



CSIR-CGCRI

RESEARCH HIGHLIGHTS 2020-21



सीएसआईआर-केंद्रीय काँच एवं सिरामिक अनुसंधान संस्थान, कोलकाता
CSIR-Central Glass & Ceramic Research Institute, Kolkata

DIRECTOR'S FOREWORD



It is a pleasure for me to present the Annual Research Highlights 2020-21. This short publication is an endeavour to capture some illustrative scientific achievements of the institute during the year along with a snapshot of some of the key performance metrics. I am sure that users would find this useful for getting a feel of scientific progress of the institute. For those who wish to have greater details, I invite them to visit our website and also have a look at the full Annual Report 2020-21.

Dr (Mrs) S.K. Mishra
Director



IN A NUTSHELL

PhD Completion	: 08
Patents Filed and Granted	: 15
Publications	: 165
External Projects Initiated	: 40
Major Events Organized	: 21
External Cash Flow	: Rs 15.9 crores
Human Resources	: 284

(as on 31.03.2021)



R&D TOWARDS ADVANCING THE SUSTAINABLE DEVELOPMENT GOALS



- Biodegradable Sanitary hygiene products
- Mesoporous antibacterial bioactive glass
- Thulium fibre laser for surgical application
- Injectable hydrogel based on PEG
- Anti-microbial coatings on glass



- PhD and other training teaching programmes through universities and AcSIR
- ICG-CGCRI Tutorial 2021



- Adsorbent for simultaneous removal of fluoride and arsenic from ground water
- SiC membranes for oily water filtration application



- Demonstration of 8-cell SOFC
- Phase pure MIEC air electrodes
- Paper based ceramic separators



- Toxic wastes as sources of colouring ingredients for glass
- Skill development programmes for potters and artisans





- Direct energy deposition additive manufacturing techniques
- Nano engineered silica based optical fibres
- Er-Yb co-doped fibres
- FBG based packaged array sensor for temperature profiling
- Low ppm moisture sensor
- Ultra-low expansion glass ceramics
- Nano composites to detect exhaled breath ammonia



- Easy access to state of art testing and characterisation facilities
- Facilitate usage of scientific infrastructure and equipment for multiple application among various stakeholders



- Glasses from fly-ash, tannery and electronic waste
- Biochar from jute industry solid waste
- Improved ramming mass for induction furnace in steel industry



- Collaborative R&D with industries, academia and other institutions in India and abroad



R&D FOR OUR NATIONAL MISSIONS



- RSW glass technology through refractory crucible
- Development of large sized glass blocks for high power lasers
- RBSN Electromagnetic window of large size
- Improved refractory ramming mass
- High power fibre lasers
- Thermal barrier coatings for gas turbine applications
- Chalcogenide glasses for night vision optics



- Skill development programmes for potters, artisans and entrepreneurs



- FBG sensors for structural applications
- Ceramic membrane technology for water filtration
- Characterization of architectural glasses for buildings



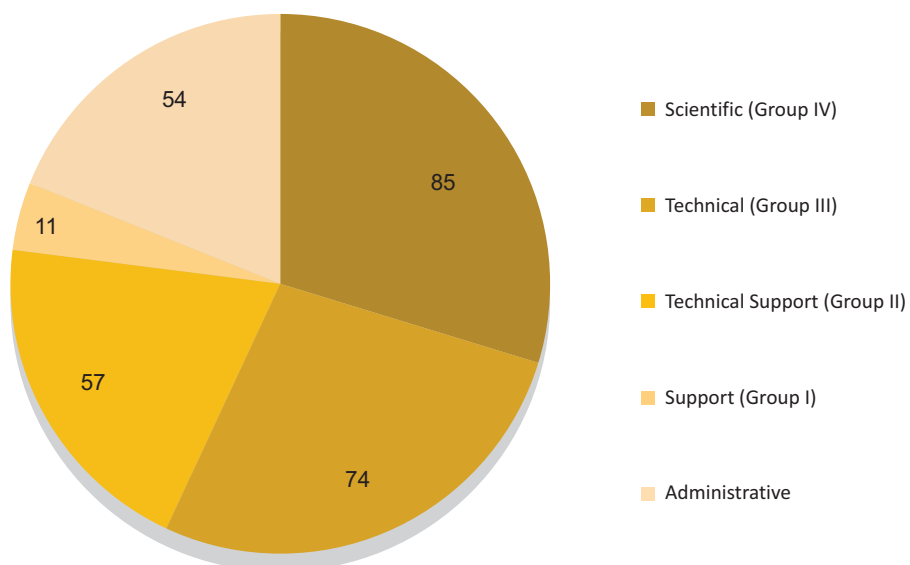
- Utilization of toxic waste for colouring ingredients in glass making
- Defluorination technology of water
- Heavy metal detoxification of water



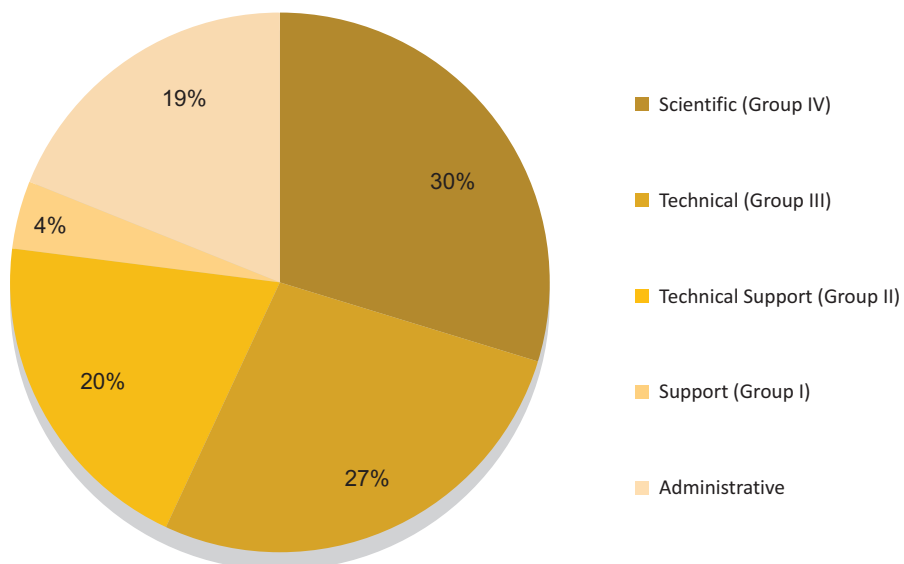
KEY R&D INPUTS

Human Resources

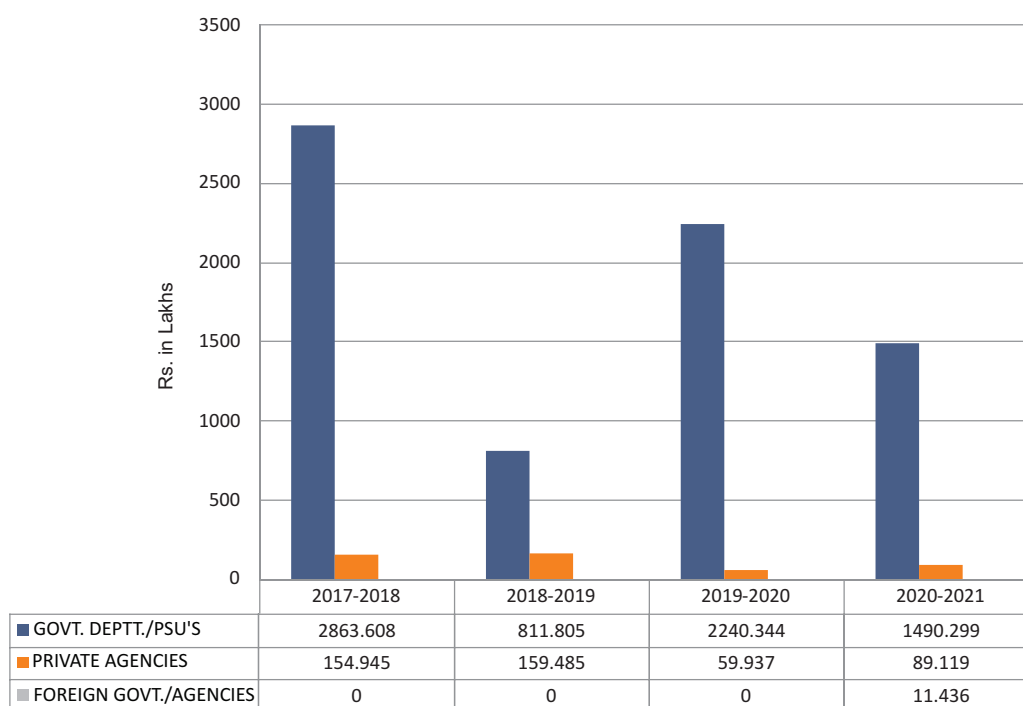
HR Distribution (in Numbers)



HR Distribution (in Percentage %)



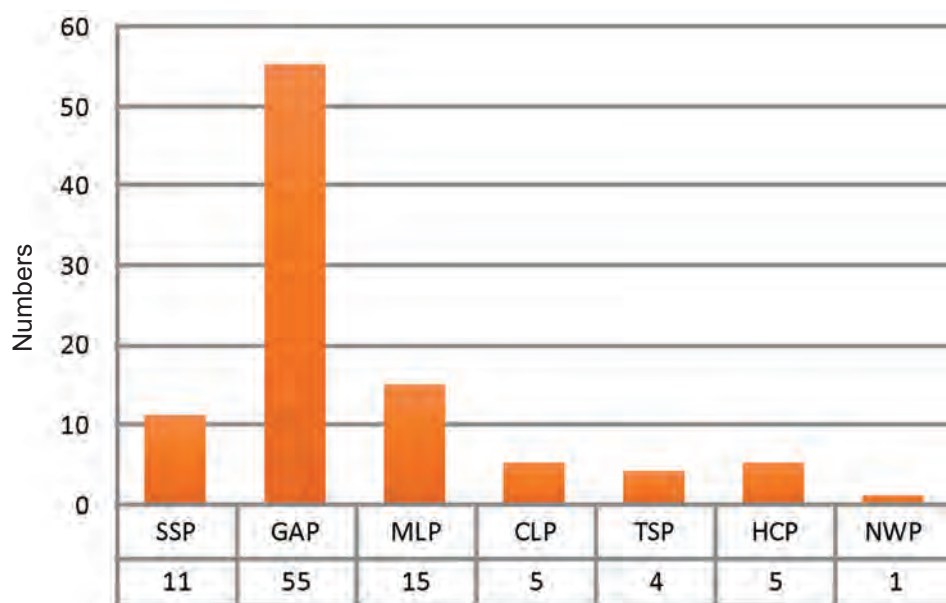
External Funds



Up to March 31st 2021

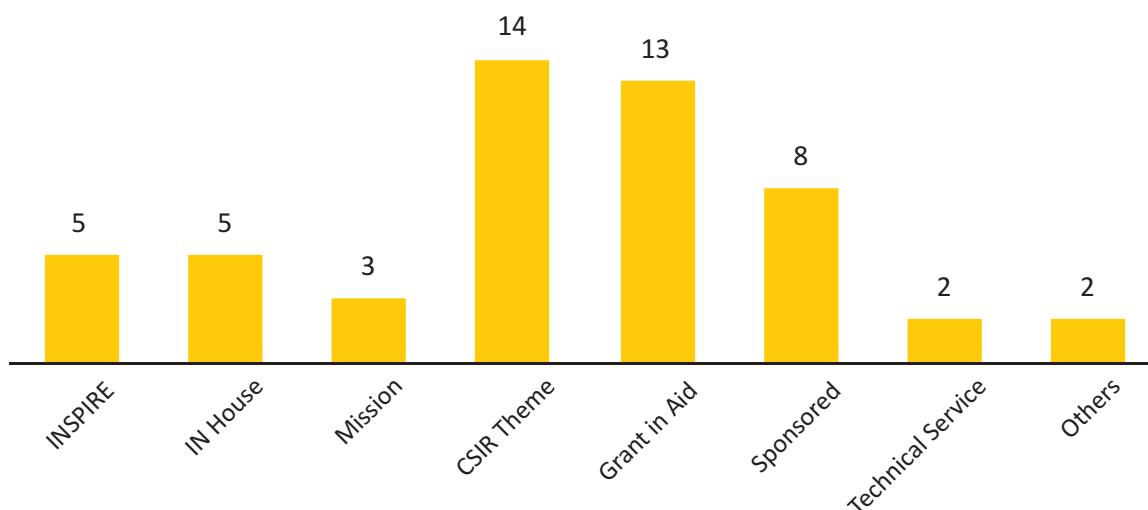
Projects Executed (ongoing and newly initiated)

Category-wise distribution

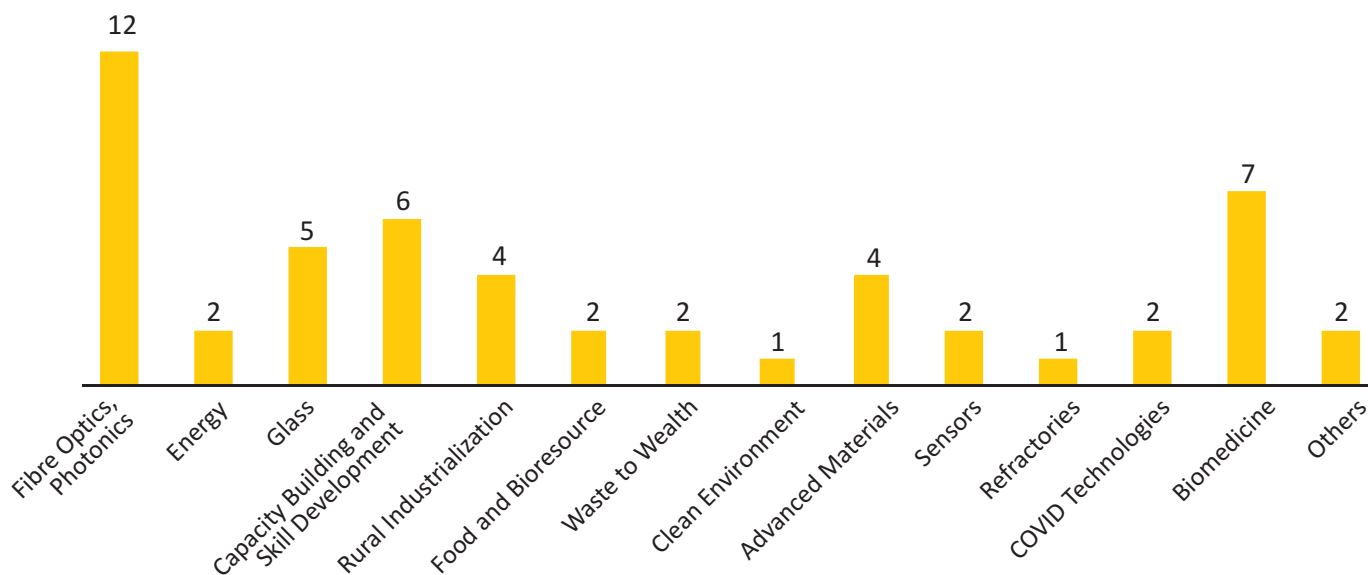


New Projects Initiated

Project Type

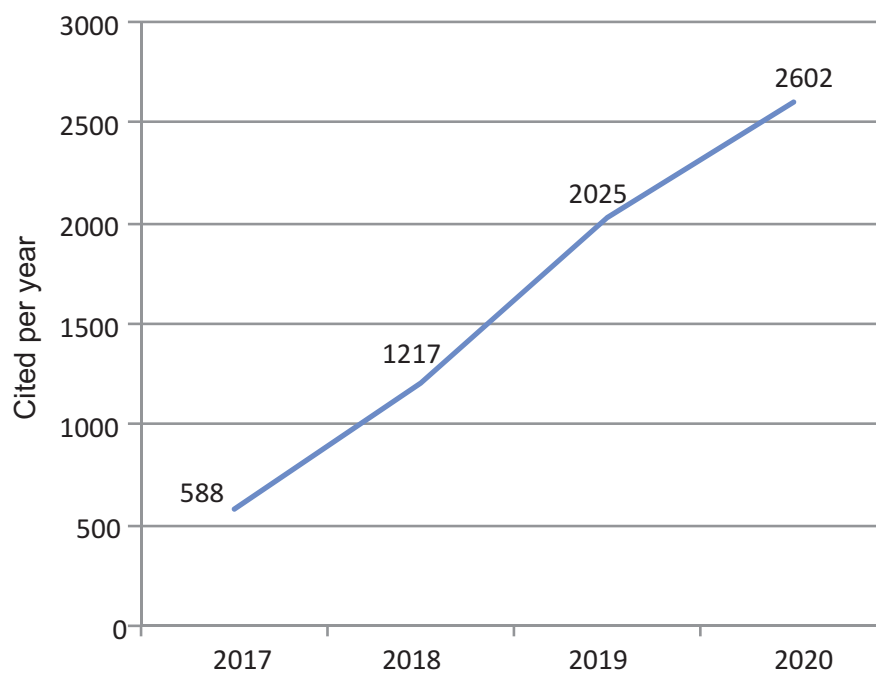
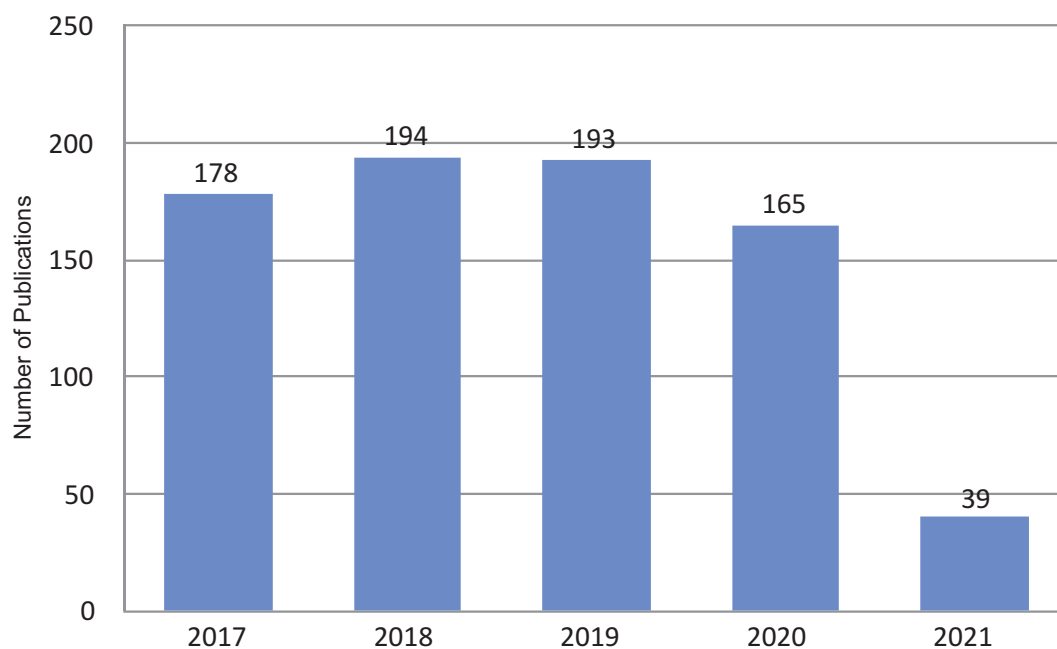


Project Domain Distribution



KEY R&D OUTPUT AND OUTCOMES

Publications

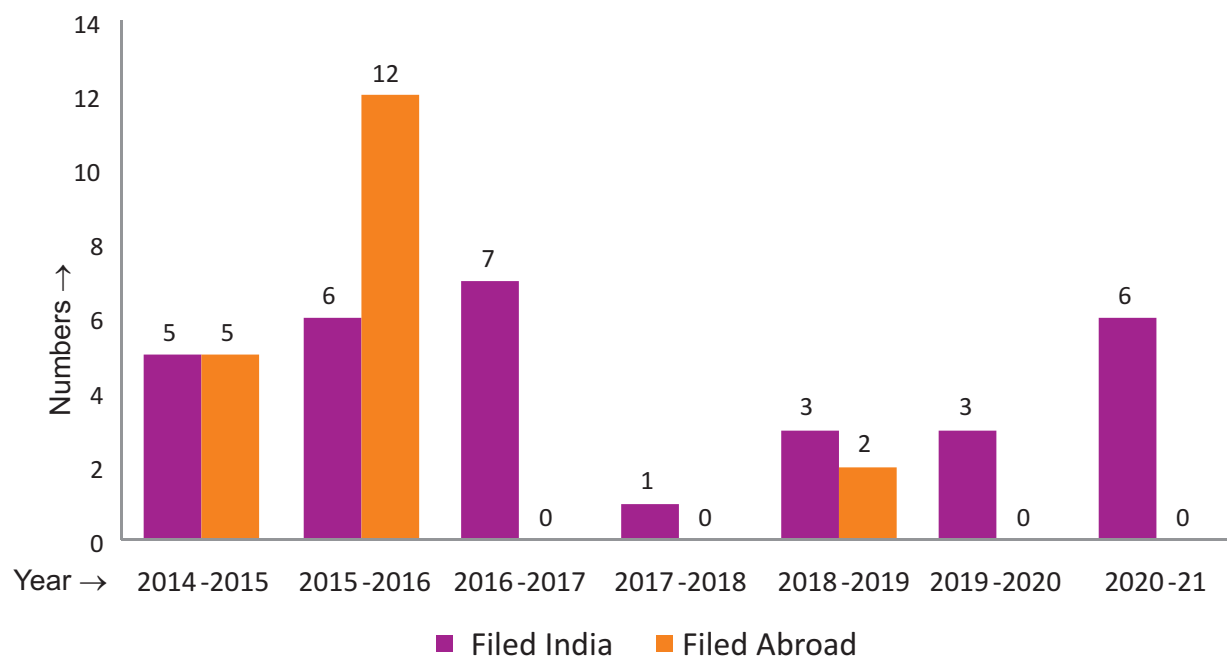


Source: Web of Science

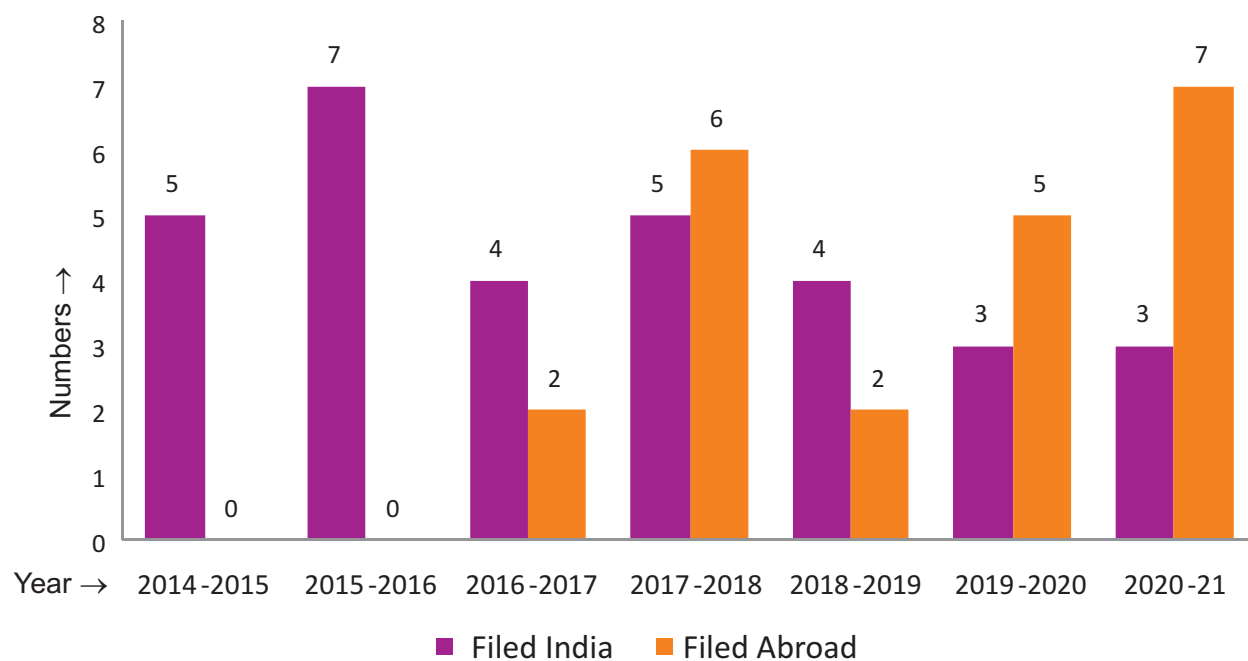
Note: Publications till March 31, 2021



Patents Filed



Patents Granted



SOME GLIMPSES OF R&D PERFORMANCE

Explorations for the Future

The institute has undertaken a number of initiatives in basic research that are aimed at developing knowledge foundations which could serve as starting points for technology development in future. Notable developments during the current year covered functional materials, energy materials and photonics. Some of the illustrative areas include the following:

- Development of graphene-metal oxide nanocomposite-based ammonia sensing device for medical application
- Novel boron-rich B-C, B-O and B-P phases for sensing applications in harsh environment: establishing correlation between charge-density distribution and sensing property.
- Development and performance characterization of crosslinked - cyclodextrin polymers based thin-film composite nanofiltration ceramic membrane
- The fabrication process for pump combiner, key component for power scaling in fiber laser, has been optimized. 5 packaged 4x1 Pump Combiner with transmission efficiency of 98% and power handling till 200 Watt.
- Development of Glass-based solid electrolytes for Na-ion battery.
- Energy Storage Platform on Batteries.

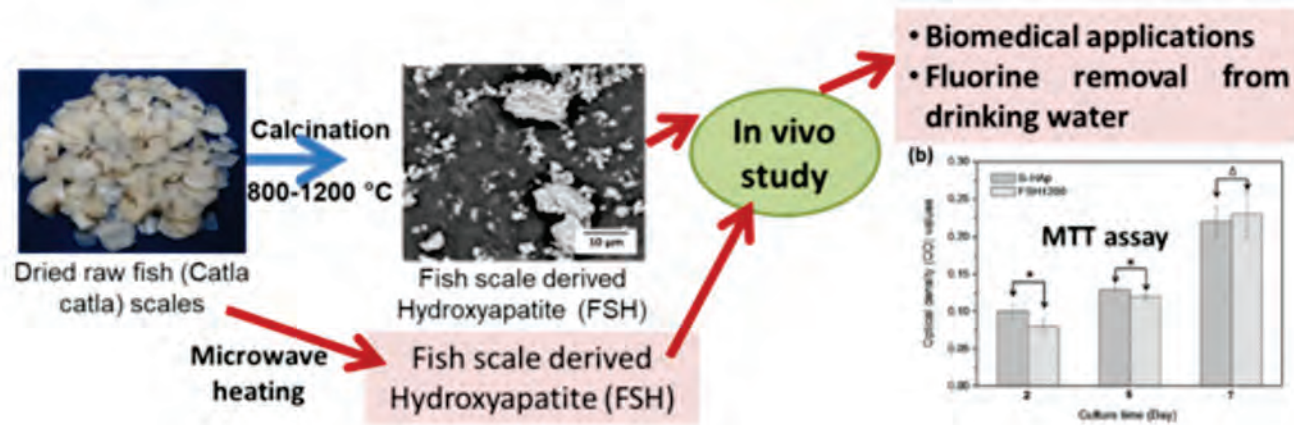
Leveraging our Knowledgebase

Biogenically derived materials for converting waste to wealth

A cost-effective process technology at validation level to produce bioactive calcium phosphate-based powders from fish scale for biomedical applications has been perfected. The derived Calcium phosphate retained natural trace elements like Mg and Sr present in the fish scale and showed



superior osteo-conductivity potential than the synthetic CaP. Currently the process is being evaluated for consistency and the material is being prepared for pre-clinical studies.



Specialty Coating on High Density Radiation Shielding Window Glass Block

The drain coating technique was adopted for the coating on RSW glass blocks from an optimized silica-based precursor sol/solution at low temperature. A single layer quarter wavelength optical design has been adopted for deposition of the coating through the indigenously developed drain coating facility. The coated glass blocks were hydrophobic in nature and show increase in VT and no damage of the glass surface was observed.



Drain Coater Facility

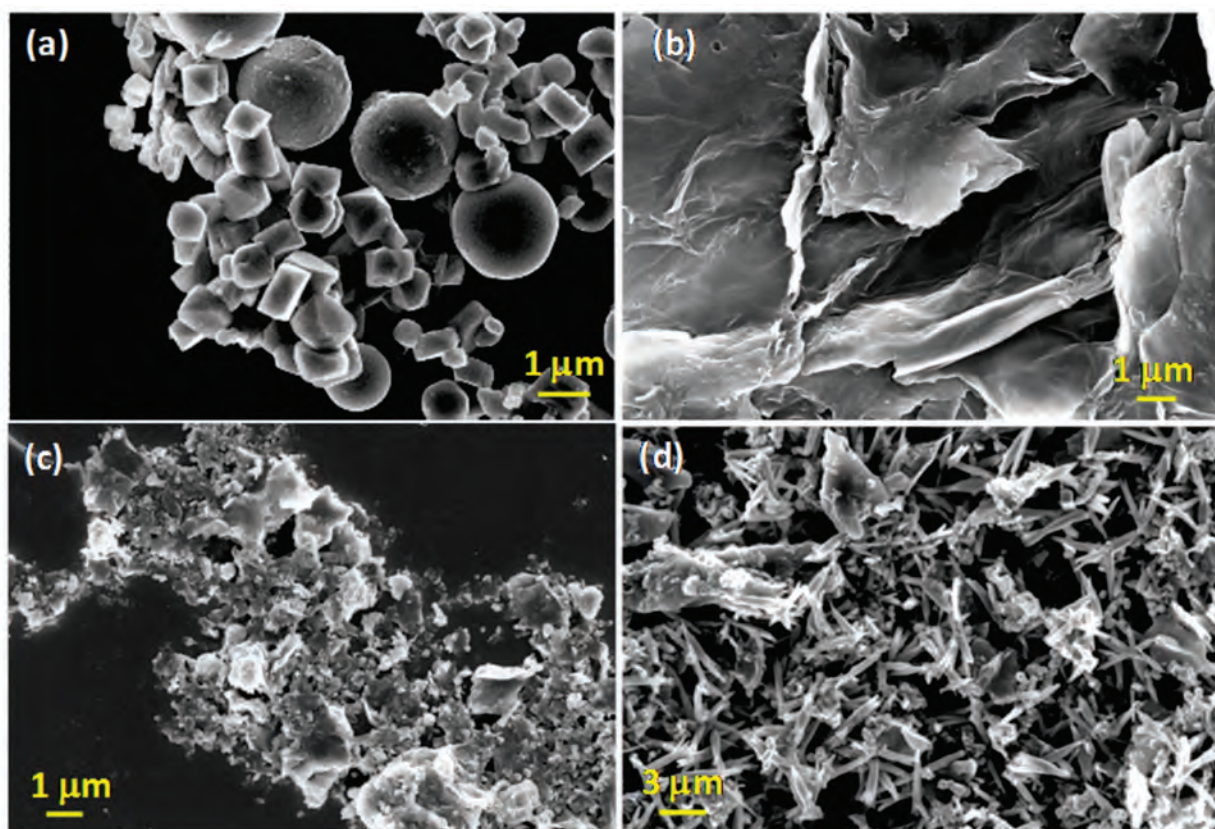


Coated RSW Glass block
(dimension: 400 x 400 x 100mm³)



Hydrogen Generation through Solid Oxide Electrolyser Cell and Photoelectrochemical Cells

Phase pure mixed ionic and electronic conducting (MIEC) – based air electrodes in the La/Ba-Sr-Co-Fe-O (LSCF/BSCF) systems have been synthesized using soft chemical route for SOEC application. Such developed electrodes have been utilized for fabrication of single cells. Cells have been fabricated and tested for electrochemical performance under SOEC operating conditions. Hydrogen generation rate as high as $0.72 \text{ Nl.cm}^{-2}.\text{h}^{-1}$ at 1.4 V, 800°C has been realized for such cells. Efforts are now on to augment the existing TRL level of 3 to 6 with suitable institute-industry consortium.



Breath Analyzer for Non-invasive Detection and Monitoring of Diabetes

Breath acetone is biomarker of diabetes and for a healthy person the concentration remain within 1 ppm. Higher concentration of acetone in exhale breath indicates the tendency of diabetes. Determination of breath

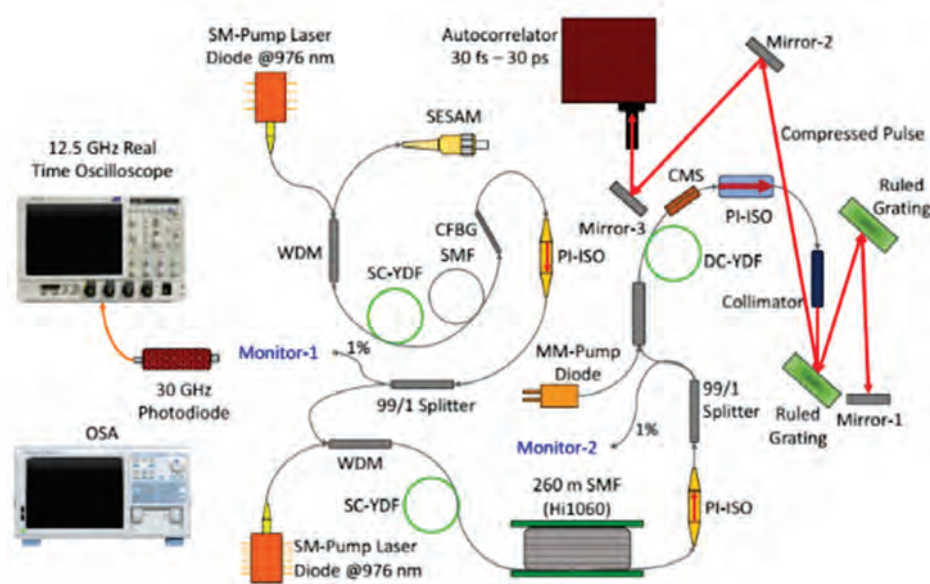


acetone using gas sensor could be an alternative of detection / monitoring of diabetes. Functional materials and devices division over the years has created a niche in developing chemiresistive based sensor for different gases and VOCs detection in ppm levels. Recently they have successfully developed novel chemiresistive sensing materials as well as fabricated a prototype device for detection of exhaled breath acetone; biomarker of diabetes. Laboratory label performance verification in real breath was satisfactory.



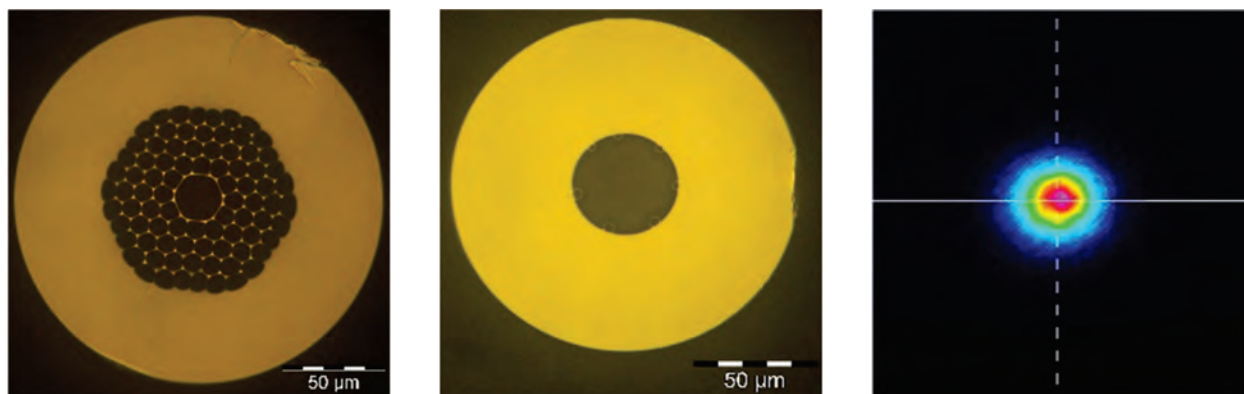
Demonstration of Ultra-fast Fibre Laser Source:

- Ultra-fast laser pulse (seed-source) is generated by applying passive mode-locking techniques (SESAM, nonlinear Optical/ amplifying loop mirror (NOLM/NALM))
- Pulse energy is enhanced by CPA (Chirped Pulse Amplification) technique
- Finally pulse is compressed down to femto-second domain using a pair of diffraction grating



Hollow core photonic crystal fibers (HC-PCFs) for efficient laser beam delivery

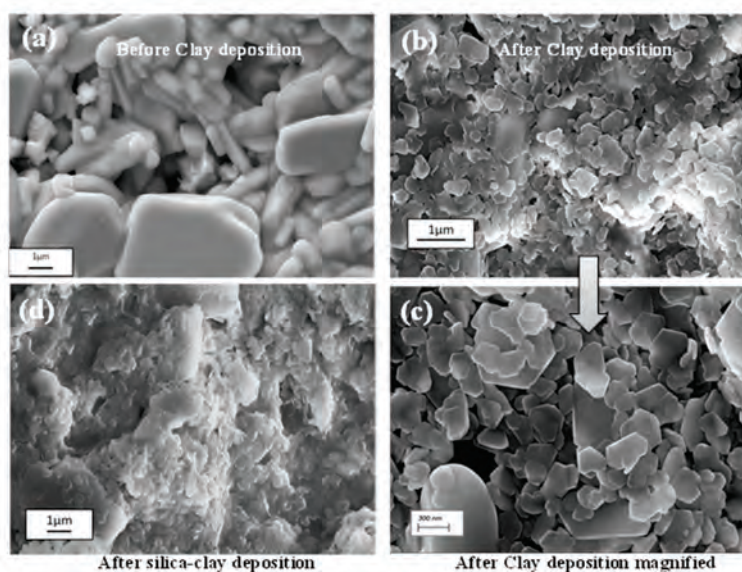
- Photonic band gap fiber and single-ring antiresonant fiber have been successfully fabricated.
- Experiments are being conducted for efficient laser beam transmission at specified wavelengths through the fabricated fibers.



Cross section of PBG fiber (left) and single-ring antiresonant fiber (middle). Beam profile at 1µm from the output end of the antiresonant fiber (right)

Newer Separation Technologies

Membrane surface modification by layer deposition up to mesoporous and microporous level for specific separation application and Installation & commissioning of gas fired furnace at industry premises for pilot production of commercially exploitable ceramic membranes.



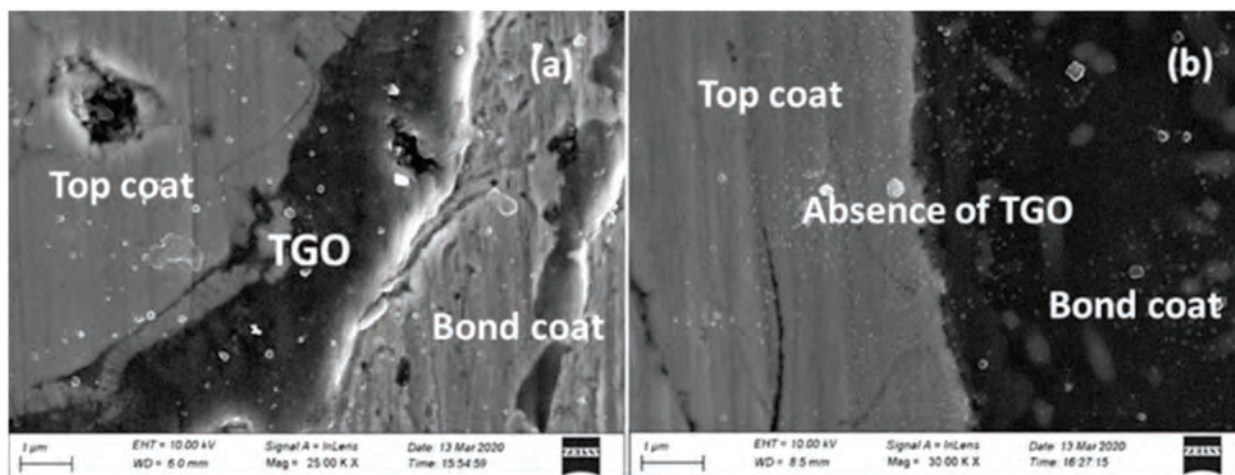
Membrane surface morphology analysis using FESEM



Advancing our Technological Frontiers

Development of Thermal Barrier Coatings

Conventional TBCs fail because of formation of thermally grown oxide layers at the interface. This technology circumvents the challenge and find application in gas turbines by providing enhanced coating stability.



Thermal cycling study at 1000°C (a) conventional TBC system and (b) no TGO formed in glass-ceramic bonded TBC system.

Bioactive glass with enhanced properties

Bioactive glass containing hydrogels exhibit superior storage modulus and shear thinning behavior in copolymer and composite materials. This provide potential for being used as an injectable material for prosthesis.

Advanced Sensors

- The applicability of nano-composites in monitoring medical morbidities demonstrated
- Compounds to sense low conc. ammonia (in harsh environment) at high temperatures tested.
- Technology for development of low ppm moisture sensor and digital meters for online measurement of trace moisture present in transformer oil was leveraged further.
- High Piezoelectric coefficient of 25 pC/N developed for application in flank array sensor.





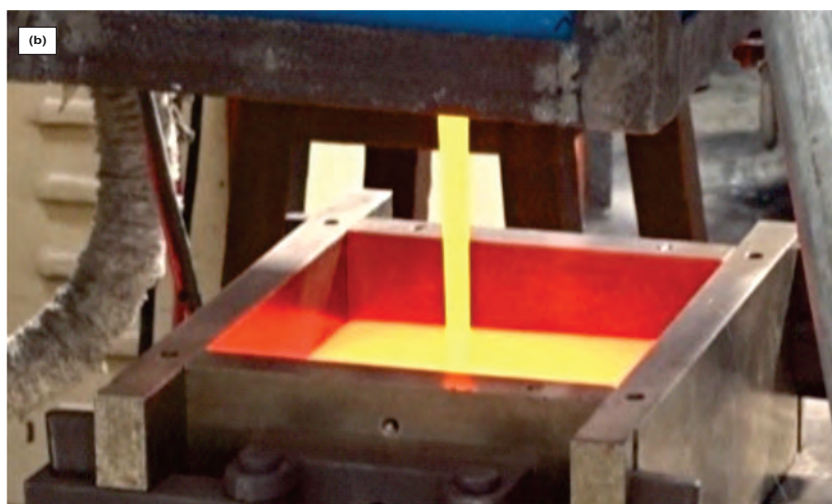
Sensor in Transformer oil with Transmitter

Sensor data receiver with standard ppm meter

Improvement of Radiation Shielding Glass Technology using Refractory Crucible

Development of newer crucibles could withstand long hours of glass melting operation.

- Optimization of process parameters both for defect free refractory pot development with dent tube along with flawless RSW glass development in the said pot is in progress.



Bottom pouring refractory pot with dent tube; and RSW glass casting through bottom pouring refractory pot

- Continued service to stakeholders using traditional platinum pot technology high density stabilized RSW glass blocks of required



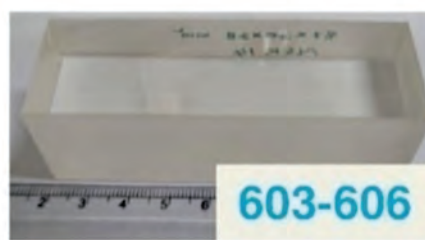
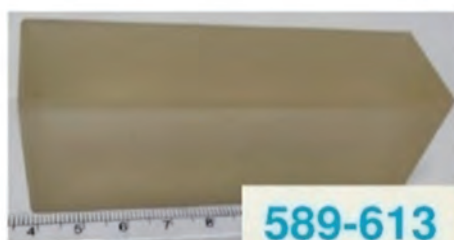
dimension have been developed successfully in the existing Induction Heating Furnace high density stabilized RSW glass blocks of required dimension have been developed successfully in the existing Induction Heating Furnace



Inspection of products by sponsor

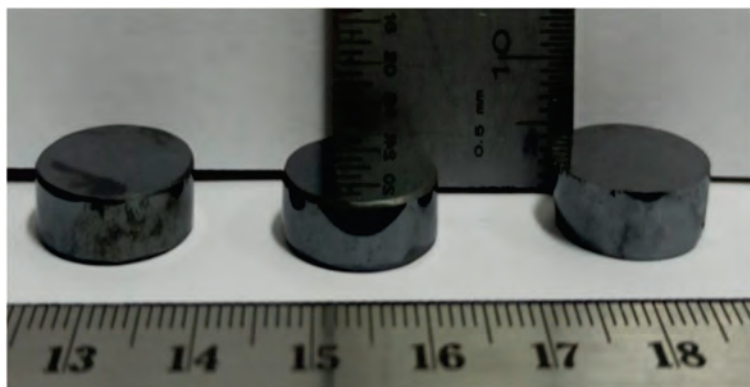
Facility Establishment and Development of Optical Glasses

Development and supply of five varieties of optical glasses with stringent optical properties for imaging and satellite navigation systems is being undertaken in the institute that is aimed towards indigenization of technology.

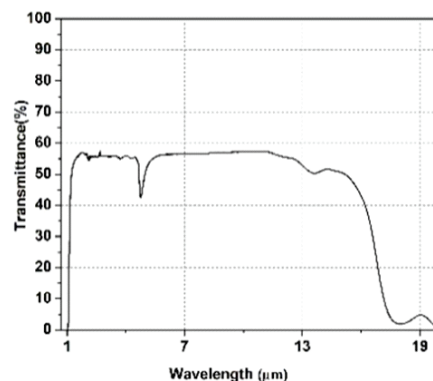


Development of indigenous process technology for the production of chalcogenide based infrared glasses for thermal imagers

The institute has worked towards development of arsenic-free chalcogenide based infrared transmitting (SWIR, MWIR and LWIR band) glasses suitable to use in thermal imagers, night vision device and imaging infrared seekers by replacing existing crystalline infrared optics. Non-arsenic chalcogenide based infrared transmitting glasses discs for use in thermal imaging devices has shown transmission up to 13 μm .



(a)



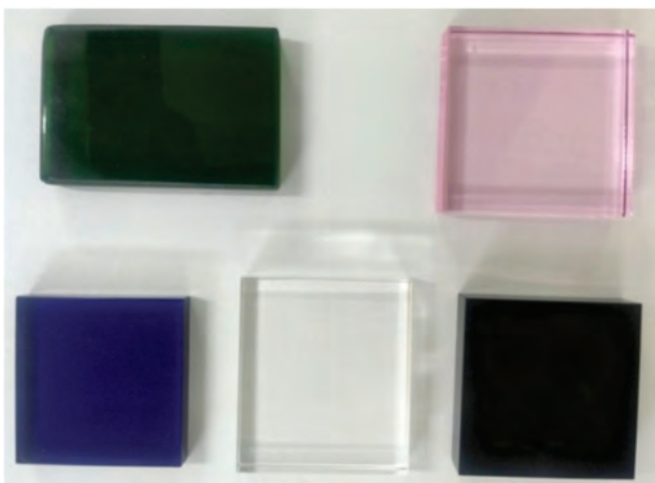
(b)

Photographs of developed glass discs and Representative transmission spectrum of a sample

Glass from Waste

Developing glasses from waste material such as flyash, saw interesting developments in a collaborative endeavour with CSIR-IMMT, Bhubaneswar.

Using quartz extracted from fly ash standard soda lime silicate (SLS) container glass was produced and up to 20 wt% quartz was replaced with quartz extracted from fly ash. The optical, thermal properties etc. were compared with commercial SLS glass and found closely matching. Sealing glass and different colored glasses using quartz extracted from fly ash have been produced.

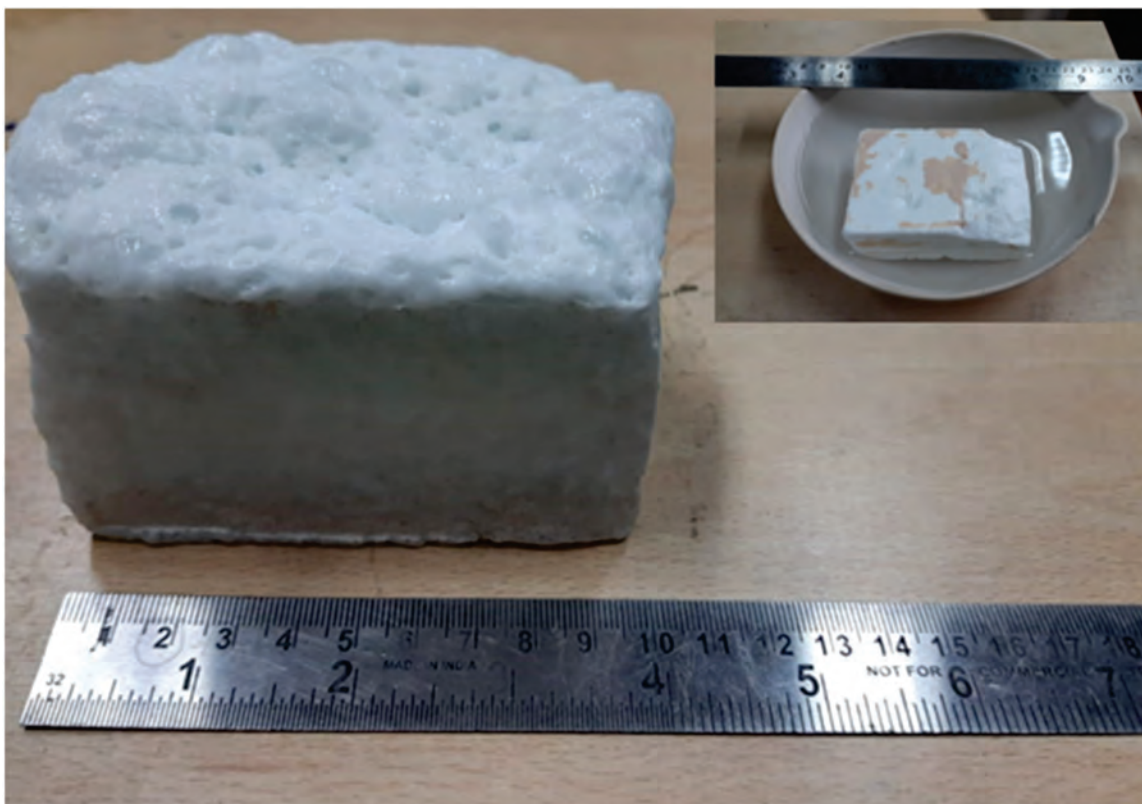


The images of different colored, transparent and sealing (black) glasses produced using quartz extracted from fly ash.



Utilization of toxic wastes as potential sources of coloring ingredient in glass making

Towards achieving recycling of waste glasses dumped into land-filling sites, these materials were subjected to low cost treatment that produced light weight porous foam glass suitable for insulation, sound proof application and in construction material (alternative of clay brick) for both road and building. The developed light weight porous foam glass exhibited density range and porosity within required specification optimized thermal conductivity and compressive strength.



Light weight porous foam glass brick of size 50 x 70 x 100 mm³ developed at CGCRI (Inset: Foam glass is floating on water)

Advanced Ceramics of EM Windows

Tungsten Carbide moulds for replicative forming of glass optics have been precision fabricated with very high surface finish (< 5 nm). Near net shape glass optics as per requirements have also been fabricated using these moulds. Deposition of silicon carbide and silicon oxycarbide thin films on various



substrates have been successfully carried out towards development of materials for direct white light emission.

Improved Ramming mass through induction furnace

Develop a suitable ramming mass composition for induction furnace lining under which slag can be suitably conditioned for effective sulphur and phosphorous removal from steel. Magnesia based basic ramming mass was developed for induction furnace lining, which will enable refining of steel in induction furnace.

Fiber Bragg Grating (FBG) array sensor for temperature profile measurement of billet caster

- Suitable sensor packaging has been done as per copper mould dimension and shifted to TATA steel.
- Packaged sensor has been

installed in mould structure at TATA steel production areas. Sensor lead fiber taken out from billet caster and connected to signal acquisition unit for further analysis.

Some key achievements include:

- During casting temperature profile has been measured for particular billet caster and data has been compared as per simulation (fig.3).
- It has easily able to detected the

break out (sudden temperature rise of lower FBG sensor) phenomena of billet caster (fig.4).

- One patent application has prepared and ready for filing at Indian Patent Office.



Fig.1. FBG sensor array in copper mould

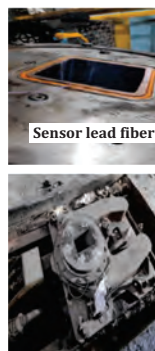


Fig.2. FBG sensor in billet caster during casting process

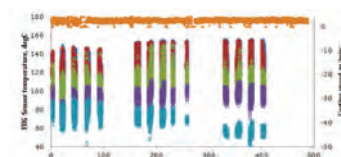


Fig. 3. Temperature data of 5 FBGs at different position. Data was stored during life time of one copper mould

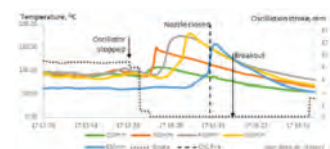


Fig. 4. Temperature profile during breakout detection



Mission Mode Initiatives

Fast Track Translation

- High piezoelectric coefficient composites for application as flank array sensors

Niche Creating Endeavours

- Development of an array based low temperature sensing device for early detection of multiple diseases by monitoring exhaled breath
- Demonstration of Pulsed Fiber Laser Sources for Additive Manufacturing and Precision Material Processing (PFLS)
- Development of Fiber Bragg Grating Long Gauge Sensors for Structural Health Monitoring
- Development of ultra-low expansion glass-ceramics from low cost resources for application in Cook-top panel of LPG gas oven

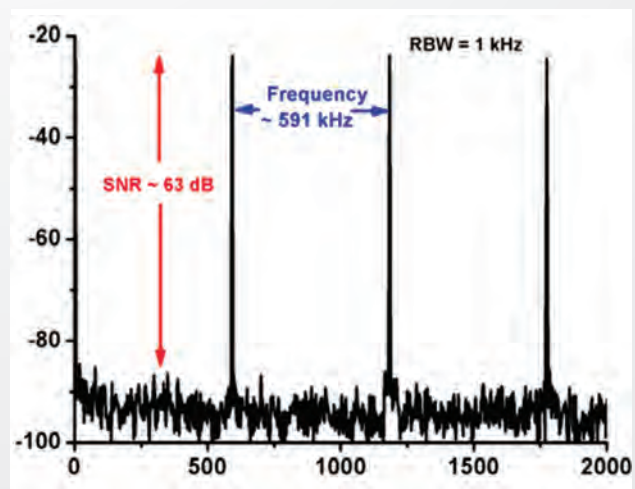
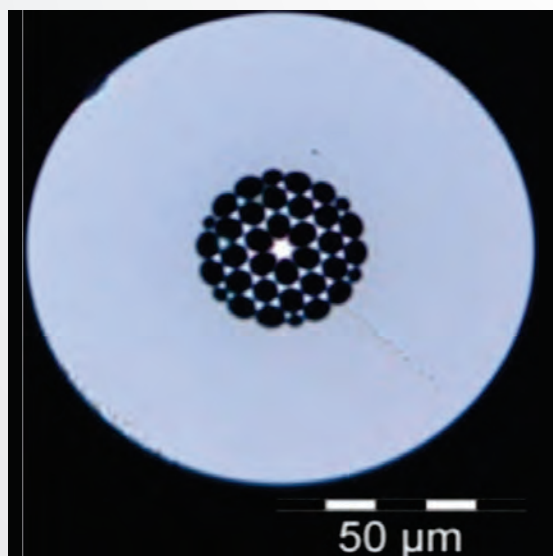
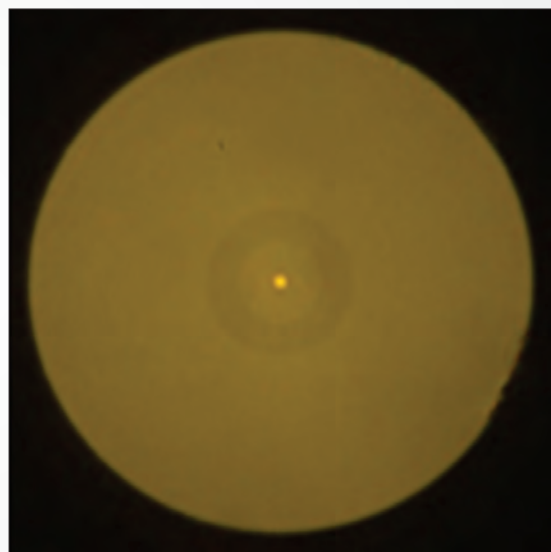
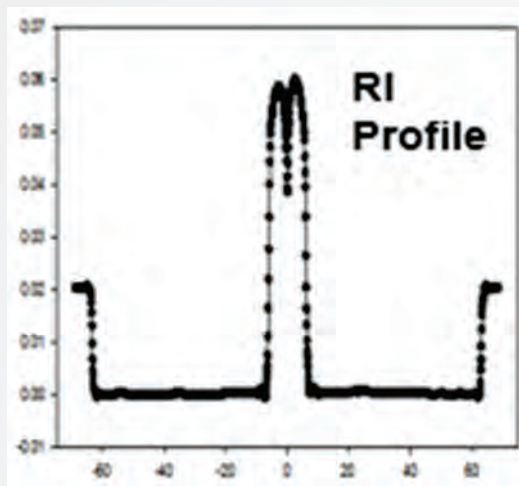
Focused Basic Research

- Multicomponent glass based optical fibers for Vis-MIR photonic applications
- Efficient Supercontinuum Sources in the Mid-IR and Visible-NIR using Photonic Crystal Fibers: Innovative Solutions for Deep-Penetration and Ultrahigh-Resolution OCT
- Development of thermally stable and antimicrobial bioactive glass-based bone graft material
- Microwave melting of glass: A potential method for tailoring glass properties

Projects Under CSIR Missions:

- Development and Characterization of Lamb Wave Transducers with Adaptive Tunability and High Directionality using Piezo Wafers and Patches for Health Monitoring of Metallic Aircraft Structures
- Development of WO_3 /Graphene nanocomposite thin films for k electrochromic display
- Development and performance characterization of crosslinked b-cyclodextrin polymers based thin-film composite nanofiltration ceramics
- Development of advanced nano-engineered specialty optical fibers for OCT application





SUSTAINABLE DEVELOPMENT GOALS



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