Specialty glass and optical fibre R&D focus in India

The history and present-day activities of India's CSIR-Central Glass and Ceramic Research Institute are discussed in the following contribution that originally appeared in *Glass Worldwide,* preferred international AIGMF journal.

During the late 1940s, it was decided to create a national institute dedicated to glass science and technology for India, located in Calcutta. The Central Glass and Silicate Research Institute came into being in 1950 and was later renamed the Central Glass and Ceramic Research Institute (CGCRI).

CGCRI was one of the first four laboratories set up under the Council of Scientific & Industrial Research (CSIR), established in 1942 with leading industrial scientist Shanti Swarup Bhatnagar at its helm. The mandate of CSIR was to bolster competitiveness of the Indian industry and cater to the needs of the nation's manufacturing sector.

Initially, most of the work at CSIR-CGCRI was directed towards identifying suitable mineral resources within the country and their suitability for specific product development. Quality control aspects in glass and ceramics received attention, together with work on glass forming machines and glass-lined equipment. As a logical continuation of the work carried out in the 1950s, the organisation's development during the following decade marked a very important milestone in the history of economic development in India.

The development of various types of optical glasses brought CSIR-CGCRI into the limelight in the international arena.Years of technology denial to India's defence, space and atomic energy sectors served as an impetus to develop a core knowledge base in these sectors. Optical glasses for use in lenses and prisms for specialised strategic applications were among the earliest areas of focus. Emphasis was on evolving an indigenous process technology that enables import substitution.

Among the organisation's other major advances during this period were the creation and casting of radiation shielding glasses for atomic energy establishments. Eventually, the R&D efforts emerged as the key backward linkage for major technological missions in atomic energy, defence and space that accelerated the ingenuity of product/ process development and import substitution for raw materials and components. This trend continues to the present day. Specialty glasses, optical fibres, lasers and functional materials are among the core domains that form the backbone of the institute.

With the establishment of an Academy of CSIR (AcSIR), tailored courses are offered in advanced glass science and technology, thereby paving the way for effective capacity strengthening.

Specialty glasses

Specialty glass development constitutes a major activity at CSIR-CGCRI, in view of the country's demand for various civil and strategic applications. A state-of-the-art facility exists within the institute for melting, forming and characterisation of specified properties of different glass varieties. Upscaling with pilot-scale production is also taken up to meet indigenous demand.

Nuclear installations use specialised glass windows for viewing the nuclear assembly lines while shielding radioactive exposure to the working areas. Such glasses, characterised by high density and radio opacity, known

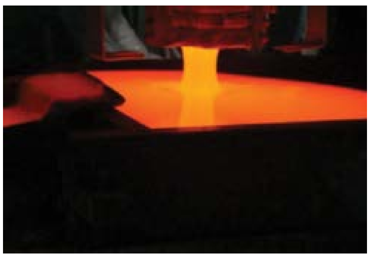

Figure 1: Manufacturing specialty glass.

Figure 2: Specialty glass beads for nuclear waste immobilisation.

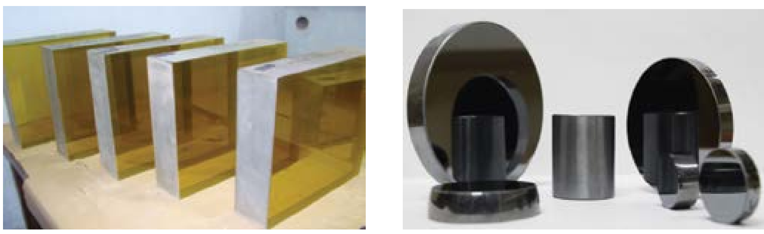

Figure 3: Finished RSW glass blocks and chalogenide glass blanks.

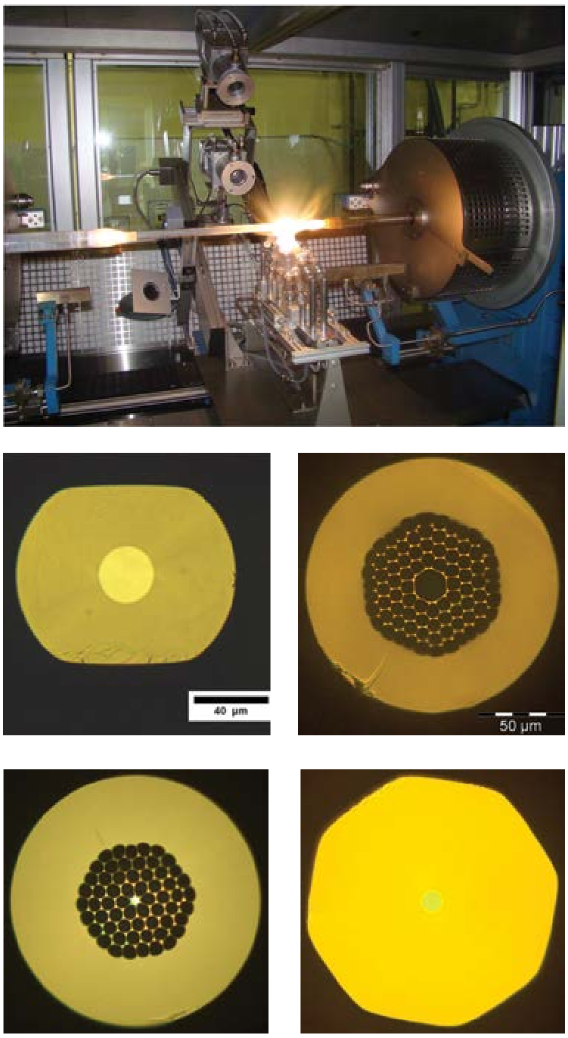

Figure 4: Specialty optical fibres produced in-house. The production facility (top) and a cross-section of specialty optical fibres.

Dave Fordham of Glass Worldwide, preferred international journal of the AIGMF, was greeted by CSIR-CGCRI dignitaries last July.

The CGCRI and AIGMF interactive session in Kolkata attracted figureheads and stalwarts from the Indian glass industry.

as radiation shielding window glasses represent important technological challenges in terms of their design, processing and manufacture. Starting from lab-scale development, over the years CSIR-CGCRI has perfected the process of development of blocks of desired sizes ad quality (figures 1 and 3). A pilot-scale facility exists that caters for special requirements. Indigenous development of the glass has been a notable contribution towards the country's self-capability building.

Radioactive waste in nuclear installations pose a significant health and environmental threat and warrant innovative containment techniques. CSIR-CGCRI has developed the process technology to make specialty glass nodules (frits) with specific properties using a borosilicate glass composition that can immobilise the wide spectrum of the fission elements by interring the elements into the structure of certain glass materials (figure 2). While the random network structure of the glass provides an ideal platform for the immobilisation process, the material used for this purpose has a special composition with stringent physical, mechanical and electrical properties. The materials are amenable to form nodules of desired sizes and flow properties and are endowed with properties to avoid corrosion of the melter during fixation of the waste. This flagship technology has been transferred for commercialisation.

CSIR-CGCRI has developed a moderate-scale production facility for chalcogenide glasses. These infra-red (IR) transmitting glass materials are formed from one or more chalcogen elements such as sulphur, selenium and tellurium in combination with other elements such as Ge, As, Ga, Sb, Si, P etc. Known for their extended infrared transmission up to 20µm, these glasses are indispensable for IR optical components, especially for thermal imaging applications. Conventional thermal cameras use lenses made of single-crystalline germanium or polycrystalline zinc selenide. The chalcogenide glasses are the best alternatives that are relatively cheaper and provide superior performance in terms of higher working temperature, wider IR window and lower thermal coefficient of refractive index (figure 3).

Different approaches to glass melting

Inherent challenges and technical bottlenecks associated with glass melting techniques have encouraged institutions to search from different approaches through innovative methods. While conventional melting techniques are increasingly perfected, the institute has embarked on developing capabilities for the microwave melting of glass. Shorter processing time (20-30 minutes compared to three-four hours in conventional processes) and significant energy saving are hallmarks of this process. This is also associated with maintaining a lower redox ratio for iron to enable low IR transmittance, which has led to the development of heat absorbing glasses.

Heat absorbing glasses effectively absorb wavelengths beyond the visible spectrum and are used mainly in illuminating equipment to absorb heat, which is emitted from a light source. CSIR-CGCRI has an established programme for the development of such glasses.

Anti-reflective coatings

CSIR-CGCRI has developed anti-reflective cum hydrophobic coatings on textured solar cover glass to obtain better light conversion efficiency. Field trials are ongoing, with a solar module built in-house to demonstrate the technology.

The institue has also developed refractive index (RI) controlled coatings on plastics, acrylics, ophthalmic glasses and sheets that have scratch-resistant properties. These coatings could have applications on solar panels, railway locomotive windscreens etc.

Specialty optical fibres

The Fibre Optics Laboratory at CSIR-CGCRI has a long history of research on the fabrication of silica-based optical fibre. The institute initiated R&D on fibre optics in the early 1980s towards establishing an indigenous capability of fabricating different fibre types.

With an initial funding from CSIR, a group of scientists, engineers and technicians came forward to build up a facility for fabricating preforms by the MCVD (modified chemical vapour deposition) technique and the subsequent drawing of fibres. The main focus was application-oriented research. With the growing application of optical fibres in several important areas, the activity has now been expanded in the field of specialty optical fibres, with particular emphasis on fibre-based components and devices.

Last July, CGCRI and AIGMF jointly organised an interactive session in Kolkata, covering the role of publications in brand promotion.

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Fibre lasers

Fibre lasers, endowed with properties of output power stability and excellent beam quality at high output powers, have made them technologies of choice for a variety of sectors, replacing conventional laser systems. Despite high market demand, the product continues to be imported.

CSIR-CGCRI has been instrumental in establishing a comprehensive fibre laser facility that includes preform and fibre fabrication, laser design and characterisation and making packaged modules.The process technology of vapour phase doping has been successfully demonstrated for fabricating rare earth doped preforms/fibres, suitable for high power fibre laser application.

Indigenous technology development is in progress to build up fibre laser systems, both continuous wave and pulsed at 1μm and 2μm wavelengths for industrial and medical applications (figure 4). A number of patents have also been filed in this area.

Fibre Brag gratings

Optical fibre Brag grating-based sensors with high precision and reliability have been developed at CSIR-CGCRI for structural health monitoring and industrial process control. Smart pantographs for online health monitoring of overhead infrastructure of railways, FBG-based distributed temperature monitoring of air preheaters in thermal power plants and online temperature monitoring of moulds in billet casters during continuous casting of steel are some of the established applications.

A comprehensive facility exists for writing of the gratings in-house, including packaging for the targeted applications. The demand for such optical sensors is on a steady rise in India (figure 5).

Optical fibre amplifiers

CSIR-CGCRI has an array of patented technologies and products related to optical fibre amplifiers. Erbium doped fibre amplifers for cable television, C-band optical amplifiers and double-clad Erbium-ytterbium doped high power amplifier (EYDFA) are some of the key technologies and products developed under this initiative.

The mid to high power EYDFA modules are of great potential for LIDAR, CATV and free space communication. Such specialty fibres produced in-house are already in use for making products and devices in collaboration with industrial partners, in readiness for being exploited commercially.

Photonic crystal fibres

Photonic crystal fibres (PCFs) have extended the range of possibilities in optical fibres by improving already established properties, as well as introducing new features. CSIR-CGCRI has a state-of-the-art facility for fabricating both solid and hollow core PCFs following an indigenously developed (patented) PCF fabrication process.

Nonlinear PCFs designed and fabricated at CSIR-CGCRI have led to the development of completely packaged supercontinuum (SC) light sources in collaboration with an industrial partner for biomedical applications. The spectrum of the source extends from 500nm to 2200nm, thus spanning the entire visible and near-IR region.

Recently, hollow core PCFs are being developed for efficient high power infrared laser delivery, as well as mid-IR SC generation for exploiting exciting prospects in industrial and biomedical fields (figure 4).

As glass and optical fibre technologies continues to evolve, CSIR-CGCRI continues to reposition and sharpen its capabilities to remain competitive and relevant amidst the growing demands of globalisation. ●

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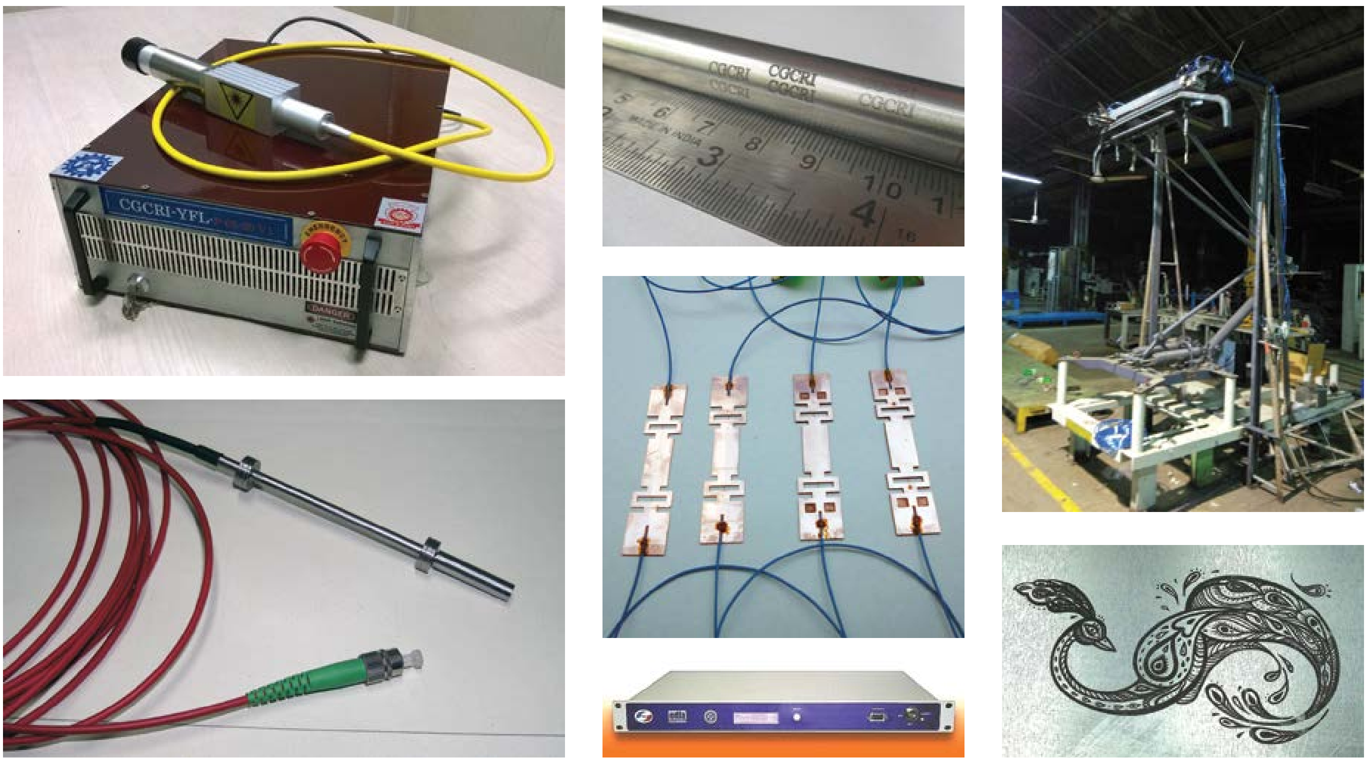

Figure 5: Pulsed fibre laser module for marking and engraving on metal, EDFA module for CATV application, instrumented pantograpgh with FBG sensors.