. 21(6), p 3612-3620, 2011.
7. K. Rajeswari, M.B. Suresh, U.S. Hareesh, Y.S. Rao, D. Das and R. Johnson, "Studies on Ionic Conductivity of Stabilized Zirconia Ceramics (8YSZ) Densified through Conventional and Non-Conventional Sintering Methodologies", Ceramics International, Vol.37(8), p 3557-3564, 2011.
8. Neha Y. Hebalkar, S. Acharya and T.N. Rao, "Preparation of Bi-Functional Silica Particles for Antibacterial and Self Cleaning Surfaces", Journal of Colloid and Interface Science, Vol. 364(1), p 24-30, 2011.
9. S. Obara, T. Yamada, K. Matsumura, S. Takahashi, M. Kawai and B. Rengarajan, "Operational Planning of an Engine Generator using a High Pressure Working Fluid Composed of CO_2 Hydrate", Applied Energy, Vol.88(12), p 4733-4741, 2011.
10. G.V. Ramana, B. Padya, V.V.S. Srikanth, P. K. Jain, G. Padmanabham and G. Sundararajan, "Electrically Conductive Carbon Nanopipe-Graphite Nanosheet/ Polyaniline Composites", Carbon, Vol.49(15), p 5239-5245, 2011.
11. D. Chakravarty, H. Gokhale and G. Sundararajan, "Optimizing Mechanical Properties of Spark Plasma Sintered ZTA using Neural Network and Genetic Algorithm", Materials Science and Engineering A-Structural Materials Properties Microstructure and Processing, Vol.529, p 492-496, 2011.
12. I. Ganesh, "Fabrication of Near Net Shape Magnesium Aluminate (MgAl2O4) Spinel Components via Aqueous Processing", Advances in Applied Ceramics, Vol. 110(8), p 496-511, 2011.
13. S. Obara, S. Watanabe and B. Rengarajan, "Operation Planning of an Independent Microgrid for Cold Regions by the Distribution of Fuel Cells and Water Electrolyzers using a Genetic Algorithm", International Journal of Hydrogen Energy, Vol. 36(22), p 14295-14308, 2011.
14. V.S. Velan, G. Velayutham, Neha Y. Hebalkar and K.S. Dhathathreyan, "Effect of SiO_2 Additives on the PEM Fuel Cell Electrode Performance", International Journal of Hydrogen Energy, Vol.36(22), p 14815-14822, 2011.
15. G. Velayutham, "Effect of Micro-Layer PTFE on the Performance of PEM Fuel Cell Electrodes", International Journal of Hydrogen Energy, Vol. 36 (22), p 14845-14850, 2011.
16. K. Ramya, J. Sreenivas and K.S. Dhathathreyan, "Study of a Porous Membrane Humidification Method in Polymer Electrolyte Fuel Cells", International Journal of Hydrogen Energy, Vol. 36(22), p 14866-14872, 2011.
17. Y. Markandeya, K. Suresh and G. Bhikshamaiah, "Strong Correlation between Structural, Magnetic and Transport Properties of Non-Stoichiometric $Sr_2FexMo_{2-x}O_6$ ($0.8<=x<=1.5$) Double Perovskites", Journal of Alloys and Compounds, Vol. 509(40), p 9598-9603, 2011.
18. K. Murugan, T.N. Rao, G.V.N. Rao, A.S. Gandhi and B.S. Murty, "Effect of Dehydration Rate on Non-Hydrolytic TiO_2 Thin Film Processing: Structure, Optical and Photocatalytic Performance Studies", Materials Chemistry and Physics, Vol. 129(3), p 810-815, 2011.
19. K. Pattabiraman and K. Ramya, "Phosphotungstic Acid Modified Expanded PTFE based Nafion Composites", Journal of New Materials for Electrochemical systems, Vol.14(4), p217-222, 2011.

20. P.H. Borse, C.R. Cho, K.T. Lim, J.S. Bae, E.D. Jeong, T.E. Hong, H.J. Kim and H.G. Kim, “Effect of Co-Dopant Ratio (Cr/Fe) on Visible Light Photocatalytic Activity of Cr-Fe Co-Doped TiO_2 Nanoparticles”, Journal of Ceramic Processing Research, Vol. 12(5), p 592-598, 2011.
21. P.H. Borse, J.S. Jang, J.S. Lee, F.N. Khan, M.G. Ha, J.P. Kim, J.S. Bae, E.D. Jeong and H.G. Kim, “Enhanced Photocatalytic Properties due to Electron-Rich Ti-Ion Doping in $ZnFe_2O_4$ under Visible Light Irradiation”, Journal of the Korean Physical Society, Vol.59(4), p 2750-2755, 2011.
22. P. Sathiya, M.Y.A. Jaleel, D. Katherasan and B. Shanmugarajan, “Optimization of Laser Butt Welding Parameters based on the Orthogonal Array with Fuzzy Logic and Desirability Approach”, Structural and Multidisciplinary Optimization, Vol. 44(4), p 499-515, 2011.
23. I. Ganesh, “An Opinion on Conversion of Carbon Dioxide to Methanol using Solar Energy”, Current Science, Vol. 101(6), p 731-733, 2011.
24. I. Ganesh, “Conversion of Carbon Dioxide to Methanol using Solar Energy-A Brief Review”, Materials Science and Applications, Vol. 2, p 1407-1415, 2011.
25. D. Chakravarty, B.V. Sarada, S.B. Chandrasekhar, K. Saravanan and T.N. Rao, “A Novel Method of Fabricating Porous Silicon”, Materials Science and Engineering A-Structural Materials Properties Microstructure and Processing, Vol. 528(25-26), p 7831-7834, 2011.
26. V. Balek, T.N. Rao, D.A. Tryk and A. Fujishima, “Diffusion Structural Diagnostics of Polycrystalline Boron-Doped Diamond Films”, Thermochimica Acta, Vol. 524(1-2), p 104-108, 2011.
27. H.A. Colorado, S.R. Dhage and H.T. Hahn, “Thermo Chemical Stability of Cadmium Sulfide Nanoparticles under Intense Pulsed Light Irradiation and High Temperatures”, Materials Science and Engineering B-Advanced Functional Solid-State Materials, Vol. 176(15), p 1161-1168, 2011.
28. A. Kaniyoor, T.T. Baby, T. Arockiadoss, N. Rajalakshmi and S. Ramaprabhu, “Wrinkled Graphenes: A Study on the Effects of Synthesis Parameters on Exfoliation-Reduction of Graphite Oxide”, Journal of Physical Chemistry C, Vol. 115 (36), p 17660-17669, 2011.
29. M. Maidhily, N. Rajalakshmi and K.S. Dhathathreyan, “Electrochemical Impedance Diagnosis of Micro Porous Layer in Polymer Electrolyte Membrane Fuel Cell Electrodes”, International Journal of Hydrogen Energy, Vol. 36 (19), p 12352-12360, 2011.
30. R.V.R. Naidu, P. Hajra, A. Datta, S. Bhattacharya and D. Chakravorty, “Multiferroic Behavior in Composites of Nickel-Exchanged Glass Containing Nanoparticles of Barium Titanate”, Journal of the American Ceramic Society, Vol. 94(9), p 3006-3011, 2011.
31. B.Y. Sarada, K.S. Dhathathreyan and M. Ramakrishna, “Meliorated Oxygen Reduction Reaction of Polymer Electrolyte Membrane Fuel Cell in the Presence of Cerium-Zirconium Oxide”, International Journal of Hydrogen Energy, Vol. 36(18), p 11886-11894, 2011.
32. I. Ganesh, “Fabrication of Magnesium Aluminate (MgAl2O4) Spinel Foams”, Ceramics International, Vol. 37(7), p 2237-2245, 2011.
33. R.S. Kumar, U.S. Hareesh, P. Ramavath and R. Johnson, “Hydrolysis Control of Alumina and AlN Mixture for Aqueous Colloidal Processing of Aluminum Oxynitride”, Ceramics International, Vol. 37(7), p 2583-2590, 2011.
34. K. Valleti, A. Jyothirmayi, M. Ramakrishna and S.V. Joshi, “Influence of Substrate Temperature and Bias Voltage on Properties of Chromium Nitride Thin Films Deposited by Cylindrical Cathodic Arc Deposition”, Journal of Vacuum Science and Technology A, Vol. 29(5), p 051515, 2011.
35. L. Venkatesh, Naveen M. Chavan and G. Sundararajan, “The Influence of Powder Particle Velocity and Microstructure on the Properties of Cold Sprayed Copper Coatings”, Journal of Thermal Spray Technology, Vol. 20(5), p 1009-1021, 2011.
36. Nitin P. Wasekar, A. Jyothirmayi and G. Sundararajan, “Influence of Prior Corrosion on the High Cycle Fatigue Behavior of Microarc Oxidation Coated 6061-T6 Aluminum Alloy”, International Journal of Fatigue, Vol. 33(9), p 1268-1276, 2011.
37. K. Hembram, D. Sivaprahasam and T.N. Rao, “Combustion Synthesis of Doped Nanocrystalline ZnO Powders for Varistors Applications”, Journal of the European Ceramic Society, Vol. 31(10), p 1905-1913, 2011.
38. S. Obara, S. Watanabe and B. Rengarajan, “Operation Method Study based on the Energy Balance of an Independent Microgrid using Solar-Powered Water Electrolyzer and an Electric Heat Pump”, Energy, Vol.36(8), p 5200-5213, 2011.
39. B. Shanmugarajan, G. Padmanabham, H. Kumar, S.K. Albert and A.K. Bhaduri, “Autogenous Laser Welding Investigations on Modified 9Cr-1Mo (P91) Steel”, Science and Technology of Welding and Joining, Vol.16(6), p 528-534, 2011.
40. M. Masanta, S.M. Shariff and A.R. Choudhury, “A Comparative Study of the Tribological Performances

of Laser Clad TiB_2-TiC-Al_2O_3 Composite Coatings on AISI 1020 and AISI 304 substrates", Wear, Vol. 271(7-8), p 1124-1133, 2011.

41. Naveen M. Chavan, M. Ramakrishna, P.S. Phani, D.S. Rao and G. Sundararajan, "The Influence of Process Parameters and Heat Treatment on the Properties of Cold Sprayed Silver Coatings", Surface and Coatings Technology, Vol.205(20), p 4798-4807, 2011.
42. R. Sharma, S.V. Kamat, M. Srinivas, A.K. Singh and P.R. Rao, "Mixed Mode I/III Fracture Toughness in Extruded Magnesium Alloys", Materials Science and Engineering A-Structural Materials Properties Microstructure and Processing, Vol.528 (18), p 5875-5882, 2011.
43. K.M. Reddy, T.N. Rao and J. Joardar, "Stability of Nanostructured W-C Phases during Carburization of WO_3", Materials Chemistry and Physics, Vol. 128(1-2), p 121-126, 2011.
44. P.H. Borse, C.R. Cho, K.T. Lim, Y.J. Lee, J.S. Bae, E.D. Jeong and H.G. Kim, "Ratio Dependence of the Visible Light Photocatalytic Efficiency for $Zn_2Ti_{0.9}$CryFe[0.1-y]O_4: Cr/Fe ($0.02 < y < 0.08$) Photocatalyst Synthesized by using a Solid State Reaction Method", Journal of the Korean Physical Society, Vol. 59(1), p 65-70, 2011.
45. I. Ganesh, G.J. Reddy, G. Sundararajan, S.M. Olhero, P.M.C. Torres and J.M.F. Ferreira, "Hydrolysis-Induced Aqueous Gelcasting of Magnesium Aluminate Spinel", International Journal of Applied Ceramic Technology, Vol. 8(4), p 873-884, 2011.
46. A.S. Sharma, K. Biswas, B. Basu and D. Chakravarty, "Spark Plasma Sintering of Nanocrystalline Cu and Cu-10 Wt Pct Pb Alloy", Metallurgical and Materials Transactions A-Physical Metallurgy and Materials Science, Vol. 42A(7), p 2072-2084, 2011.
47. V. Udhayabanu, K.R. Ravi, K. Murugan, D. Sivaprahasam and B.S. Murty, "Development of Ni-Al2O3 In-Situ Nanocomposite by Reactive Milling and Spark Plasma Sintering", Metallurgical and Materials Transactions A-Physical Metallurgy and Materials Science, Vol.42A(7), p 2085-2093, 2011.
48. R. Mariappan, S. Kumaran, T.S. Rao and S.B. Chandrasekar, "Microstructure and Mechanical Properties of Duplex Stainless Steels Sintered in Different Atmospheres", Powder Metallurgy, Vol. 54(3), p 236-241, 2011.
49. M. Masanta, S.M. Shariff and A.R. Choudhury, "Evaluation of Modulus of Elasticity, Nano-Hardness and Fracture Toughness of TiB_2-TiC-Al_2O_3 Composite Coating Developed by SHS and Laser Cladding", Materials Science and Engineering A-Structural Materials Properties Microstructure and Processing, Vol.528 (16-17), p 5327-5335, 2011.
50. P. Ramavath, V. Mahender, U.S. Hareesh, R. Johnson, S. Kumari and N.E. Prasad, "Fracture Behaviour of Chemical Vapour Deposited and Hot Isostatically Pressed Zinc Sulphide Ceramics", Materials Science and Engineering A-Structural Materials Properties Microstructure and Processing, Vol.528(15), p 5030-5035, 2011.
51. S.R. Dhage, H.A. Colorado and T. Hahn, "Morphological Variations in Cadmium Sulfide Nanocrystals without Phase Transformation", Nanoscale Research Letters, Vol.6, Article No. 420, 2011.
52. P.H. Borse, C.R. Cho, K.T. Lim, Y.J. Lee, T.E. Hong, J.S. Bae, E.D. Jeong, H.J. Kim and H.G. Kim, "Synthesis of Barium Ferrite for Visible Light Photocatalysis Applications", Journal of the Korean Physical Society, Vol. 58(6), p1672-1676, 2011.
53. N. Jha, R.I. Jafri, N. Rajalakshmi and S. Ramaprabhu, "Graphene-Multi Walled Carbon Nanotube Hybrid Electrocatalyst Support Material for Direct Methanol Fuel Cell", International Journal of Hydrogen Energy, Vol. 36(12), p7284-7290, 2011.
54. S.V. Kamat, M. Srinivas and P.R .Rao, "Effect of Temperature on the Mode I and Mixed Mode I/III Fracture Toughness of SA333 Steel", Materials Science and Engineering A-Structural Materials Properties Microstructure and Processing, Vol. 528(12), p 4141-4146, 2011.
55. H.G. Kim, P.H. Borse, J.S. Jang, C.W. Ahn, E.D. Jeong and J.S. Lee, "Engineered Nanorod Perovskite Film Photocatalysts to Harvest Visible Light", Advanced Materials, Vol. 23(18), p 2088-2092, 2011.
56. P.S. Babu, B. Basu and G. Sundararajan, "The Influence of Erodent Hardness on the Erosion Behavior of Detonation Sprayed WC-12Co Coatings", Wear, Vol. 270(11-12), p 903-913, 2011.
57. D.S. Rao, K. Valleti, S.V. Joshi and G.R. Janardhan, "Processing-Structure-Property Relationships in Electron Beam Physical Vapor Deposited Yttria Stabilized Zirconia Coatings", Journal of Vacuum Science and Technology A, Vol. 29(3), Article No. 031501, 2011.
58. H. Lalhruaitluanga, M.N.V. Prasad and K. Radha, "Potential of Chemically Activated and Raw Charcoals of Melocanna Baccifera for Removal of Ni(II) and Zn(II) from Aqueous Solutions", Desalination, Vol.271(1-3), p 301-308, 2011.
59. S.M. Shariff, T.K. Pal, G. Padmanabham and S.V. Joshi, "Comparative Study on Dry Sliding Wear Behavior of Various Railroad Steels", Journal of

Tribology-Transactions of the ASME, Vol.133(2), Article No. 021602, 2011.

60. I. Ganesh, "Aqueous Slip Casting of $MgAl_2O_4$ Spinel Powder", Bulletin of Materials Science, Vol. 34(2), p 327-335, 2011.

61. I. Ganesh, G. Sundararajan, S.M. Olhero and J.M.F. Ferreira, "Influence of Chemical Composition on Sintering Ability of ZTA Ceramics Consolidated from Freeze Dried Granules", Ceramics International, Vol. 37(3), p 835-841, 2011.

62. A. Balakrishnan, C.L. Martin, B.P. Saha and S.V. Joshi, "Modelling of Compaction and Green Strength of Aggregated Ceramic Powders", Journal of the American Ceramic Society, Vol. 94(4), p1046-1052, 2011.

63. P. Sathiya, M.Y.A. Jaleel, D. Katherasan and B. Shanmugarajan, "Optimization of Laser Butt Welding Parameters with Multiple Performance Characteristics", Optics and Laser Technology, Vol. 43(3), p 660-673, 2011.

64. P. Ramavath, P. Biswas, R.S. Kumar, V. Mahendar, G.V.N. Rao, U.S. Hareesh, R. Johnson and N.E. Prasad, "Effect of Sphalerite to Wurtzite Crystallographic Transformation on Microstructure, Optical and Mechanical Properties of Zinc Sulphide Ceramics", Ceramics International, Vol. 37(3), p1039-1046, 2011.

65. U.S. Hareesh, R. Anantharaju, P. Biswas, K. Rajeswari and R. Johnson, "Colloidal Shaping of Alumina Ceramics by Thermally Induced Gelation of Methylcellulose", Journal of the American Ceramic Society, Vol. 94(3), p 749-753, 2011.

66. R. Dom, R. Subasri, K. Radha and P.H. Borse, "Synthesis of Solar Active Nanocrystalline Ferrite, MFe2O4 (M: Ca, Zn, Mg) Photocatalyst by Microwave Irradiation", Solid State Communications, Vol. 151(6), p 470-473, 2011.

67. S. Chatterjee, J.D. Majumdar, K. Singaiah, S.M. Shariff, G. Padmanabham and A.R. Choudhury, "Performance Evaluation of Laser Surface Alloyed Hard Nanostructured Al_2O_3-TiB_2-TiN Composite Coatings with In-Situ and Ex-Situ Reinforcements", Surface and Coatings Technology, Vol. 205(11), p 3478-3484, 2011.

68. T. Gururaj, R. Subasri, K.R.C. Somaraju and G. Padmanabham, "Effect of Plasma Pretreatment on Adhesion and Mechanical Properties of UV-Curable Coatings on Plastics", Applied Surface Science, Vol. 257(9), p 4360-4364, 2011.

69. I. Ganesh, G. Sundararajan and J.M.F. Ferreira, "Aqueous Slip Casting and Hydrolysis Assisted Solidification of $MgAl_2O_4$ Spinel Ceramics", Advances in Applied Ceramics, Vol. 110(2), p 63-69, 2011.

70. I. Ganesh and G. Sundararajan, "Novel Route to Beta-SiAlON-SiO_2 Ceramic Composites", Advances in Applied Ceramics, Vol. 110(2), p 87-94, 2011.

71. R. Kathiravan, R. Kumar, A. Gupta, R. Chandra and P.K. Jain, "Pool Boiling Characteristics of Multiwalled Carbon Nanotube (CNT) based Nanofluids over a Flat Plate Heater", International Journal of Heat and Mass Transfer, Vol. 54(5-6), p 1289-1296, 2011.

72. C.K. Subramaniam, C.S. Ramya and K. Ramya, "Performance of EDLCs using Nafion and Nafion Composites as Electrolyte", Journal of Applied Electrochemistry, Vol. 41(2), p197-206, 2011.

73. S.R. Dhage, H.S. Kim and H.T. Hahn, "Cu(In,Ga) Se-2 Thin Film Preparation from a Cu(In,Ga) Metallic Alloy and Se Nanoparticles by an Intense Pulsed Light Technique", Journal of Electronic Materials, Vol. 40(2), p 122-126, 2011.

74. B.M. Girish, K.R. Prakash, B.M. Satish, P.K. Jain and P. Prabhakar, "An Investigation into the Effects of Graphite Particles on the Damping Behavior of ZA-27 Alloy Composite Material", Materials and Design, Vol. 32(2), p1050-1056, 2011.

75. J.S. Jang, P.H. Borse, J.S. Lee, K.T. Lim, O.S. Jung, E.D. Jeong, J.S. Bae and H.G. Kim, "Photocatalytic Hydrogen Production in Water-Methanol Mixture over Iron-Doped $CaTiO_3$", Bulletin of the Korean Chemical Society, Vol.32(1), p 95-99, 2011.

76. K. Nischala, T.N. Rao and Neha Y. Hebalkar, "Silica-Silver Core-Shell Particles for Antibacterial Textile Application", Colloids and Surfaces B-Biointerfaces, Vol.82(1), p 203-208, 2011.

77. K. Murugan, S.B. Chandrasekhar and J. Joardar, "Nanostructured Alpha/Beta-Tungsten by Reduction of WO_3 under Microwave Plasma", International Journal of Refractory Metals and Hard Materials, Vol. 29(1), p 128-133, 2011.

78. S.S.J. Aravind, R.I. Jafri, N.Rajalakshmi and S. Ramaprabhu, "Solar Exfoliated Graphene-Carbon Nanotube Hybrid Nano Composites as Efficient Catalyst Supports for Proton Exchange Membrane Fuel Cells", Journal of Materials Chemistry, Vol.21(45), p 18199-18204, 2011.

79. K. Wegner, B. Schimmoeller, B. Thiebaut, C. Fernandez and T.N. Rao, "Pilot Plants for Industrial Nanoparticle Production by Flame Spray Pyrolysis", Kona Powder and Particle Journal, Issue: 29, p 251-265, 2011.

80. K. Murugan, T.N. Rao, K. Radha and H. Gokhale, "Microwave Plasma Process Optimization to Produce Nano Titania through Design of Experiments", Materials and Manufacturing Processes, Vol. 26(6), p 803-812, 2011.

81. I. Ganesh, "Development of β-SiAlON based Ceramics for Radome Applications", Processing

and Application of Ceramics, Vol. 5 (3), p113-138, 2011.

82. M. Chandra Sekhara Reddy, V. Vasudeva Rao, T.N. Rao and L. Syam Sundar, "Enhancement of Convective Heat Transfer Coefficient with TiO_2 Nanofluid in a Double Pipe Heat Exchanger", International Journal of Nanotechnology and Applications, Vol. 5, p 59-68, 2011.
83. B. Nagaraj, N.B. Krishnamurthy, P. Liny, T.K. Divya and D. Rangappa, "Biosynthesis of Gold Nanoparticles of Ixora Coccinea Flower Extract and their Anti-microbial Activities", International Journal of Pharma and Bio Sciences, Vol. 2(4), p 557-565, 2011.
84. P.K. Jain, B. Padya, P.S. Rao, K.M.K. Chowdary, B. Aswani Kumar and G. Anusha, "Thermal and Mechanical Properties of Multiscale Carbon Nanotubes and Carbon Fiber Reinforcement in Epoxy Hybrid Nanocomposites", Journal of Nanostructured Polymers and Nanocomposites, Vol. 7 (3), p 81-86, 2011.
85. K. Lalitha, G. Sadanandam, V.D. Kumari, M. Subrahmanyam, B. Sreedhar, Neha. Y. Hebalkar, "Highly Stabilized and Finely Dispersed Cu_2O/TiO_2: A Promising Visible Sensitive Photocatalyst for Continuous Production of Hydrogen from Glycerol: Water Mixtures", Journal of Physical Chemistry C, Vol. 114, p 22181-22189, 2011
86. K. S. Dhathathreyan, "Fuel Cell Development in India", The Journal of Fuel Cell Technology, Japan Special issue Vol.11(1), p 36-49, 2011
87. M. B. Suresh and R. Johnson, "Densification and Electrical Properties of Co-Doped Ceria Electrolyte for Intermediated Temperature Solid Oxide Fuel Cell Application", International Journal of Ionics (2011), DOI 10.1007/s11581-011-0633-4.
88. M. B. Suresh and R. Johnson, "Structural and Electrical Properties of Co-Doped Zirconia Electrolyte for Intermediate Temperature Solid Oxide Fuel Cell Application" International Journal of Energy Research (2011) – DOI: 10.1002/er.1943.
89. L. Sowntharya, S. Lavanya, G. Ravi Chandra, Neha Y. Hebalkar and R. Subasri, "Investigations on the Mechanical Properties of Hybrid Nanocomposite Hard Coatings on Polycarbonate", Ceramics International, Vol.38 (5), p 4221-4228, 2012.
90. K. Jeevajothi, D. Crossiya and R. Subasri, "Non-Fluorinated, Room Temperature Curable Hydrophobic Coatings by Sol-Gel Process", Ceramics International, Vol.38 (4), p 2971-2976, 2012.
91. D.B. Dhwajam, M.B. Suresh, U.S. Hareesh, J.K. Thomas, S. Solomon and A. John, "Impedance and Modulus Spectroscopic Studies on 40PrTiTaO(6)+60YTiNbO(6) Ceramic Composite", Journal of Materials Science-Materials in Electronics, Vol.23(3), p 653-658, 2012.
92. A. Venugopal, R. Panda, S. Manwatkar, K. Sreekumar, L. Rama Krishna and G. Sundararajan, "Effect of Micro Arc Oxidation Treatment on Localized Corrosion Behaviour of AA7075 Aluminum Alloy in 3.5% NaCl Solution", Transactions of Nonferrous Metals Society of China, Vol. 22(3), p 700-710, 2012.
93. D. Rangappa, K.D. Murukanahally, T. Tomai, A. Unemoto and I. Honma, "Ultrathin Nanosheets of Li_2MSiO_4 (M = Fe, Mn) as High-Capacity Li-Ion Battery Electrode", Nano Letters, Vol. 12(3), p 1146-1151, 2012.
94. R. Dom, G. Sivakumar, Neha Y. Hebalkar, S.V. Joshi and P.H. Borse, "Deposition of Nanostructured Photocatalytic Zinc Ferrite Films using Solution Precursor Plasma Spraying", Materials Research Bulletin, Vol. 47(3), p 562-570, 2012.
95. P. Sandhyarani, M.B. Suresh and R. Subasri, "Investigations on the Phase Stability of Na+-Conducting Sodium Dysprosium (Phospho) Silicates", Ceramics International, Vol. 38(2), p 1435-1440, 2012.
96. M.B. Suresh and R. Johnson, "The Effect of Strontium Doping on Densification and Electrical Properties of $Ce_{0.8}Gd_{0.2}O_2$-Delta Electrolyte for IT-SOFC Application", Ionics, Vol.18(3), p 291-297, 2012.
97. P.H. Borse, C.R. Cho, K.T. Lim, T.E. Hong, E.D. Jeong, J.H. Yoon, S.M. Yu and H.G. Kim, "Comparison of Zn_2TiO_4 and Rutile TiO_2 Photocatalysts for H_2 Production under UV and Near-Visible Light Irradiation", Journal of Ceramic Processing Research, Vol. 13(1), p 42-46, 2012.
98. J. Janaki, T.G. Kumary, N. Thirumurugan, A. Mani, A. Das, G.V.N. Rao and A. Bharathi, "Influence of Ni Doping on the Low Temperature Properties of Layered Fe1+Delta Te", Journal of Superconductivity and Novel Magnetism, Vol. 25(2), p 209-214, 2012.
99. D. Rangappa, S. Ohara, S. Takami, T. Naka, A. Kondo, M. Ishii, T. Kobayashi and T. Adschiri, "Preparation of Aqueous Dispersible Styrene-Maleic Amide Encapsulated $CoAl_2O_4$ Nanocrystals using Supercritical Water Flow Type Apparatus", Materials Research Innovations, Vol. 16(1), p 30-37, 2012.
100. R. Subasri, C.S. Madhav, K.R.C. Somaraju and G. Padmanabham, "Decorative, Hydrophobic Sol-Gel Coatings Densified using Near-Infrared Radiation", Surface and Coatings Technology, Vol. 206(8-9), p 2417-2421, 2012.

101. B.P. Vinayan, R. Nagar, V. Raman, N. Rajalakshmi, K.S. Dhathathreyan, S. Ramaprabhu, "Synthesis of Graphene-Multiwalled Carbon Nanotubes Hybrid Nanostructure by Strengthened Electrostatic Interaction and its Lithium Ion Battery Application", Journal of Materials Chemistry, Vol. 22(19), p 9949-9956, 2012.

102. I. Ganesh, "Hydrolysis-Induced Aqueous Gelcasting: The Latest Concept for Net-Shape Consolidation of Ceramics-A Review", Materials and Manufacturing Processes, Vol. 27(3), p 233-241, 2012.

103. J. Janaki, R. Govindaraj, T.G. Kumary, A. Mani, G.V.N. Rao and A. Bharathi, "Synthesis, Electrical Transport and Mossbauer Spectroscopy Study of the Layered Iron Tellurides Fe1.1-xNixTe", Physica Status Solidi B-Basic Solid State Physics, Vol. 249(1), p 134-137, 2012.

104. K.B. Jaimy, V.P. Safeena, S. Ghosh, Neha Y. Hebalkar and K.G.K. Warrier, "Photocatalytic Activity Enhancement in Doped Titanium Dioxide by Crystal Defects", Dalton Transactions, Vol. 41(16), p 4824-4832, 2012.

105. B.P. Vinayan, R.I. Jafri, R. Nagar, N. Rajalakshmi, K. Sethupathi and S. Ramaprabhu, "Catalytic Activity of Platinum-Cobalt Alloy Nanoparticles Decorated Functionalized Multiwalled Carbon Nanotubes for Oxygen Reduction Reaction in PEMFC", International Journal of Hydrogen Energy, Vol. 37(1), p 412-421, 2012.

106. K. Rajeswari, M.B. Suresh, D. Chakravarty, D. Das and R. Johnson, "Effect of Nano-Grain Size on the Ionic Conductivity of Spark Plasma Sintered 8YSZ Electrolyte", International Journal of Hydrogen Energy, Vol. 37(1), p 511-517, 2012.

107. S. Shalini, P. Sandhyarani, Y.S. Rao, D. Chakravarty and R. Subasri, "Wet Chemical Synthesis and Characterization of Na+-Conducting Sodium Dysprosium Silicates", Ceramics International, Vol. 38(1), p 295-300, 2012.

108. P. Sathiya, M.K. Mishra and B. Shanmugarajan, "Effect of Shielding Gases on Microstructure and Mechanical Properties of Super Austenitic Stainless Steel by Hybrid Welding", Materials and Design, Vol. 33, p 203-212, 2012.

109. I. Ganesh, A.K. Gupta, P.P. Kumar, P.S. Chandra Sekhar, K. Radha, G. Padmanabham and G. Sundararajan, "Preparation and Characterization of Fe-doped TiO_2 Powders for Solar Light Induced Voltage and Photocatalytic Applications", Processing and Applications of Ceramics, Vol.6 (1), p 21-36, 2012.

110. D.K. Das, S.G. Laxmi, D.S. Rao, S. Banumathy and A.K. Singh, "Microstructure, Texture and Thermal Cycling Performance of EBPVD TBC's Deposited under Different Processing Conditions", Journal of High Temperature Materials and Processes, Vol.30, p 539-548, 2012.

111. K. Valleti, C. Rejin and S.V. Joshi, "Factors Influencing Properties of CrN Thin Films Grown by Cylindrical Cathodic Arc Physical Vapor Deposition on HSS Substrates", Material Science and Engineering A, Vol. 545, p 155-161, 2012.

112. P. Sai Pramod, K. Valleti, M. Ramakrishna, K. V. Rajulapati, G. Ravi Chandra and S. V. Joshi, "Structure-Property Correlations in Cathodic Arc Deposited TiAlN Coatings", Material Science Forum, Vol. 702(3), p 967-970, 2012.

113. B.P. Saha, Vinoth Kumar, S.V. Joshi, A. Balakrishanan and C.L. Martin, "Investigation of Compaction Behaviour of Alumina Nano Powder", Powder Technology, Vol. 224, p 90-95, 2012.

114. P. Karthika, N. Rajalakshmi, R. Imran Jaffri, S. Ramaprabhu and K. S. Dhathathreyan, "Functionalised 2D Graphene Sheets as Catalyst Support for Proton Exchange Membrane Fuel Cell Electrodes", Advanced Science Letters, Vol. 4, p 01–06, 2012.

115. I. Ganesh, A.K. Gupta, P.P. Kumar, P.S.C. Sekhar, K. Radha, G. Padmanabham and G. Sundararajan, "Preparation and Characterization of Co-Doped TiO2 Materials for Solar Light Induced Current and Photocatalytic Applications", Materials Chemistry and Physics, Vol. 135, p 220-234, 2012.

116. G. Ravichandra and S.P. Pemmasani, "Characterization of Coatings by SEM based Microdiffraction", Materials Science Forum, Vol. 702(3), p 570-573, 2012.

117. L. Venkatesh, I. Samajdar, Manish Tak, G. Ravi Chandra and S.V. Joshi, "Process Parameter Impact on Microstructure and Phase Constitution of Laser Clad Inconel-Chromium Carbide Layers", Materials Science Forum, Vol. 702(3), p 963-966,2012.

118. S.M. Kumar, K. Murugan, S.B. Chandrasekhar, Neha Y. Hebalkar, M. Krishna, B.S. Satyanarayana and G. Madras, "Synthesis and Characterization of Nano Silicon and Titanium Nitride Powders using Atmospheric Microwave Plasma Technique", Journal of Chemical Sciences, Vol. 124 (3), p 557-563, 2012.

119. A. Venugopal, R. Panda, S. Manwatkar, K. Sreekumar, L. Rama Krishna and G. Sundararajan, "Effect of Microstructure on the Localized Corrosion and Stress Corrosion Behaviours of Plasma-Electrolytic-Oxidation-Treated AA7075 Aluminum Alloy Forging in 3.5wt.%NaCl Solution", International Journal of Corrosion, Article ID 823967, 2012.

120. I. Ganesh, A.K. Gupta, P.P. Kumar, P.S.C. Sekhar, K. Radha, G. Padmanabham and G. Sundararajan, "Preparation and Characterization of Ni-doped TiO2 Materials for Photocurrent and Photocatalytic Applications", The Scientific World Journal, p 01-06, Article ID: 127326, 2012.
121. I. Ganesh, "A Review on Magnesium Aluminate (MgAl2O4) Spinel: Synthesis, Processing and Applications", International Materials Reviews, DOI: 10.1179/174328042Y.0000000001.
122. M. Haritha, M. B. Suresh and R. Johnson, "Synthesis and Evaluation of Thermal, Electrical and Electrochemical Properties of $Ba_{0.5}Sr_{0.5}Co_{0.04}Zn_{0.16}Fe_{0.8}O_3$-d as a Novel Cathode Material for ITSOFC Applications", International Journal of Ionics, DOI 10.1007/s11581-012-0692-1.
123. Y.S. Bhagavatula, M.T. Bhagavatula and K.S. Dhathathreyan, "Application of Artificial Neural Network in Performance Prediction of PEM Fuel Cell", International Journal of Energy Research, DOI:10.1002/er.1870.
124. P. Biswas, M. Swathi, P. Ramavath, K. Rajeswari, M. B. Suresh and R. Johnson, "Diametral Deformation Behaviour and Machinability of MethylCellulose Thermal Gel Cast Processed Alumina Ceramics", Journal of Ceramics international, DOI: 10.1016/j.ceramint.2012.04.059.
125. I. Ganesh, P.S.C. Sekhar, G. Padmanabham and G. Sundararajan, "Influence of Li-Doping on Structural Characterization and Photocatalytic Activity of ZnO Nanopowder formed in a Novel Solution Pyro-Hydrolysis Route", Applied Surface Science, DOI: 10.1016/j.apsusc.2012.07.077.
126. G. Sundararajan, P. Biswas and N. Eswara Prasad, "Mechanical Properties of Transparent Polycrystalline Alumina Ceramics Processed using an Environmentally Benign Thermal Gel Casting Process", International Journal of Experimental Mechanics in special issue of Transparent Armour *(In Press)*.
127. S.R. Polaki, R. Ramaseshan, Feby Jose, N. Ravi, S. Dash and A.K. Tyagi, "Evaluation of Structural and Mechanical Properties of TiN Films on SS304 L Steels", Applied Ceramic Technology *(In Press)*.
128. R. Subasri, R. Malathi, A. Jyothirmayi and Neha Y. Hebalkar, "Synthesis and Characterization of CuO-Hybrid Silica Nanocomposite Coatings on SS 304", Ceramics International *(In Press)*.
129. S. Chaterjee, J.D. Majumdar, S.M. Shariff, G. Padmanabham and A.R. Choudhary, "Effect of Laser Post-Treatment on Al_2O_3-TiB_2-TiN Composite Coating with Free hBN", International Journal of Advanced Manufacturing Technology *(In Press)*.
130. K. Rajeswari, P. Biswas, M. B. Suresh, Dibakar Das, U. S. Hareesh and R. Johnson, "Colloidal Shaping of 8 mol% Yttria Stabilized Zirconia Electrolyte Honeycomb Structures by Microwave Assisted Thermal Gelation of Methyl Cellulose", International Journal of Applied Ceramic Technology *(In Press)*.
131. R. Johnson, P. Biswas, P. Ramavath, R.S. Kumar and G. Padmanabham, "Transparent Polycrystalline Ceramics: An Overview", Transaction of Indian Ceramic Society *(In Press)*.
132. A, Bhaskar, M. Deepa, T.N. Rao and U.V. Varadaraju "Enhanced Nanoscale Conduction Capability of a MoO_2/Grapheme Composite for High Performance Anodes in Li ion Batteries", Journal of Power Sources *(In Press)*.
133. K.R.C. Soma Raju, L. Sowntharya, S. Lavanya and R. Subasri, "Effect of Plasma Pretreatment on Adhesion and Mechanical Properties of Sol Gel Nano Composite Coatings on Polycarbonates", Composite Interfaces *(In Press)*.
134. Nirmal Kumar, A. Jyothirmayi, K.R.C. Soma Raju and R. Subasri, "Effect of Functional Groups (Methyl, Phenyl) on Organic-Inorganic Hybrid Sol-Gel Silica Coatings on Surface Modified SS316", Ceramics International *(In Press)*.
135. R. Papitha, M. B. Suresh, Dibakar Das and Roy Johnson, "Mineral Oxide Doped Aluminum Titanate Ceramics with Improved Thermo - Mechanical Properties", Journal of Ceramics *(In Press)*.

Publications by ARCI Personnel in Conference Proceedings

1. H. Purushotham and K. Madhuri, "Knowledge Management and Regulatory Issues-Key for Sustainable Development of Nanoscience and Technology in India", Proceedings of International Conference on Nanoscience Engineering and Technology (ICONSET- 2011), Chennai, (published by IEEE explore) p 78-83, 2011.

2. G.Venkata Ramana, Balaji Padya and P.K. Jain, "Surface Modification Effect on the Thermal and Mechanical Properties of MWCNT/Epoxy Nanocomposites", Proceedings of International Conference on Nanoscience Engineering and Technology (ICONSET-2011), Chennai, (published by IEEE explore), p110-114, 2011.

3. H. Purushotham, "A Frame Work for Knowledge Management of Nanoscience and Technology in India", Proceedings of International Conference on Nanoscience and Technology and Societal Implication (published by IEEE explore), p 01-05, 2011.

4. Sanjay Bhardwaj, G. Padmanabham, Karuna Jain and Shrikant Joshi , "Innovation Paradigms: Contractual Models for Research and Technology Organizations", Proceedings of IP for Development: The Emerging Paradigm published during the 1st International Conference on Management of Intellectual Property and Strategy (MIPS) 2012 (organized by IIT Bombay's SJM School of Management), p 462-471, 2012.

Chapters in Books by ARCI Personnel

1. I. Ganesh, P.S.C. Sekhar, G. Padmanabham and G. Sundararajan, "Preparation and Characterization of Li-Doped ZnO Nanosized Powder for Photocatalytic Application", a chapter in the book 'Photocatalytic Materials and Surfaces for Environmental Cleanup-II', Tramtech Publications-Switzerland *(In Press)*.

Conferences/ Workshops Conducted by ARCI

1. A business opportunity workshop on "Sol-Gel Nanocomposite Coatings for Diverse Applications" was organized at ARCI, Hyderabad on September 16, 2011.
2. International Conference on Nanoscience and Technology (ICONSAT-2012), organized by ARCI and sponsored by DST was held at Taj Krishna, Hyderabad during January 20-23, 2012.

Awards and Honours

1. Dr. T.N. Rao was conferred the 'The Federation of Andhra Pradesh Chambers of Commerce and Industry (FAPCCI) Excellence Award' by the honorable Chief Minister of Andhra Pradesh Sri N. Kiran Kumar Reddy at Hyderabad on July 28, 2011 in recognition of his contributions as an outstanding scientist or engineer for the benefit of industry, trade or agriculture.

2. Dr. K. Murugan won the 'Platinum Best Groups Award' at the Asia Nanotech Camp 2011 held at South Korea during August 15-28, 2011 for oral presentation of his work carried out at ARCI.

3. Dr. Roy Johnson and Dr. U.S. Hareesh were awarded the 'Malavya Award-2011' by the Indian Ceramic Society at the 'International Conference on Energy Efficient Materials and Manufacturing Methods and Machineries of Ceramic Industries (IC2E4MCI-11) and the Platinum Jubilee Annual Session of the Indian Ceramic Society' held at Agra during December 19-22, 2011 for contribution in the field of Ceramic Science and Technology.

4. Ms. Papiya Biswas was adjudged 2nd for oral presentation of her paper on "Methyl Cellulose based Gel Casting: An Energy Efficient and Environmentally Benign Process for the Shaping of Alumina" in the 'Platinum Jubilee Annual Session of the Indian Ceramic Society' held at Agra during December 20-22, 2011.

5. Dr. Roy Johnson was conferred the 'MRSI Medal' by the Materials Research Society of India at Patiala on February 13, 2012, in recognition of his contributions to the field of Materials Science and Engineering.

Dr. T. N. Rao receiving the FAPCCI Excellence Award from Honorable Chief Minister of Andhra Pradesh Shri N. Kiran Kumar Reddy

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OFFICERS ON DEPUTATION/LIEN TO OTHER ORGANIZATIONS

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Dr. K Ramya
Dr. Sanjay Dhage (till 29/09/2011)
Dr. Easwaramoorthi Ramasamy (till 29/09/2011)
Dr. T Mohan
Dr. K Suresh
Dr. Dinesh Rangappa
Dr. Raju Prakash (from 02/01/2012)
Dr. Rajappa Tadepalli (from 01/02/2012)