India: Crossroads of traditional and advanced ceramics

Although the sudden IT boom has diverted some skilled engineers and technical workers from more traditional fields of research to this new area of interest, many of India's historically recognized ceramic sectors are experiencing rapid growth and laying the foundation for market expansion.

By Alex Talavera and Randy B. Hecht

Within the international market, India is perhaps best known for the many professionals employed in the information technology industry. However, as its rise to prominence as a major player in the global economy gives birth to a huge new middle class in the world's second most populous country, consumer and industrial demands are sparking new growth in the traditional ceramics industries.

Advanced ceramics R&D related to, for example, energy and biomedical applications, is emerging in India. However, much of the research focus has been on traditional applications, such as whitewares and structural ceramics. Moreover, national institutes and some private companies are pursuing advanced research that is expected to change the landscape of India over the long term. On the other hand, for now, perhaps the most prominent sectors are industrial ceramics, particularly refractories, and glass.

"Presently, our country is pitching for improving the infrastructure sectors consisting of metallurgical, cement and thermal power plants; commercial and residential buildings; and roads and bridges. Therefore, the emphasis with regard to ceramics is on bulk refractory products based on silica, aluminosilicates, alumina, magnesia, spinel, silicon carbide, zircon(ia) and combinations thereof," says A.L. Shashi Mohan, president of the Indian Ceramics Society.


(Credit: InCerS.)

InCerS' Mohan

"As far as glass products are concerned, newer plants for float glass and container glass have sprung up and are springing up regularly to meet the demands of the growing middle-class population. Here, the trend seems to be toward green buildings and the like."

InCerS, an influential group within the nation's ceramics and glass communities for more than 75 years, is organized in 14 local chapters that include individuals and corporations among their members. InCerS sponsors a multiday annual national meeting. The chapters, depending on their size, host monthly or quarterly events that range from presentations by subject matter experts to forums in which university students and companies have an opportunity to interact. The goal is to promote networking and information sharing within the industry and to encourage a collaborative approach to seeking solutions to engineering challenges. In addition, InCerS works in association with other professional societies to "enthuse students to pursue careers in science and engineering," Mohan says. The organization does not have a formal program dedicated to encouraging interest in ceramics careers. However, Mohan says its members work individually to that end in anticipation of increased need for professionals as the industry continues to grow.

Refractories positioned for continued growth

India has seen a strong increase in demand in the areas of fired, nonfired and fusion-cast refractories for metallurgical, power and structural- and container-glass plants. The "significant upsurge" in refractories has been sparked by expansion in ironmaking and steelmaking as well as new thermal and nuclear power plants, Mohan says. "The only hitch is with regard to obtaining requisite land and environmental clearances." He notes that Greenpeace and other environmental activists have kept one nuclear power plant in the south of India dormant for almost a year.

"Refractories for metallurgical industries and power plants have the greatest scope for growth," he adds, citing such prominent companies—and InCerS members—as TRL Krosaki Refractories, Calderys India Refractories, Vesuvius India and IFGL Refractories. "All these have technical research and manufacturing collaborations with leading refractory makers from across the world."

Siddharth Kumar is president of ACE Calderys, which commands 40 percent of the monolithics market in India. The company produces and sells annually almost 185,000 tons, and Kumar anticipates continued growth over the next five years, predominantly in the area of aluminosilicates.

Most competing companies have a market share of 10–15 percent, and market growth will lead to some consolidation, he says. "Some has already happened. But, many companies are small, fragmented, family owned and may not be interested in consolidation.

From emerging market to economic powerhouse

India's economic growth spurt sets the stage for greater global opportunity.

By Alex Talavera and Randy B. Hecht

Any understanding of the Indian market must begin with comprehension of its size. The country is a behemoth by any demographic or economic measure. Its population, estimated in July 2012 at 1.2 billion people, represents approximately 17.1 percent of the entire population of the planet. Its active labor force alone is approximately 55 percent bigger than the total US population—487.6 million versus 313.8 million people.

Although a quarter of its population lives below the poverty line, the US State Department notes, "There is a large and growing middle class of more than 50 million Indians with disposable income ranging from 200,000 to 1,000,000 rupees ($4,166 to $20,833) per year. Estimates are that the middle class will grow tenfold by 2025." That upward mobility is expected to create a new demand for a wide variety of goods, including a large volume of ceramic products—beginning with household basics and, with increased economic growth, moving on to anything from high-end decorative glass and tile to medical and dental devices.

An example of the former was the subject of a recent *Harvard Business Review* online report. Author Alfredo Behrens observed that India "expects to see some 350–400 million people becoming urban residents in the next three decades. That could mean demand for as many as 150 million new toilets."

But, "the world demand and supply gap is daunting," writes Behrens, a professor of cross-cultural management at the Fundação Instituto de Administração in Sao Paolo, Brazil. His story noted, for example, that most of the 20 million toilet units produced each year by Kohler are "unsuitable for low-income markets" and that although India and China are undergoing a "reconversion from tile to ceramic sinks and toilets … Italy, first in tile sales, and the United Arab Emirates, first in tile volume, have yet to adjust." And that's just one marker of the approaching market opportunity, he added: "Additional demand for new toilets, and derived demand for raw materials and energy, is only the tip of the housing demand iceberg coming from emerging markets."

Building economic muscle

The Indian economy has thrived during the global economic crisis: Gross domestic product grew 6.6 percent in 2009, 10.6 percent in 2010 and 7.2 percent in 2011. Calculated on the basis of the official exchange rate, 2011 GDP was $1.676 trillion. However, economists often calculate "purchasing power parity GDP" as a more accurate gauge for comparing the economic performance of one country against that of another. The International Monetary Fund explains, somewhat longwindedly, that purchasing power parity GDP figures reflect "the rate at which the currency of one country needs to be converted into that of a second country to ensure that a given amount of the first country's currency will purchase the same volume of goods and services in the second country as it does in the first."

India's purchasing power parity GDP for 2011 was $4.515 trillion, or $3,700 per capita. This is the world's fourth highest for the year, after the European Union, the United States and China, and it is just ahead of Japan and Germany.

Industry occupies 14 percent of the workforce but generates more than 36 percent of GDP. Leading industries include textiles, chemicals, food processing, steel, transportation equipment, cement, mining, petroleum, machinery, software and pharmaceuticals. Services occupy 34 percent of the workforce and generate more than 56 percent of GDP. Agriculture, which employs 52 percent of the workforce, generates only 17 percent of GDP.

The trade perspective

The US is India's third-largest source of imports, second-largest market for exports and largest investment partner. "Principal US exports are diagnostic or lab reagents, aircraft and parts, advanced machinery, cotton, fertilizers, ferrous waste/scrap metal and computer hardware," the State Department reports. "Major US imports from India include textiles and ready-made garments, Internet-enabled services, agricultural and related products, gems and jewelry, leather products and chemicals." Indian export volume reached almost $300 billion in 2011, up from $225 billion in 2010, and imports increased to more than $461 billion in 2011 from $358 billion in 2010.

As these numbers demonstrate, the market opportunity is enormous, but so are the challenges. Among the constraints to economic growth cited by the State Department are "inadequate infrastructure, a cumbersome bureaucracy, corruption, labor market rigidities, regulatory and foreign investment controls, the 'reservation' of key products for small-scale industries and high fiscal deficits."

For guidance on competing successfully in India and connecting with local trading or business partners, contact the American Chamber of Commerce in India, the US India Chamber of Commerce, or the US India Business Council. Madhvi Kataria, deputy executive director of the American Chamber of Commerce in India, also recommends reviewing online guides to doing business in India published by Ernst & Young, KPMG, and HSBC, in partnership with PricewaterhouseCoopers.

Fortunately, the market is growing, so everyone is surviving."

Little research is done in areas other than monolithics, Kumar says. "Because even if [manufacturers] come out with some product, they fear that they will not be competitive on price—against China or other developing countries—or technology—against European countries. Even if they come up with a good product, it will not be economically viable. So I don't see much development on the basic refractory front, but for monolithics. Even our company is continuously engaged in [monolithics] development work."

One challenge the industry faces is obtaining a sufficient quantity and quality of some raw materials. Some shortages are creating a growing discussion about the need for synthetic raw materials.

Competition for talent also has posed some difficulties, but that is changing in response to the growth of the middle class and the resulting increased domestic demand for steel, concrete/cement and power. Kumar notes that as information technology triggered the first wave of India's emergence as a global economic power, most college graduates sought IT jobs. "Ceramic engineers were going for IT companies. Civil engineers, mechanical engineers—they were all looking for IT jobs. The last decade and a half, we were really facing a problem attracting good engineers," he says. The landscape changed as the ceramics sector's fortunes rose and companies in the industry could offer competitive salaries. "They are paying comparable to IT industry, if not better. Now we see some change, and people are now willing to continue in the ceramics industry. I think we will not have a problem of lack of talent in the field."

A broad range of research initiatives

Most ceramics research in India is conducted at publicly funded laboratories. "There is a vast scope for indigenous research and development work in our country," Mohan says. "The government, off and on, comes out with research-friendly policies like tax


(Credit: CGCRI.)

Founded in 1950, the Central Glass and Ceramic Research Institute in Kolkata (above) has been a hub for basic and advanced R&D projects.

exemptions and weighted deductions in tax for specified types of research and development."

India's Central Glass and Ceramic Research Institute, which has its roots in InCerS, established a Fuel Cell and Battery Division in 2004. Under the direction of scientist and division head Rajendra N. Basu, its primary areas of research focus are solid oxide fuel cells, lithium-ion batteries and mixed ionic- and electronic-conductor-based dense ceramic membranes for gas separation. Among the technologies that the division has developed or has under development include

- Anode-supported SOFC single cells of dimensions 10 centimeters × 10 centimeters × 1.5 millimeters;
- Indigenous design and fabrication of grooved bipolar plates, cell holders and current collectors and associated gas manifolding systems for SOFC stacks;
- Production of glass-based sealants for SOFC stacks;
- Demonstration of working SOFC short stacks (up to 10 cells);
- Nanocrystalline ceria-based electrolyte for low-temperature SOFC application;
- Development of nanomaterials for use as lithium-ion battery cathodes and anodes; and
- Fabrication/testing of coin-type SOFC cells.

Another center of research is the Indian Institute of Science, where Bikram Basu is an associate professor at the Materials Research Center and an associate faculty member in the Bio-Engineering Program. In addition to his research activities, he has served as lead author of books on structural ceramics and tribology. Both were published in 2011 by John Wiley & Sons in association with The American Ceramic Society.

For the past decade, Basu has been engaged in research intended "to bridge the gap between materials science and biological sciences to develop new biomaterials and to emerge with a comprehensive understanding of cell–material interactions at various length scales."

To date, the commercial potential of products developed as a result of his research has not been tested. "I have never tried to commercialize any of the products that have been developed in my laboratory," he says. "Our research is mostly academic-oriented research, but I lately have been collaborating with other research institutes, such as R&D labs."

Basu also is active in promoting increased interest in ceramics research in India and throughout the world. Since 2008, he has served as principal investigator of the Indo–US Science and Technology Forum-Funded Biomaterials Center and the UK–India Education and Research Initiative. He also has organized several international conferences held in India to promote the fields of biomaterials and nanoceramics.


(Credit: InCerS.)

Manocha

Lalit Manocha, professor of materials science at Sardar Patel University, calls bioceramics an up-and-coming area of focus in India, where implants, stents and other medical devices are attracting research interest. "It only started a couple of years back, and there is great interest in that from government, from [academic] institutions and from industry," he says.

Manocha continues, "Another area of R&D is high-performance ceramics, carbon oxide and composite materials. Professor Satish Manocha, who happens to be my wife, is working on solder processing of advanced ceramics and high-temperature ceramic foams. There's a lot of work that has been done on ceramic membranes, and we have industries manufacturing these membranes. The Ceramic Research Institute and National Institute for Interdisciplinary Science and Technology laboratories also have developed technologies for ceramic membranes. These are supported by government research and development programs. The technology has gone to industries that are producing ceramic membranes, which are being used for water purification. These water purification units are being supplied to the villages."

(Credit: InCerS.)

Celebrants at InCerS' Platinum Jubilee included two ACerS members, Jay Singh (fourth from left) and Arun Varshneya (fourth from right).

Those partnerships reflect a high awareness of the value of knowledge sharing, Manocha adds. The Indian government, institutes and industry are all interested in opportunities for collaboration with other countries on research and development in advanced ceramics.

Traditional ceramics power export growth

All of this is in addition to expansion of whitewares, sanitarywares and wall and floor tile—areas of ceramics in which exports are on the rise. Organizers of Ceramics Asia 2012—which will be held December 13–15 at the Gujarat University Exhibition Center in Ahmedabad—note that India ranks third in the world in production and consumption of ceramic tile. According to the event's website, India's ceramic tile production volume grew more than 25 percent in 2009. In 2010, the country's total ceramic production accounted for 6 percent of global output.

Lalit K. Sharma is the Central Glass & Ceramic Research Institute's scientist in charge and chair of the Western Uttar Pradesh Chapter of the Indian Ceramic Society. He says the global market for Indian tile, including those of traditional handcrafted design, has been so great that Indian companies have opened showrooms in countries as distant as Australia and Canada. Sharma adds that India made its entry into this area of international trade by offering a quality and price advantage over Chinese products. However, the industry now is pursuing technological upgrades so that Indian companies are not forced to compete largely on price.

Manocha reinforces this point and notes that, for example, many Indian companies are collaborating with Italy to improve the glazes they use. "The tile industry in India is working at both ends—that is, economical tile as well as the advanced tile with good glazes and coatings," he says. "[More than] 75 percent of Indian tile are exported to more than 70 countries, so there is a lot of effort going on in traditional ceramics for improvements."

Overall, the industry's prospects continue to evolve. Right now, the opportunities are in large part being driven by the steel or concrete/cement producing industries. Mohan says it will be some years before India will be prepared to commercialize most of the advanced ceramic research now underway. However, the country is making a significant commitment to engaging in that research now to establish a foundation for further expansion of the ceramics industry as India's economic fortunes and commercial demands advance. ■

Indian ceramics trade snapshot

CG&CRI scientist Lalit K. Sharma, who also is chair of the Western Uttar Pradesh Chapter of InCerS, reports that India is self-sufficient in terms of domestic availability of a wide range of raw materials. These include clays, feldspar, quartz, silicon carbide, silicon, bauxite, dolomite, liquid gold and silver, zirconia, zircon, mullite, aluminum oxide, magnesite, chromite, talc, wollastonite, calcite, fluorspar, kyanite, sillimanite, gypsum, titanium dioxide, limestone, fused aluminas and traditional fire refractory raw materials such as fire clays.

The country's ceramics exports include super refractories to the Middle East; sanitarywares to the Middle East and Asia; alumina ceramics to Europe; wall and floor tile to the Middle East, Australia, Europe and Canada; porcelain laboratorywares to the United States; and ferrites and ceramic tablewares throughout the world.

On the other side of the equation, Sharma notes that India faces a scarcity of lithium feldspar, which it imports from China; spodumene, which it imports from Australia; and microsilica and high-quality refractory high-alumina cements, which it imports from Germany.

He adds that India is not engaged to any large degree in the manufacture of nanoceramic powders, electronic substrates, bioceramics, recrystallized alumina products, solid oxide fuel cells, bulletproof armors, aerospace ceramics, special ceramic pastes and automobile emission filters.

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A brief history and overview of The Indian Ceramic Society

The founding and growth of The Indian Ceramic Society have been profound.

The long cooperative history between InCerS and The American Ceramic Society—although they are separated by thousands of miles—is one that may be largely unknown to the worldwide ceramics community.

The concept of a society for Indian ceramists began to percolate as early as 1921 as documented in letters circulated by Sardar Krishan Singh. As a result, a fledgling group was formed.

Although the idea for a society did not soar immediately, it gained new life after T.W. Talwalkar visited the United States and learned about the success of ACerS. When he returned to India in 1927, he became a strong advocate for a similar type of organization in India. Talwalkar met with Singh and several others, including Sardar Dogar Singh and Mulkh Raj. Together, they reached out to others in the pottery, glass, enamel, ceramics, refractories and allied disciplines. They used the organizational structure and reach of ACerS as a model.

There were initial difficulties in generating a "critical mass" to launch a society. However, the above-mentioned forefathers—whose names are revered in InCerS like those of Edward Orton and Ross Purdy are within ACerS—and others coalesced personal and organizational commitments of support for a founding meeting. In a show of support, the India Glass Manufacturers Association agreed to hold one of its sessions at a concurrent time and location.

On April 15, 1928, a three-day inaugural meeting of The Indian Ceramic Society was held at Banarus Hindu University, located in Varanasi, Uttar Pradesh. Although only 26 people attended this first meeting, they represented ceramic interests from across the nation. The group also was buoyed by communications of support from 22 other ceramists. This group of 48 became the founding nexus of InCerS. Besides participating in the detailed work of establishing a formal organization, all participants were excited about elevating ceramic practices and profes-

India ceramics directory and profiles

By Alex Talavera and Randy B. Hecht

The following is only a partial list of the many private companies, institutions and research centers in India, and is only meant to provide a representative sample

BUSINESSES

Alumina Chemicals & Castables

Website: www.aluminachem.com
E-mail: response@aluminachen.com
Phone: 2769 6595 / 65134020 / 65101490
Fax: (022) 27602424
Address: Plot R-32, MIDC, TTC Industrial Estate, Rabale Telephone Exchange Lane, Thane - Belapur Road, Navi Mumbai 400 701, Thane (Maharashtra), India

Bharat Heavy Electricals Limited★

Website: www.bhel.com/home.php
E-mail: contactio@bhelindustry.com
Phone: +91 11 66337000
Fax: +91 11 26493021; +91 11 26492534
Address: BHEL House, Siri Fort, New Delhi 110049, India

Ceramic Technological Institute, a corporate R&D wing of Bharat Heavy Electricals Ltd., is engaged in industrial process and product development for ceramic products connected with energy and environment; microwave drying and sintering of large ceramic products; porous ceramics for thermal power plant pollution control; nanomaterials synthesis and application development program. areas of focus include high density hot pressed boron carbide components and such advanced materials as alumina, borides, carbides and spinel.

Bhaskar Refractories & SW Pipes Ltd.

Website: www.tradeindia.com/
Contact: Vibhu N. Bhaskar (MD)
Phone: +91-129-2275221/2257033
Fax: +91-129-2257033
Address: Bhaskar Estate, 20th km, Mathura Road, Amar Nagar, Faridabad 121 003 (Haryana), India

Boron Carbide (India) Ltd.

Website: www.b4cind.in/B4C-Division.html
E-mail: info@b4cind.in
Phone: +91-22-40649000
Fax: +91-22-66920604-05
Address: 8th Floor, 'Bhukhanvala Chambers'
Plot No. B-28, Veera Industrial Estate,
Veera Desai Road Extension,
Off. Link Road, Andheri (West), Mumbai 400 053, India

Boron Carbide is a wholly-owned subsidiary of The Bhukhanvala Group, which began operation in 1970 as a small tool manufacturing workshop and grew into one of the largest diamond tool manufacturers in the world. The company's core strength today is in advanced materials technologies used throughout the manufacturing sector, including cold and hot pressing of materials, design and precision engineering.

Bhukhanvala is India's only manufacturer of boron carbide powder and is a leading supplier of nuclear grade boron carbide to Indian power companies and government agencies. Its nuclear grade boron carbide powder is compliant with ASTM C 750 specifications. The company also is the leading supplier of hot pressed and sintered boron carbide neutron shielding components to the India's nuclear program. The website describes these components as "manufactured using highly controlled manufacturing processes with high purity formulations" and notes, Our process allows us to make complex shapes to meet even the most challenging design requirements. Our modular design and manufacturing process allow us to make customized designs even in low volumes."

Additional areas of focus include high density hot pressed boron carbide components and such advanced materials as alumina, borides, carbides, and spinel.

Calderys India Refractories Ltd. (Calderys India)

Website: www.calderys.co.in

Calderys India's network includes manufacturing plants in Katni (Madhya Pradesh) and Nagpur (Maharashtra), 14 manufacturing partners, 68 distributors. *See the main article for information about refractory trends in India and insights from the company president.* In addition to its manufacturing work, Calderys has developed an international refractory training program called Calderys Academy.

CUMI Carborundum Universal Ltd.

Website: www.cumi-murugappa.com/refractories
E-mail: cumiref@cumi.murugappa.com
Phone: +91 44 39813301 / 02 / 03 / 04 / 05 / 06
Address: 105, Sreela Terrace, III Floor, Western Side, Gandhi Nagar I Main Road, Adyar, Chennai 600 020, India

CUMI Super Refractories specializes in the manufacture of both fired and monolithic refractories for industrial applications. The industrial segments it serves include ceramics, carbon black, cement, glass, chemical process, sponge iron, non-ferrous, iron and steel, and foundry. Its products conform to ISO 9001 standards. The company's primary fired product lines are silicon carbide, nitride bonded silicon carbide, mullite and zircon-mullite, high alumina, and insulating fire bricks. Monolithic product lines include conventional, low cement, insulation, and self-flow castables; gunning materials; ramming masses; and laying mortars.

Dileep Ceramics Pvt. Ltd.

Website: www.dileep.in
E-mail: dtc@dileep.in
Phone: +91-141-3075806
Fax: +91-141-2552599
Address: 618, Mahaveer Nagar, Tonk Road
Jaipur 302 018, India

sions. Participants in the first meeting also found time to absorb the presentation of six technical papers delivered during the proceedings.

The original group also had a broad vision for the group. The founding documents of this meeting note that the purpose of InCerS would be:

> "To promote friendship and cooperation between all those who are engaged in the manufacture of ceramic goods or in teaching ceramics or in any way connected with ceramics and interested in the advance of the knowledge, art and technology connected therewith. Through such cooperation, the Society aims at improving the condition of the ceramic industries of India and also to add to the general knowledge of ceramics of the world."

Quickly, InCerS leaders targeted three key activities for the Society: start a journal; establish a central library and museum; and form a standing committee to advise universities about the professional and technical requirements needed by industry.

InCerS leaders also added to this list of duties the need to hold annual general and sectional meetings.

InCerS launched its first journal in 1928. Talwalkar was the initial editor.

The next decade, however, was a struggle for survival for InCerS while enthusiasm waxed and waned. Fortunately, a lifeline of support that would be crucial arrived with the creation of the Department of Ceramic Technology at Banarus Hindu University. Moreover, Pandit Madan Mohan Malaviya and N.N. Godbole provided important support for ceramics and the Society at BHU at Varanasi. The former is considered to be the main architect for establishing BHU, and the latter was the university's pro-vice-chancellor at the time.

Fortunately, this new department at BHU flourished and did pioneering work with its sister Department of Glass Technology. The staff at BHU, especially H.N. Roy, relaunched the organization under the name "BHU–Indian Ceramic Society." Roy agreed to take over the work of revitalizing the Society. In 1941, its official headquarters was transferred from Talwalkar's residence in Jamshedpur to BHU. InCerS held its fifth annual meeting a few months later, an event attended by 94 members, which was a remarkable number for that time.

Besides the growing number of meeting attendees, InCerS received an important financial boost when several members, including Talwalkar, stepped forward to offer payment for "life membership" in the organization. These funds created a valuable endowment for the Society to achieve its goals of maintaining a journal and setting up a library. Indeed, the group launched the library in 1942 at its offices in BHU.

In 1947, BHU made a generous donation to the Society that allowed the construction of a new building for the group's library and museum, which continue in operation today.

An important event helped InCerS establish itself in the minds of its members and the broader scientific community. In 1943, the government of India proposed the creation of a national glass research institute. Talwalkar and others within the Society launched an effort to convince the government to instead create a "silicate research institute" that would encompass all branches of pottery, enamel, cement, refractories and glass. They and H.K. Mitra drew up plans for a Ceramic Research Institute that would be located in Calcutta, a site that would place it close to key industries and universities. The government's Board of Scientific and Industrial research approved Talwalkar and Mitra's proposal after considerable lobbying for the concept. Thereafter, the Board facilitated the launching of the Central Glass & Ceramic Research Institute at Calcutta (now Kolkata) in 1950. Society leaders shifted the headquarters of InCerS to CG&CRI in 1958.

InCerS continued a sure and steady growth in the subsequent years. Annual meetings have been held uninterrupted since 1941. The Society celebrated its Silver Jubilee in 1953 and its Golden Jubilee in 1978. The latter was attended by then prime minister of India, Shri Morarji Desai.

In 2011, InCerS celebrated its Platinum Jubilee, a huge event that honored two luminary leaders within ACerS: Mrityunjay Singh and Arun Varshneya.

Several other important events are worth noting with regard to the history of InCerS.

In 1975, InCerS wanted to leave its stamp on the growing ceramic education establishment in the nation and, therefore, helped in the birth of the Indian Institute of Ceramics. The Institute was launched to fill the pressing need for adequately trained and certified ceramic personnel for employment in industry and R&D settings. The immediate goal of the IIC was to establish criteria for degrees in ceram-

India ceramics directory and profiles, continued

Saint-Gobain Glass India Ltd.
Website: http://in.saint-gobain-glass.com
Phone: +91-44-4953 6021
Fax: +91-44-4953 6008
Address: Sigapi Aachi Building, Flr No 7, 18/3, Rukmani, Lakshmipathy Rd., Egmore, Chennai 600 008, India
SGGI is a subsidiary of Compagnie de Saint-Gobain. It manufactures and markets a wide variety of flat glass products and solutions. It started its operations in 2000 with the commissioning of the first float glass plant.

SEPR Refractories India Ltd.
Website: www.sparklerceramics.com
E-mail: mktg.seprindia@saint-gobain.com
Phone: +91 491 3080333
Fax: +91 491 3080354
Address: P B No 1, Kanjikode (West) PO, Palakkad 678 623 (Kerala), India
SEPR Refractories India Limited is a subsidiary of Saint-Gobain SEFPRO. It manufactures fused cast refractories for glass furnaces. SEPR India came into being in 2002 by acquiring the fused cast business from Carborundum Universal. It also manufactures wear-resistant fused cast materials, sintered refractories and monolithics.

Sparkler Ceramics Ltd.
Website: www.sparklerceramics.com
E-mail: piezo@sparklerceramics.com
Phone: +91-20-27130956, 27130275
Fax: +91-20-2713 0955
Address: J-508, MIDC, Bhosari, Pune 411 026 (Maharashtra), India
Sparkler Ceramics launched its commercial production in 1994 and is the largest manufacturer of piezoelectric elements in South Asia. Its manufacturing focus is on lead zirconate titanate and lead titanate-based piezoelectric elements and devices. ISO 9001-2000 certified and 9001-2008 registered, the company manufactures five grades of piezoelectric materials.

Sur Industries Ltd.
Phone:+91 22848463
Address: 163, A J C Bose Road,1st Floor, Entally, Kolkata 700 014, India

TRL Krosaki Refractories Ltd. (formerly Tata Refractories Ltd.)
Website: www.tataref.com
E-mail: infodesk@larsentoubro.com
Phone: 033-64990527
Fax: 033-22881063/1065
Address: Tata Center, 11th Floor, 43 J.L. Nehru Road, Kolkata 700 071, India

W.S.Industries Ltd.
Website: www.wsinsulators.com
E-mail: sales@wsinsulators.com
Phone: +91 665 00 723
Fax: +91 665 00 882
Address: 108, Mount Poonamallee Road, Porur, Chennai 600 116, India

INSTITUTES AND UNIVERSITIES

Anna University Chennai
Website: www.annauniv.edu/ceramic/index.html
Contact: P. Manohar
Phone: +91 044-2235 9181
Address: Department of Ceramic Technology, Alagappa College of Technology, Sardar Patel Road, Guindy, Chennai 600 025, India
Established in 1978, the University has established an extensive network that encompasses Indian industries, national research laboratories, and international universities that allow faculty and students to remain up to date with emerging technologies. The Department of Ceramic Technology's mission is "to serve as a resource centre for Ceramic Science and Technology and to stimulate R&D activities in the technological and commercial development of new products and processes, useful for the Indian Ceramic and allied industries." Its areas of focus include structural ceramics, electronic ceramics, magnetic ceramics and bioceramics. The department's activities and areas of study led to its elevation to the status of Centre for Ceramic Technology. The department also has organized 15 national or international conferences, seminars and workshops and has produced 50 research papers that have been published in national and international journals.

ARCI: The International Advanced Research Centre for Powder Metallurgy and New Materials
Website: www.arci.res.in/ccp/index.html
E-mail: info@arci.res.in
Phone: +91-40-24457104, 24457105
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ARCI describes itself as "striving to bridge the gap between conventional research institutes and laboratories and the high-technology industries." Its areas of focus include developing high performance materials and processes for niche markets; demonstrating prototype or commercial-intent technologies; transferring technologies to Indian industry; and establishing jointly operated demonstration centers with foreign partners to showcase emerging technologies.

The organization maintains Centres of Excellence for nanomaterials, engineered coatings, ceramic processing, laser processing of materials, non-oxide ceramics, materials characterization, fuel cell technology, sol-gel coatings, carbon materials, automotive energy materials, solar energy materials, and technology acquisition, transfer and international cooperation.

The Centre for Ceramic Processing is dedicated to advancing processing techniques for technology oriented advanced ceramics product development. Major areas of focus have included ceramic honeycombs for a variety ics technology and testing for associate membership in the academic institute.

After a few short-lived publishing attempts during its earliest years, InCerS launched its current technical journal, *Transactions of the Indian Ceramic Society*, in 1941. *Transactions* is currently published quarterly from InCerS headquarters, and it maintains an international editorial board. *Transactions* began to receive coverage in *Thompson Reuters' Science Citation Index* beginning in 2007.

As ACerS did for the United States, InCerS has opened opportunities to a galaxy of ceramic scientists, technologists and industrialists in India to share their experiences and mutual understandings. Today, the organization has more than 2,000 members, including foreign members, who benefit from access to its periodicals and books, meetings and expositions, and special technical information. Like ACerS, the members of InCerS comprise a wide variety of individuals and interest groups that include scientists, engineers, researchers, manufacturers, plant personnel, educators, students, marketing and sales professionals, and others in related materials disciplines.

InCerS believes that its efforts, combined with those of the IIC and the CG&CRI, have made a major difference in the progress of the ceramics industry in India.

The ties between InCerS and ACerS go back 90 years, and warm and cooperative ties continue. Therefore, the two organizations have recently completed a formal collaborative agreement that includes

- Exchange of complimentary memberships for the executive leaderships of InCerS and ACerS;
- Special discount electronic ACerS membership for current InCerS members, which will provide online access to ACerS services, publications, directories and listings, plus discounts on ACerS books and other publications;
- ACerS membership in InCerS at a membership fee one-half of the normal annual amount;
- Exchange of technical articles and reporting on broad topics in ceramics and glass between ACerS's *Bulletin* and Ceramic Tech Today blog and InCerS's *Transactions*;
- Exchange and posting of topical and timely information on each other's websites. ■

★ACerS Corporate Member

of applications, low and high alumina refractory cements, spinel aggregates, crucibles for carbon and sulphur analysis, and furnace coats and sealants.

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Registered as a Ministry of Information Technology Scientific Society, CMET's objective is to establish technology strength in electronics materials to meet current and emerging industrial needs. It maintains three laboratories, described on CMET's website as follows:

CMET Hyderabad is involved in development as well as scaling up of operations for production of high purity metals, alloys, special dopants and semiconductor materials. The gamut of operations required in purification process includes hydrometallurgy, pyrometallurgy, vacuum metallurgy, electro-metallurgy, zone refining, and electron beam melting. It also requires very advanced methods of analyzing the impurities in ppm/ppb level employing emission spectrography, atomic absorption spectrometry and mass spectrometry. To utilize national mineral resources in the most optimum manner, CMET Hyderabad plans to take up development activities for process technologies for high purity metals like indium, gold, tantalum, arsenic, gallium, bismuth, tellurium, selenium and cadmium.

CMET Pune is engaged in development of thick film materials for hybrids and surface mounted devices, specialty polymers like photoresists, polymides and conducting polymers, nano optical glass ceramics, and basic chemicals. CMET Thrissur is working on preparation of fine powders of electronic ceramics like titanates, zirconates, alumina and ferrites and their procesing to make substrates, MLCs and chip inductors using high tech ceramic processing.

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Inaugurated in 1950, the Central Glass and Ceramic Research Institute's mission is "to provide scientific industrial research and development in the area of glass, ceramics and related materials that maximizes the economic, environmental and societal benefit for the people of India." Its objectives, outlined on its website, are to:

- Carry out basic and applied research in the fields of glass, ceramics, refractories, vitreous enamels, composites and allied materials that can be developed into appropriate technologies relevant to the country's security, economic, industrial and socio-economic needs;
- Undertake advanced R&D projects which are internationally competitive and public-private partnership projects sponsored by private/public sector enterprises; and
- Provide technical advisory and infrastructural services like project engineering, testing and evaluation, training & education and dissemination of scientific information. The website contains more information on CG&CRI's contributions to the development of the following products:

- Specialty glasses and glass coatings for plasma displays
- Ceramic biomedical and orbital eye ball implants
- Silicon nitride balls for hybrid ceramic metal bearing
- Porous SiC ceramic material using biomimetic route for application in hot gas cleaning
- Hard and abrasion resistant coating
- Sol-gel based products
- Technology for arsenic and iron removal from groundwater
- Ceramic membrane based pretreatment system for BRWO/SWRO Plants
- Solid oxide fuel cells
- Erbium doped fibre amplifiers
- Synthetic refractory aggregates
- LPG and CNG sensors
- Low-cost vitrified ceramic tile
- Value-added refractory products from Indian bauxite

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IMMT "specializes in providing R&D support for process and product development with special emphasis on conservation and sustainable utilization of natural resources." Its science and technology expertise spans diverse areas, from mineralogy to materials engineering, and the laboratory has explored mining and mineral/

biomineral processing, metal extraction and materials characterization, process engineering, industrial waste management, pollution monitoring and control, marine and forest products development, utilization of medicinal and aromatic plants and appropriate technologies for societal development. The Advanced Materials Department "has designed and developed extended transferred arc plasma reactors for melting, smelting, carbide synthesis etc. and extended non-transferred arc in-flight plasma reactor for dissociation of minerals, spheroidization of materials." Areas of research listed on its website include thermal and RF plasma synthesis of structural and advanced ceramics; preparation and characterization of fine and ultra fine powders; smelting reduction, composite materials; and ceramic slurry processing, gel casting and direct coagulation casting waste utilization.

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The Dalmia Institute of Scientific & Industrial Research conducts fundamental and industrial research in refractory, cement and waste utilization on a contract basis. Refractory research includes silica refractories, high-alumina, magnesia, magnesia-chrome, magnesia-carbon, alumina-carbon, alumina-magnesia-carbon qualities. Cement research includes development of portland and high-alumina cement. Waste utilization includes sponge iron waste and other industrial wastes. Fundamental research includes development of nanometallic oxides.

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The Indian Institute of Technology, Bombay has developed an engineering curriculum that emphasizes the study of mathematics, physics and chemistry in addition to engineering. The curriculum also provides students with exposure to economics, English, philosophy and social sciences to give them a sense of the needs of the larger society beyond the world of engineering. The Department of Metallurgical Engineering and Materials Science describes its mission as "to develop and disseminate understanding of Structure-Property-Processing-Performance relationships for engineering materials through instruction and research." Its areas of focus encompass the design, creation and fundamental understanding of "materials that are capable of enhancing the human experience." Departmental research covers such materials as metals, polymers, ceramics, glasses, electronic materials, biomaterials and composites.

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NIIST engages in research and development activities in basic and applied research on advanced ceramics for structural and functional applications; sol-gel synthesis of ceramic precursors for nano-particles; coatings/membranes; catalysts; and ceramic fabrication. The organization's website lists its areas of focus in materials science and technology research and development as:

• Basic and applied research on advanced ceramics for structural and functional applications

• Sol-gel synthesis of ceramic precursors for nano-particles, coatings/membranes and catalysts

• Developmental work in the area of high *Tc* superconductivity, electronic ceramics and ceramics for communication

• Exploitation and value addition of renewable and non-renewable material resources and mineral based technologies

• Development of new light alloys and their metal matrix composites for strategic as well as societal needs

• Development of novel ceramic oxide materials

• Microstructure and microchemical analysis of materials using electron microscopy.

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InCerS membership exceeds 2,000 scientists, engineers, researchers, manufacturers, plant personnel, educators, students, marketing and sales professionals and others in related materials disciplines. Included in the total are some members based in other countries. The association provides members and subscribers with access to periodicals and books, meetings and expositions and technical information.

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