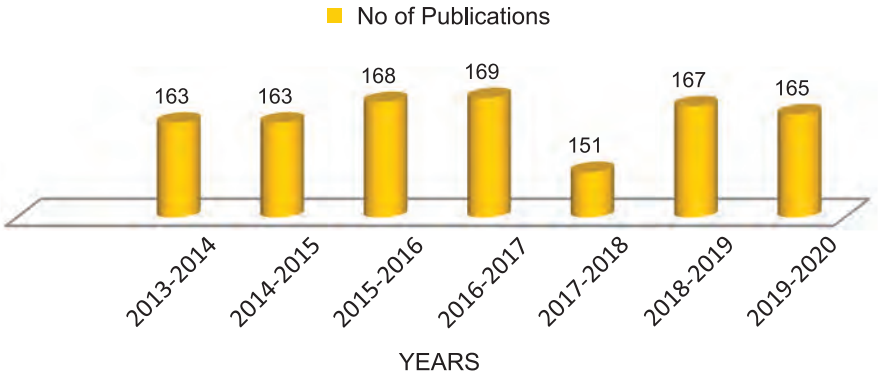
# CSIR-CGCRI RESEARCH HIGHLIGHTS 2019-20

सीएसआईआर–केंद्रीय काँच एवं सिरामिक अनुसंधान संस्थान

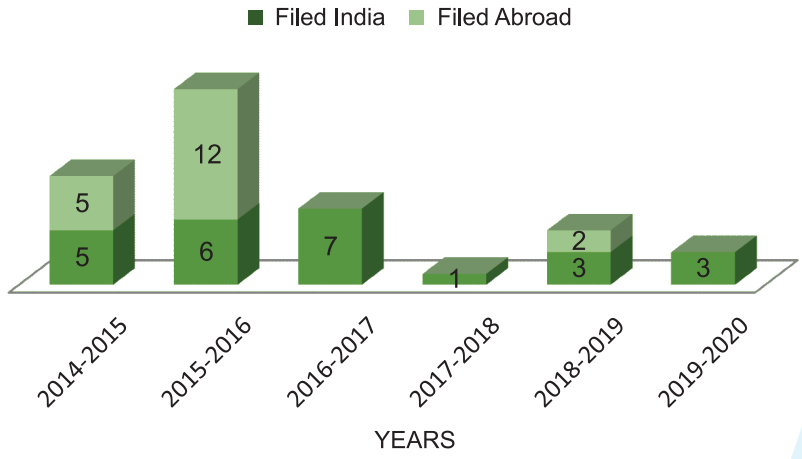
CSIR-Central Glass & Ceramic Research Institute

# RESEARCH OUTPUT TRENDS

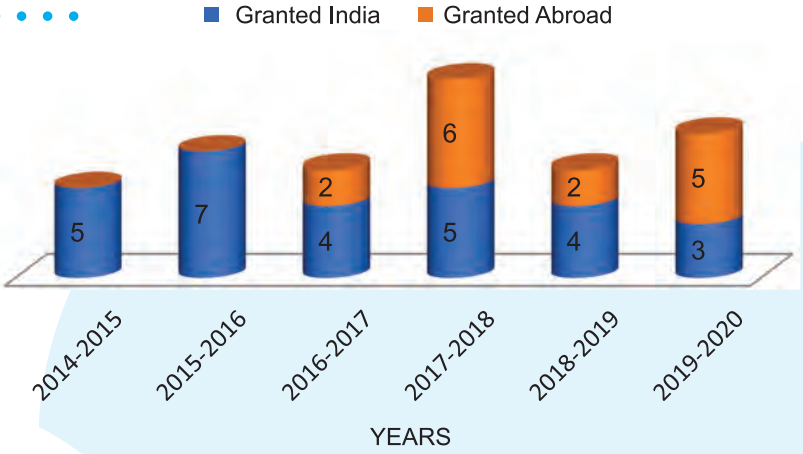
## PUBLICATIONS




## PATENTS FILED




## PATENTS GRANTED



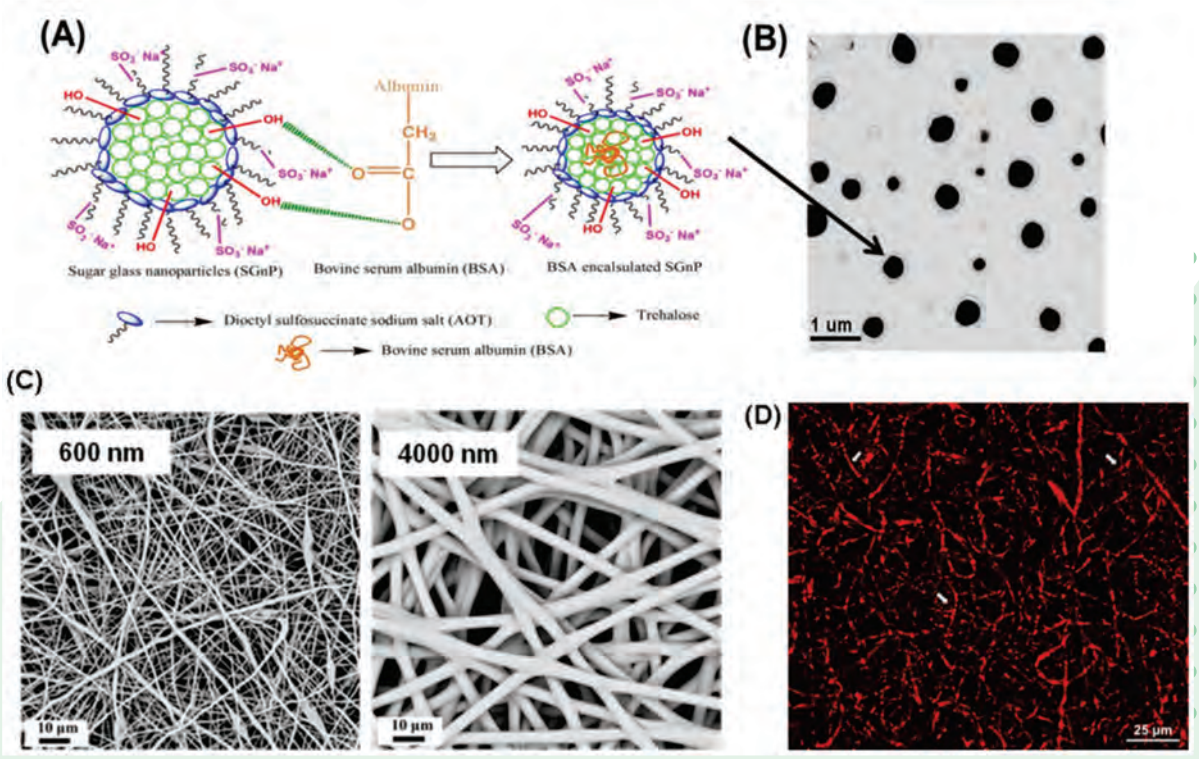
# SDG ALIGNMENT

## SDG Alignment of Institutional Programmes

3 GOOD HEALTH AND WELL-BEING

## Sugar Glass nanoparticle based nano-encapsulation system

We have successfully synthesized sugar glass nanoparticles (SGnP) based nano-encapsulation system using inverse micellization technique and subsequent optimization of process parameters to achieve agglomerate free SGnP powders with desirable particle size range. Further, bovine serum albumin (BSA) as model protein was successfully encapsulated into the core of SGnP matrix at very high (approx. 93%) encapsulation efficiency and subsequent process optimization was conducted to achieve a very sustained BSA protein release profile (23% after 30 days immersion in PBS buffer at 37°C). Our developed SGnPbased nano-encapsulation system can be potentially utilized for controlled drug/protein delivery in tissue engineering and regenerative medicine applications.

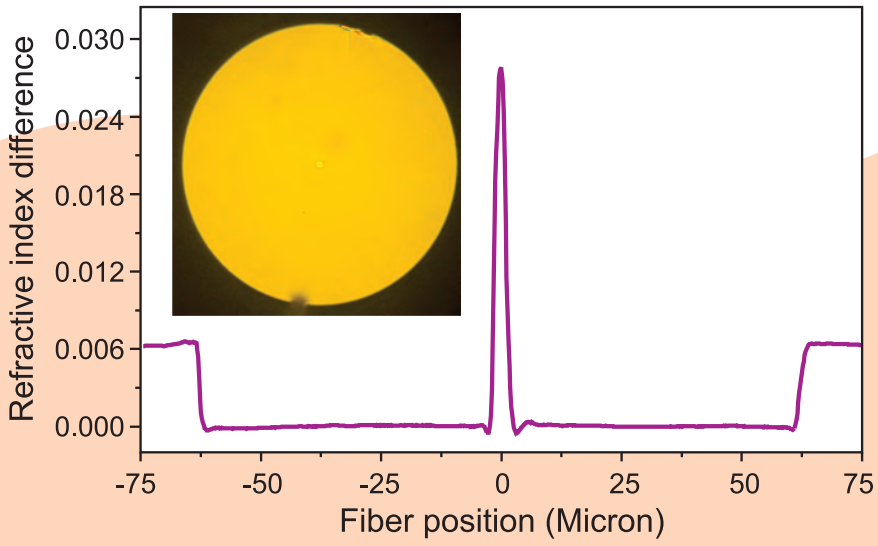



*Schematic of sugar-glass nanoparticle (SGnP) based nano-encapsulation system*

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

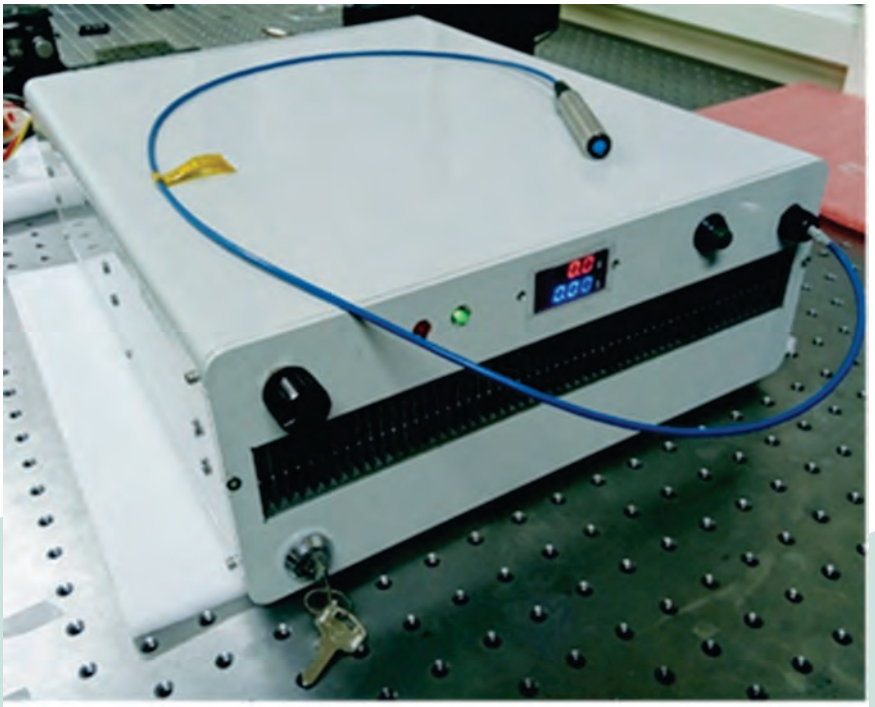
## FBG based distributed feedback laser for sensor applications

Distributed feedback fiber laser (DFB-FL) is a kind of laser consisting of a single phase shifted fiber grating directly writing in the rare earth doped fiber, depending on the narrow bandwidth, low noise, and stable single-mode operation. In this project, CGCRI developed intrinsically photosensitive erbium doped fiber having ultra high NA (~0.30) with low core diameter (~3.0 micron ). An measured refractive index profile along the diameter of the fiber cross section is shown in Fig.1. CGCRI also developed DFB-FL having output power of more than 60.0 µW @100 mw pump power at 980nm along backward direction with low threshold pump power of 5.0 mW. The phase shifted grating needed to produce the fiber laser was inscribed at CGCRI. Fig. 2 shows the spectral characteristics of the fiber laser whereas the variation of the output laser power as a function of pump power is shown in Fig. 3. The phase noise of developed DFB-FL tested by NPOL, Kochi at 1 KHz was found to be -110dB V/ rt. Hz. This corresponds to a frequency noise of about 100Hz/rt.Hz. These DFB-FL will be used for development of optical hydrophone.



## Prototype CW Yb-Fiber Laser Module of Collimated Power 60W

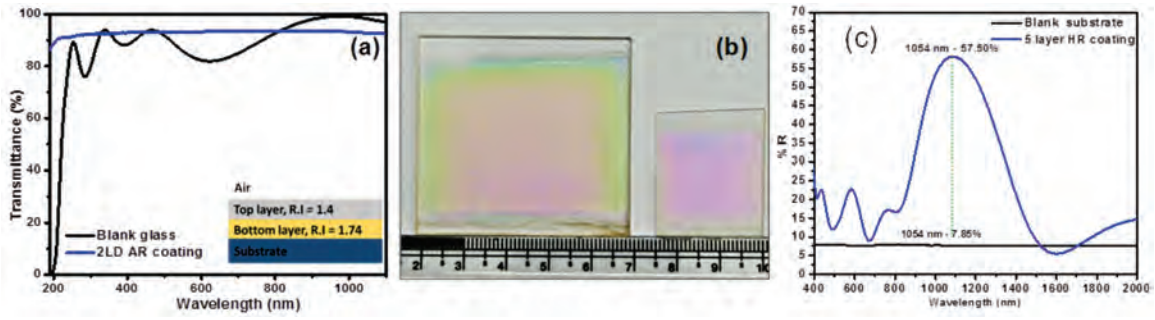
CSIR-CGCRI has developed the prototype CW Yb-fiber laser module of collimated power 60W at 1074nm with M2 value <1.10 using in-house fabricated double-clad octagonal Yb-fiber. This module was initially tested at ARCI (DST-Lab, Hyderabad) for additive manufacturing (AM) during the month of July, 2019. The performance of the module was satisfactory and the power fluctuations are within permissible limit for the targeted applications. The ARCI team expressed their keen interest for 400 W CW/QCW laser system for cutting and additive manufacturing applications and CGCRI has planned to develop this laser module.



CW Yb-Fiber Laser Module

# Development of antireflection and high reflection sol-gel derived coatings with high laser damage threshold on quartz glass and KDP optics for high power Nd:Glass laser

Quarter wavelength optical designed single layer and double-layer sol-gel derived metal oxide based antireflection (transmission, 98-99% at 1054 nm) coatings have been fabricated on quartz glass optics. In addition, high reflection (>55% at 1054 nm) of 5-layer coating on quartz glass has been developed in the reporting period. The coatings showed high laser damage threshold value.




*Transmission spectrum (a) and photograph (b) of double layer AR coated quartz glass. (c) Reflection spectrum of 5-layer high reflection coating on quartz glass*

## FBG Sensors for power plant application

CSIR-CGCRI has developed two key technologies using optical fiber Bragg grating based sensors for power plant applications. These are (a) A stator end-wind vibration monitoring system and (b) A distributed temperature monitoring system for use in Air Pre-Heater.

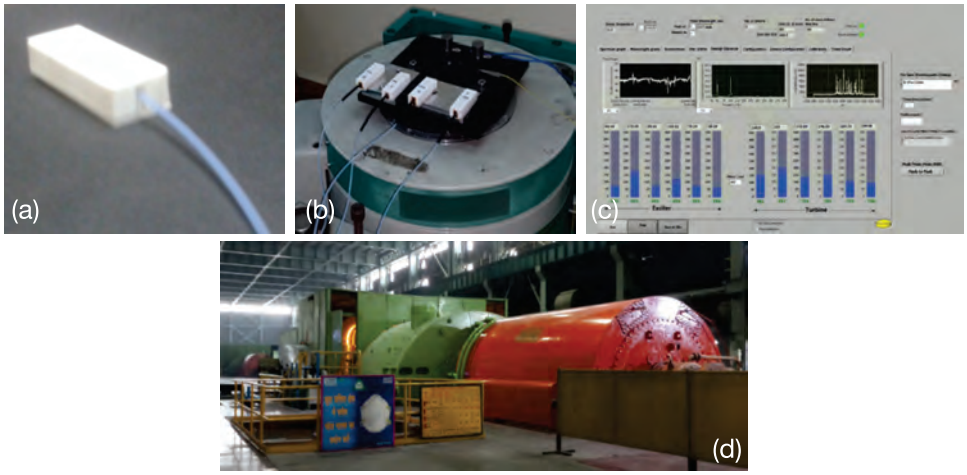



*Figure: (a) Vibration sensor, (b) Test bed,*
*(c) GUI of the control and data logging software, (d) Generator at installation site*

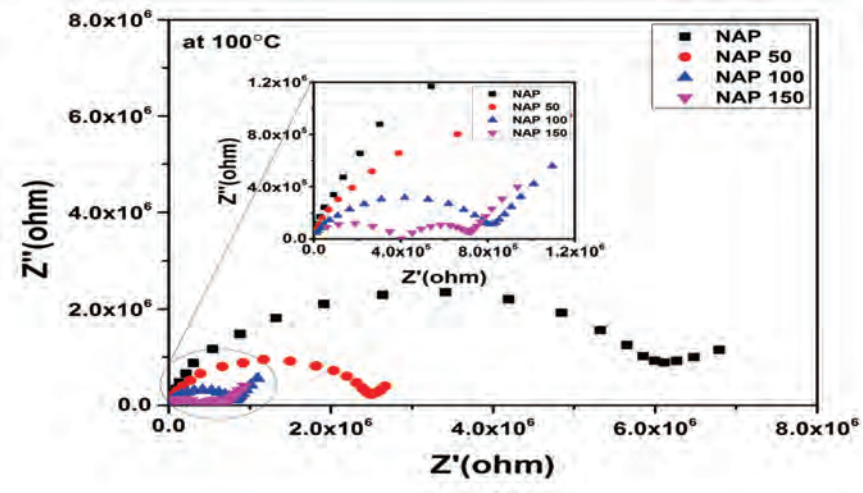
FBG based vibration sensors specifically designed and developed for use in high voltage environment is made of machinable ceramic material. Lead optical fiber coming out of the sensors directly transmit the sensor signals to the control room where the vibration signatures of twelve individual sensors deployed at different locations on the stator end winding are displayed and recorded in real time. Two prototype vibration systems, one at DADRI power plant, the other at KORBA power plant and one distributed temperature sensor at DADRI power plant of NTPC have been installed and commissioned successfully. The systems are operating satisfactorily.

Recently, NTPC has placed a development order to CGCRI to translate the prototypes into a commercial system and to supply three commercial vibration monitoring systems and four temperature monitoring systems for APH for long term monitoring and evaluation. The order value is Rs. 159.00 lakhs.

7 AFFORDABLE AND CLEAN ENERGY

## Novel glass-based solid electrolytes with high conductivity for room-temperature rechargeable Na-ion batteries

Research interest on Na-ion batteries has increased rapidly in recent years due to Eco-friendliness and abundance of sodium compared to lithium. This important work on the development of novel glass based solid electrolytes for Na-ion batteries has been initiated under earlier carrier advancement scheme of DST-SERB. In the first attempt, three glasses namely NAPS-50, NAPS-100 and NAPS-150, which are designed taking sodium superionic conductor (NASICON) type NAP ($Na_3Al_2P3O_{12}$) glass as the parent glass and doping silica for phosphorous in the stoichiometry of 0.5, 1 and 1.5, respectively. The glasses were synthesized by the melt-quenching technique. The total ionic conductivity of glasses has been calculated using the formula $\sigma = L/(RA)$, where L is the thickness of the sample, R is the total resistance and A is the area of cross section. The ionic conductivities were found to be 8.11 x $10^{-9}$, 2.02 x $10^{-8}$, 2.66 x $10^{-8}$ and 2.35 x $10^{-8}$ $Scm^{-1}$ for the NAP, NAPS-50, NAPS-100 and NAPS-150 glasses, respectively at 75°C.




*Cole-cole plots of NAPS glass series*

In the second attempt, NAPS-150 glass was taken as the parent glass and silica was added into it for alumina. The chemical formulae of the as synthesized glasses are $Na_3Al_{1.4}P_{1.8}Si_{1.95}O_{12}$ (NASPS-1.4), $Na_3Al_{1.6}P_{1.8}Si_{1.8}O_{12}$ (NASPS-1.6) and $Na_3Al_{1.8}P_{1.8}Si_{1.65}O_{12}$ (NASPS-1.8). The conductivity values calculated from the general formula $\sigma = t/(RA)$ for all the samples at 75°C are $8.22 \times 10^{-8} Scm^{-1}$ (NASPS-1.4), $9.22 \times 10^{-8} Scm^{-1}$(NASPS-1.6) and $1 \times 10^{-7} Scm^{-1}$ (NASPS-1.8), which makes it quite clear that the increase in the silica content for alumina leads to an enhancement in the ionic conductivity of the glasses. In the third attempt, NASPS-1.4, NASPS-1.6 and NASPS-1.8 glasses were taken and studied the influence of ion-exchange process on the mechanical and electrical properties. The conductivity measurements demonstrate an undistinguished variation. Nevertheless, there is a substantial rise in the indentation hardness value along with the crack propagation values, which changes from 500gf to 10kgf. This shows that ion exchange process increases the crack resistance of glass material without affecting the conductivity values much. In the fourth trial, an attempt has been made to identify the influence of NaF on the conductivity of $37.5Na_2O$-$22.5Al_2O_3$-$37.5P_2O_5$-$2.5Nb_2O_5$ (mol%) (F-0) glass. Improved ionic conductivity is observed with the addition of NaF for $Al_2O_3$.

## Development of Multi-Detection Methods (Resistive/ Opto/electrochemical) for pesticide residue in food matrix

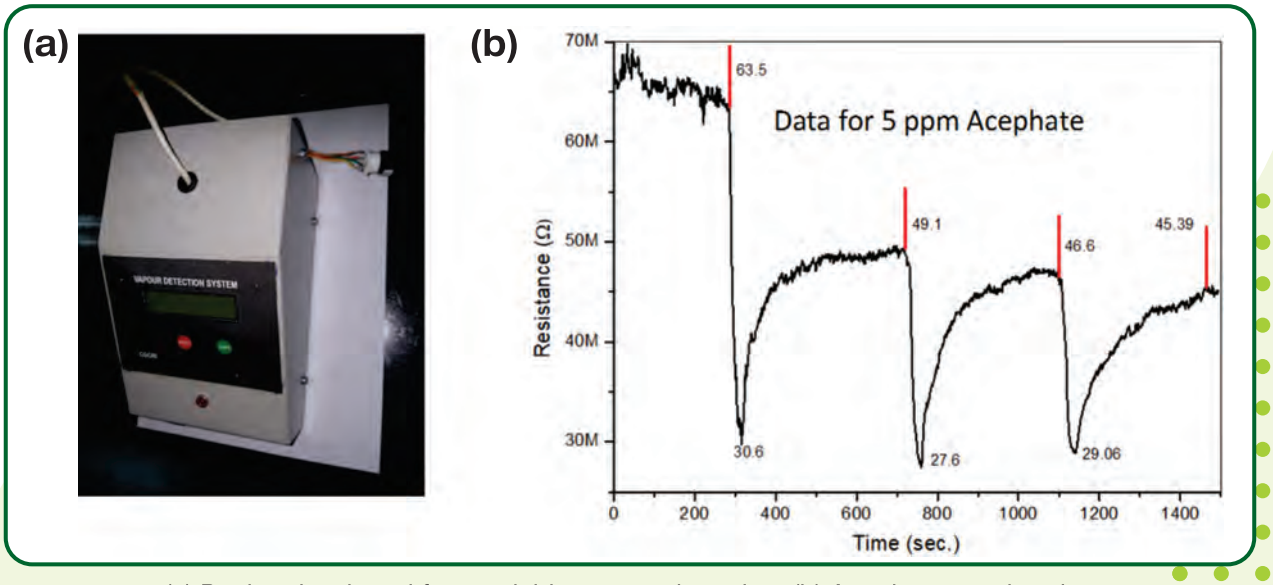
This activity has been taken up under the CSIR mission mode programme of FOCUS. Considering the national priority of safe food for all, this project envisages providing technological interventions to assist better human health through safe food commodities from field to consumer end. Out of 6 different themes, CSIR-CGCRI is participating in the theme, "Development of multi-analyte detection methods." In this theme, CSIR-CGCRI is entrusted to (i) develop and validate sensitive/cost effective and easy to use analytical method(s) for quantification of bisphenols in water and food products, and (ii) develop multi-detection methods (Resistive/Opto/electrochemical) for pesticide residue detection in food matrix.

Bisphenol A (BPA) and its substitutes are known to cause several diseases related to reproduction, development, brain function and cardiovascular health. In India, there is no strict policy regarding the use of bisphenols and hence likelihood of prevalence in water and food products is high which could put Indian population on high risk. It is important to understand the prevalence of bisphenols in water & Indian food products and the exposure risk in Indian populations so that regulatory guidelines can be formulated. Currently, the detection of bisphenol A includes gas chromatography, high performance liquid chromatography, fluorescence spectrophotometry, catalytic kinetic spectrophotometry, wherein the sensitivities are not entirely satisfactory.

The objective of one of the work packages of this project was to identify materials and develop cost effective and easy to use methods (paper based/

colorimetric) that could be used for detecting contaminants like bisphenol and bisphenol derivatives in water. In this project, Composites of various metal oxides and their interaction with bisphenol were studied using instrumental techniques. Optimization and identification of right material was carried out for sensor or kit development. The most promising composite needs further elaborate study for development of paper-based strip.

In the other work package, the goal was to develop materials for sensing organo-phosphate pesticides in food matrix and to develop a compact sensor device. Pesticide contamination in food including vegetables, fruits, cereals, beverages etc. is a present day health hazard. It is becoming increasingly important to develop sensor materials and devices for checking presence of pesticides in food in order to take precautionary measures. In this project, materials have been developed for detecting commonly used organo-phosphate pesticides and a compact low-cost prototype device for pesticide detection by chemi-resistive method has been developed.

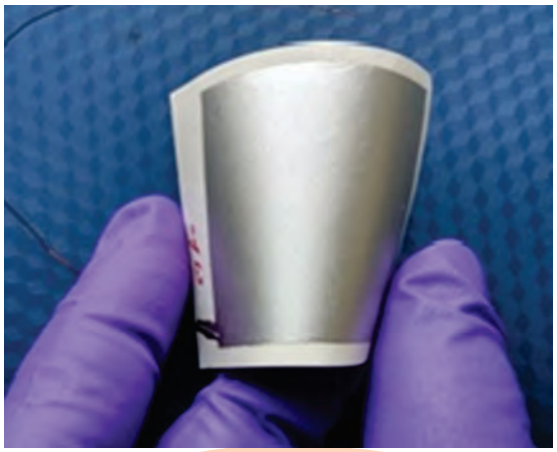



*(a) Device developed for pesticide vapour detection, (b) Acephate sensing data using the developed material.*

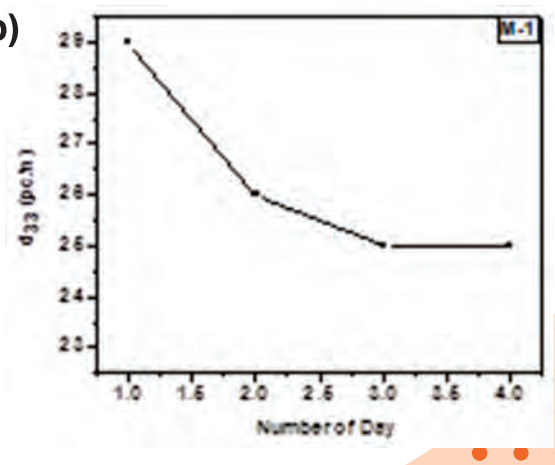
## Development of Piezoelectric PVDF and PVDF – Composite Sheets for underwater application

The focus of the project was development of thin sheets of PVDF and PVDF piezo ceramic composites of thicknesses from 0.5 mm to 1 mm and lateral dimension 100 mm x 100 mm or more and having piezoelectric coefficient of ~30 pc/N. PZT-PVDF composites of the mentioned dimensions were developed. The process was optimized and the fabricated composites were poled at different conditions for obtaining maximum piezoelectric coefficient. Films having piezoelectric coefficient varying from 25-30 pc /N were fabricated. The stability of the value of the piezoelectric coefficient was measured and supplied to NPOL (Kochi) for testing as sonar sensors.

(a)



(b)

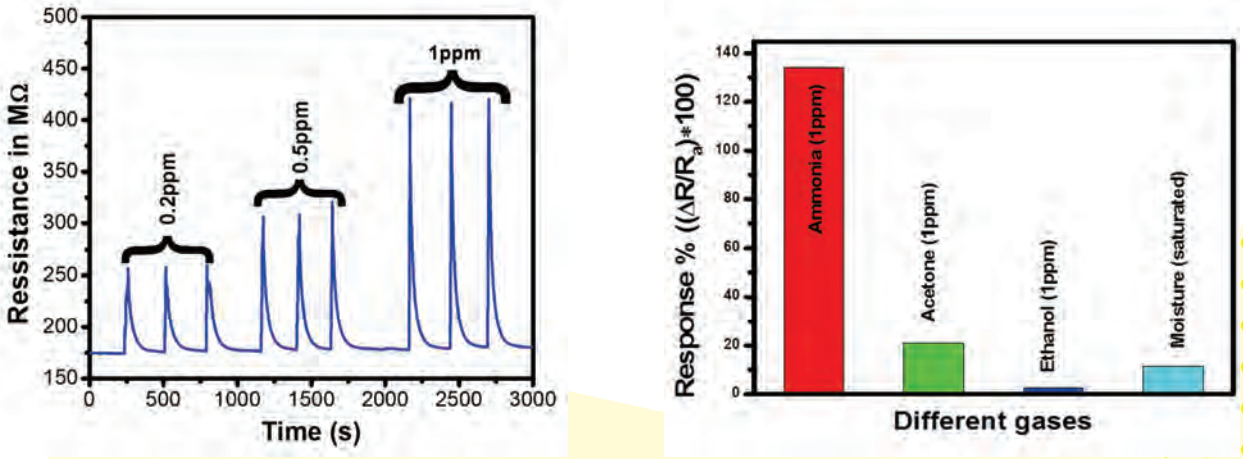



*(a) PZT-PVDF Film, (b) Stability in d33 values*

3 GOOD HEALTH AND WELL-BEING

## Development of graphene-metal oxide nanocomposite-based ammonia sensing device for medical application

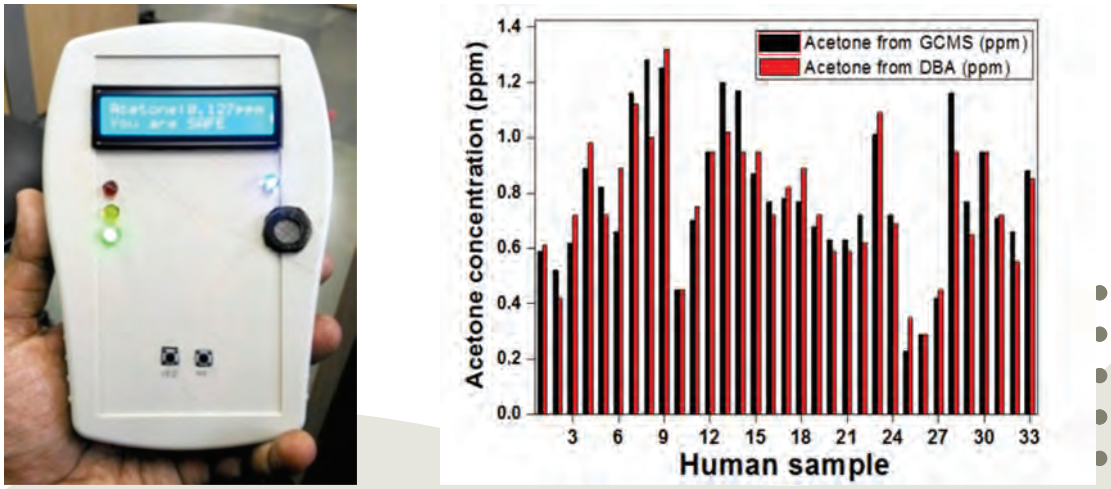
A highly sensitive, stable and selective, solid state synthesized barium hexaferrite nanoparticles-based sensor has been developed which has the capability to detect ammonia down to 0.2ppm having reasonable high sensitivity 1.46. Prepared sensor shows high sensitivity (2.34 times) towards 1ppm ammonia at 308°C. Also, prepared sensor is practically insensitive towards similar concentrations of other interfering breath volatiles, viz. acetone, ethanol, and saturated moisture. In addition, it's quick response (2.88s) and recovery (39.4s) time ensures real time breath analysis.




*(a) Dynamic response curve of the barium hexaferrite based sensor to various trace concentrations of ammonia viz. 0.2ppm, 0.5ppm, and 1ppm, (b) Cross-sensitivity check towards other major breath volatiles*

## Nano-biosensors and Microfluidics for Healthcare: Non-Invasive Techniques based on Nano-biosensors for Diabetes Detection

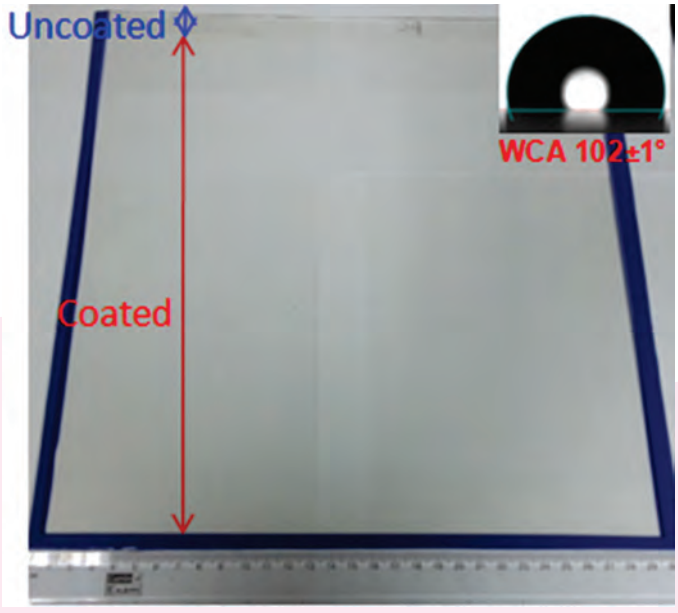
Central theme of this project is based on detection of exhale breath acetone, bio-marker for diabetes. The exhale breath acetone concentration >2 ppm in breath is considered as diabetic. Accordingly, a gas sensor has been developed based on ternary nanocomposites which can detect trace acetone of exhale breath for monitoring diabetes non-invasively. A handheld, cost effective breath analyzer has been fabricated in our laboratory to measure acetone by analyzing exhale breath. Results are being compared with GC-MS to validate the device.




*(a) Fabricated handheld device, and (b) Comparison of device results with GC-MS.*

## Thermal curable '$SiO_2$-PEO' based hard (hardness 4H) and hydrophobic (100°) nanocomposite coating on polycarbonate (PC) substrate (dimension: 300 x 300 $mm^2$).

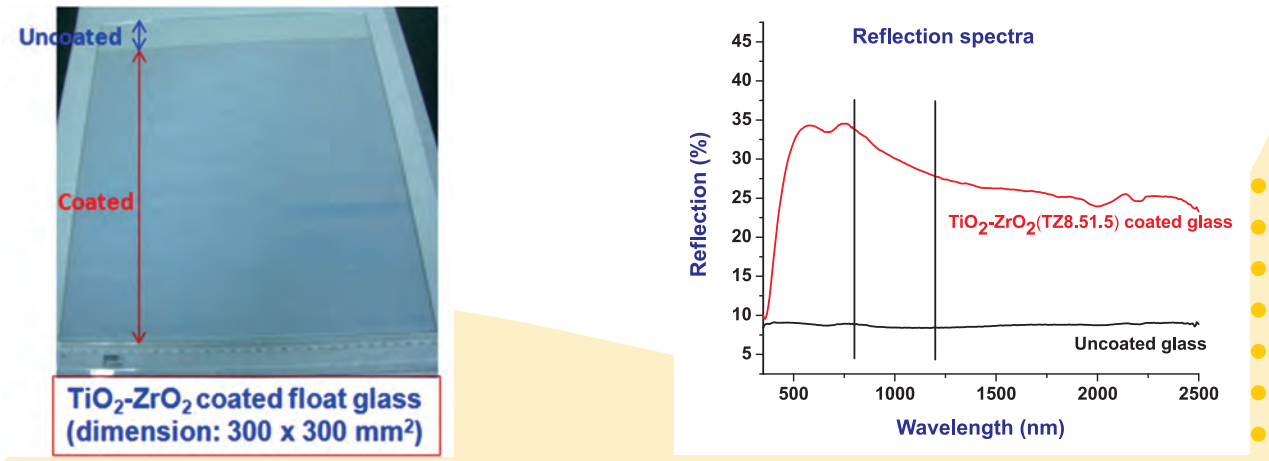
Thermal curable trimethylsilyl modified PEO (polyethylene oxide)-$SiO_2$ based inorganic-organic hybrid (IOH) nanocomposite hard hydrophobic coatings on polycarbonates (PC) substrate was prepared by the sol-gel dip-coating technique using tetraethyl orthosilicate (TEOS) and (3-glycidoxypropyl)-trimethoxysilane (GPTMS) along with chlorotrimethylsilane (CTMS) as trimethylsilyl group modifier to render hydrophobicity. The coated polycarbonate (Fig. 13) (dimension: 300 mm x 300 mm) with coating thicknesses 3 µm showed good hardness (4H) and adhesion properties having water contact angle (WCA) 1021°.




*Coated polycarbonate (water contact angle, WCA is shown in inset)*

## Developed transparent coatings ($TiO_2ZrO_2$) on glass with reflection values >30% in the Visible-NIR region (dimension: 300 x 300 $mm^2$)

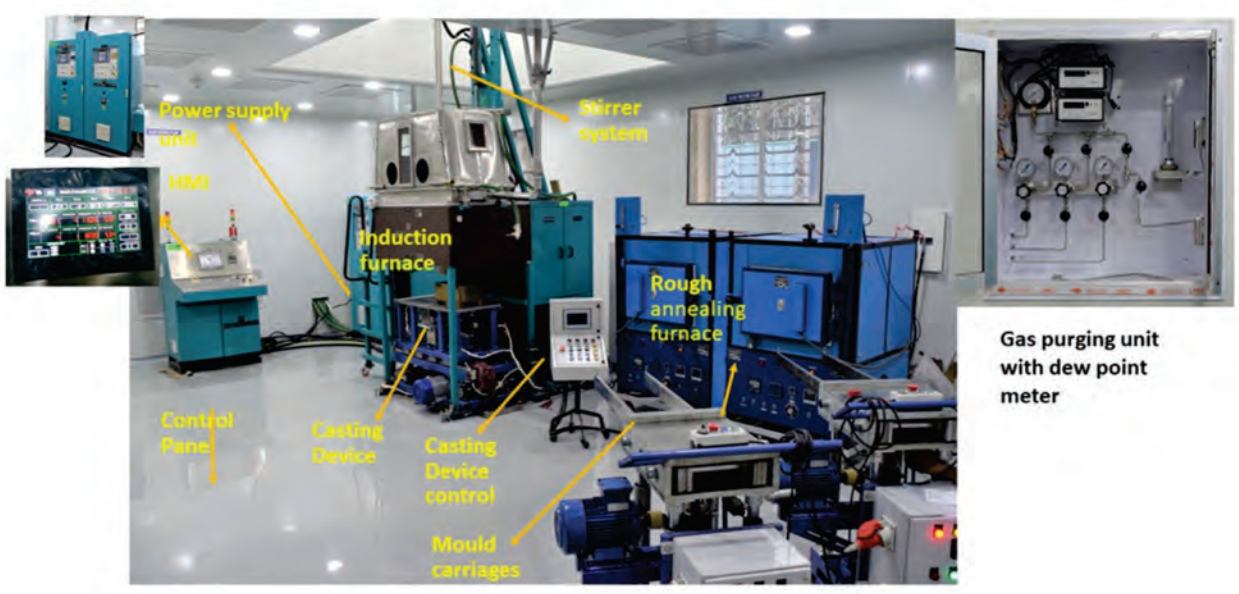
Single layer design $ZrO_2$ incorporated $TiO_2$ based transparent hard reflecting nanocomposite coatings on glass substrate have been developed by dip-coating technique using zirconium (IV) n-propoxide (ZP) and titanium (IV) isopropoxide (TTIP) followed by heat treatment. The coated glass could be used as component for efficient energy saving building materials with esthetic beauty. The coated glass (dimension: 300 x 300 $mm^2$) (Fig. 12) with coating physical thickness 90±10 nm and refractive index, 1.985±0.002 are to be uniform. The coating shows the pencil hardness 5H with good adhesion property. Coated glass shows >28% of average reflection (within wavelength range of 350-2500 nm) and 31% (wavelength range, 800-1200 nm).




*Photograph of $TiO_2$-$ZrO_2$ coated float glass along with reflection spectrum of coated glass substrate.*

## Establishment of 15L capacity glass melting facility for production of Nd-doped phosphate glass

A pilot plant of 15L scale glass melting facility has been set up recently for the production of large sized Nd-doped laser glass blocks following bottom pouring flow casting technique. The facility comprises of 15L Glass melting induction furnace having provision bottom pouring facility, semi-automatic glass casting device, annealing furnaces, and material handling devices. The facility has been shown in the following figure. It is important to mention that, all the equipment involved in this facility are indigenously developed and procured as the quality of the finally produced glass has to be very stringent the facility has been housed in 10000 class room with temperature and humidity control.

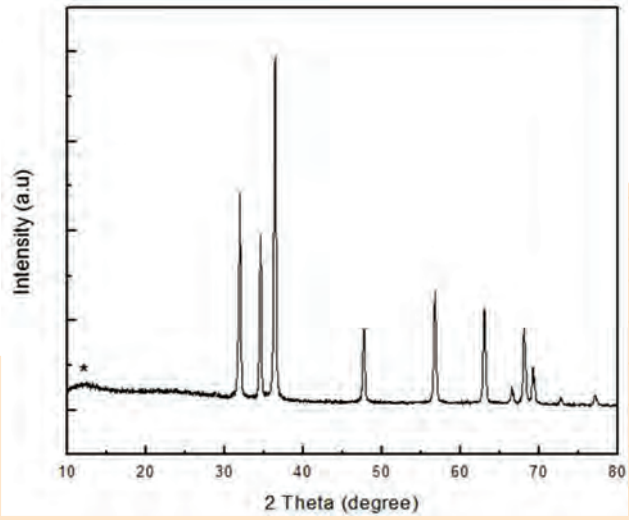



*Induction heating Glass melting facility of 15L capacity for the production of Nd-doped laser glass at CGCRI*

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

## Development of new generation nano metal oxide/ graphene-polymer composite materials for use in wearable electronics

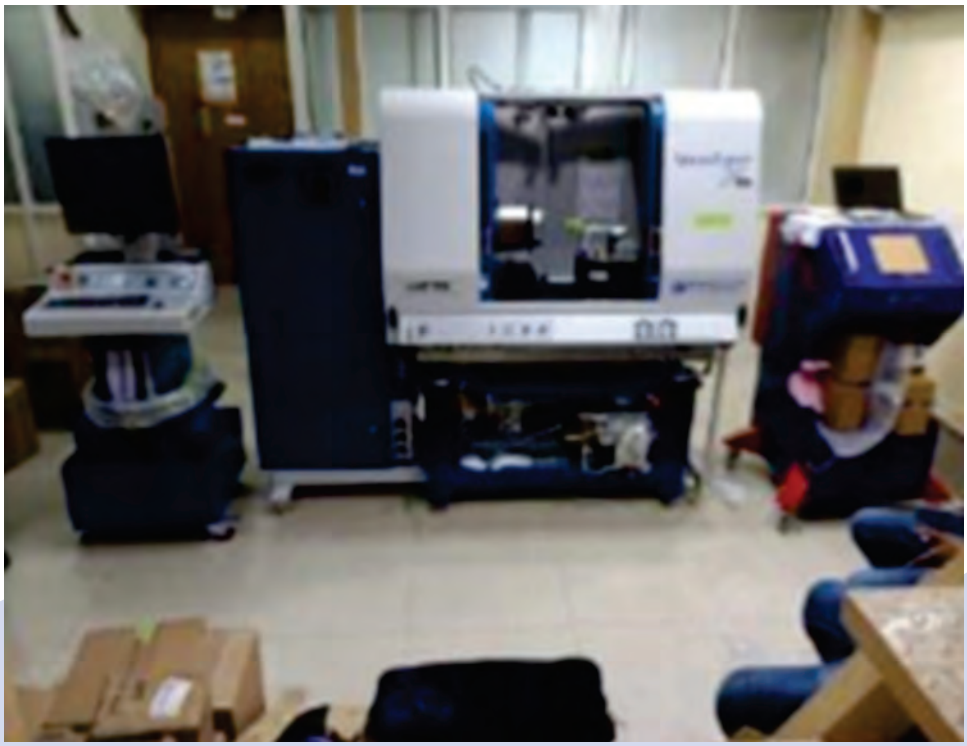
Nano zinc oxide/graphene-polymer composite materials with superior flexibility, high gauge factor and wide measurement range have been synthesized using hydrothermal, electrospinning and solvothermal methods. Mechanical, thermal, structural, morphological and piezoelectric properties of these materials have been studied in detail. The composites thus synthesized have been used to fabricate strain sensors after deposition of electrodes and were finally packaged with a thin polymeric layer for protection from mechanical wear and environmental damage. Sensors were flexible and possessed high sensitivity, linearity and reproducibility.


*(a) FESEM image and (b) X-ray Diffraction spectrum of ZnOnanorods grown on patterned substrate*

## Establishment of a Laser Assisted Ultra-Precision Machining Facility

In a major capacity strengthening exercise, a novel laser assisted ultra-precision machining facility has been established at NOCCD for fabrication of hard ceramic/alloy moulds with very high form accuracy and surface finish. The facility is slated to achieve ductile mode machining of brittle ceramic materials to enable attainment of extremely low Ra values (<5 nm) with an appreciably high material removal rate using laser assisted diamond turning compared to the finishing achieved by the traditional surface grinding process for ceramics.



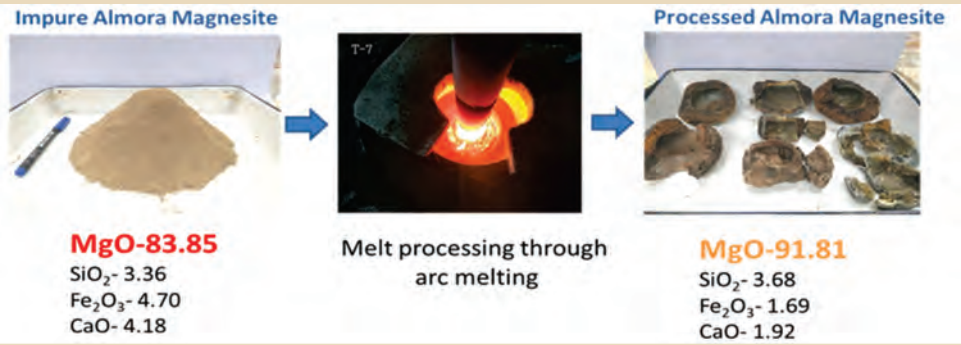
12 RESPONSIBLE CONSUMPTION AND PRODUCTION

## Superior fused magnesia from impure Indian magnesite for self-sustenance

Magnesia is the most important refractory raw materials used mainly in the steel and cement industries. Indian magnesite (mostly of Salem and Almora origin) is a less-preferred variant amidst the harsh steelmaking conditions (tapping temperature > 1700°C and slag basicity >3) due to their tendency to form low melting phases at elevated temperature, thereby affecting the refractory properties. Impurities removal has thus become an absolute necessity for proper utilization of Indian magnesite.

Keeping in view of the above, CSIR-CGCRI has taken up a project with special attention towards the purification of impure magnesite and the production of large magnesia crystals through fusion technique. These fused magnesia aggregates can be used mainly as for the production of MgO-C, Mag-chrome and fired magnesite refractory brick –which should show better corrosion resistance.

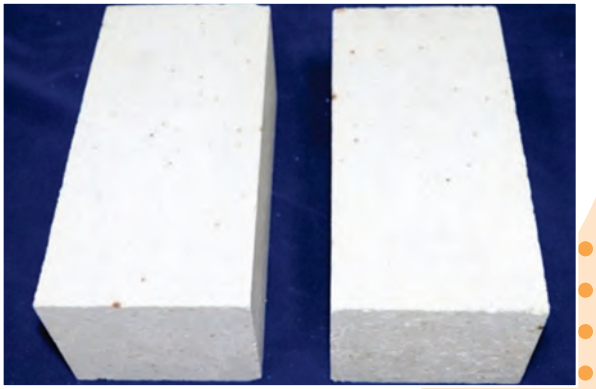
A comprehensive analysis of the indigenous magnesite of Almora was done to generate data that would build knowledgebase for future researchers and users of the raw material. Also, an arc-melting facility of 10 Litre crucible capacity has been established, which can be used for further research on magnesite and other ceramic raw materials. After extensive trials with magnesite, the correct batch composition, sequence of addition and operating conditions has been achieved. The melting operations have been progressively improved to melt and purify larger mass (2kg) of magnetite. MgO content of the fused magnesia increased from 83.85% to 91.81% with a significant reduction of impurities. The data generated from this study is scalable for the larger process.



12 RESPONSIBLE CONSUMPTION AND PRODUCTION

## Synthetic high alumina aggregates from sillimanite beach sand for refractory application

Alumina-based refractories are ubiquitous in several high temperature structural applications and the use of synthetic and purer raw materials for manufacturing of refractory products is a prerequisite for clean steel production. As a part of the work under this vertical, 100 kgs of high alumina (72%) aggregates were developed from sillimanite beach sand (a byproduct of rare earth extraction process of beach sand minerals), calcined alumina and additives through reaction-sintering process. Shaped and unshaped refractory developed from these aggregates showed better properties as compared to commercially available products.properties have been delivered to the user for further validation.




## Pyroplastic Behavior Of Clay Based Body Containing High Amount Of Fired Porcelain Scrap

Vitreous china sanitaryware is produced in large quantities in Thangadh and Morbi areas of Gujarat state in India. It is estimated that about 170000 pieces or 2380 ton of vitreous china sanitaryware articles are manufactured per day in Gujarat. Considering average 5% fired rejects, generation of vitreous porcelain scrap works out to be 119 ton per day. This is a good amount of any raw material to be considered for some value added application. Plenty of unutilized fired sanitaryware scrap is also available lying in vacant lands around the industrial areas. Ground vitreous china sanitaryware is a good source of mullite crystals, fine quartz and a glassy phase. Ground vitreous porcelain scrap (GVPS) added with talc in gradually increasing quantity was investigated for vitrification behavior in a clay based body. GVPS was added as a major component (50%) in the composition. Talc 0 to 8% and 0.5% barium were added to activate the glassy phase present in GVPS during firing and development of bonding. It is concluded that complete vitrification can be achieved without addition of feldspar in experimental clay bodies at 1160° C. Pyro-plasticity is the tendency of body to sag during firing under its own weight and softness created due to high temperature. GVPS body when added with talc in gradually increasing percentage the tendency of sag has increased proportionately. Also the increase in temperature has increased the Pyroplastic index. Lowest pyro plasticity is observed with no addition of talc at the lowest firing temperature. Pyro plasticity is increasing with increase of talc as well as increase of firing temperature. But with achieving maturity by keeping higher talc in the body and firing at lower temperature would favor low Pyroplastic index. The matured body is ultra-high strength porcelain. Further investigations on other aspects are required to develop this body for a complete production technology. However failure of above clay based bodies in crazing resistance test requires further study on body composition and suitably matching glaze composition.

## Development of light weight and anticorrosive material for shoe out soles

As a part of an initiative under LSRB of the DRDO, nano-graphite incorporated polyurethane based nanocomposite has been developed upto 2kg batch level for making light weight, anticorrosive and flexible shoe-outsoles for the use of military personnel working especially in marine environment. A facility has been created with the designed and fabricated reactor/smelter for making the nanocomposite by bottom pouring melt quenching technique. About 20 pairs of shoe-outsoles with the desired materials properties have been delivered to the user for further validation.



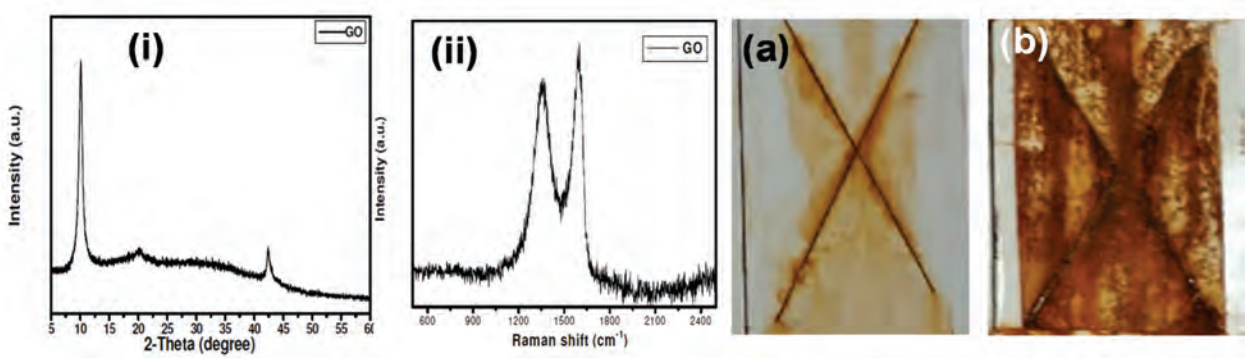
Stainless steel mould

Shoe outsoles developed at CSIR-CGCRI, Kolkata

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

## A process for the synthesis of graphene oxide and its application in paints

A lab scale (~50g/batch) synthesis of graphene oxide has been developed in partnership with industry. Based on the process technology, the sponsor is able to create a pilot plant production of graphene oxide upto 500g per batch. The produced graphene oxide has successfully been incorporated in different types of paints including epoxy based paint supplied by the sponsor to make the nanocomposite based paint high enhanced anticorrosive property.




*(i) XRD pattern and (ii) Raman spectrum of as-synthesized graphene oxide (GO). Photographs of salt spray test samples of (a) GO incorporated alkyd paint system and (b) alkyd paint system without incorporation of GO.*

## Up-scaling of refractory crucible for glass melting

RSW glass melting in indigenously developed 10L coarse body refractory crucible with fine body layer by tilt casting method using 10L scale Raising Hearth furnace, has been successful. This is currently being scaled up to a 60L scale using in-house fabricated 60L Crucible in the existing pre-melting furnace.

For complete densification and desired phase formation, these crucibles were required to be fired at higher temperature, i.e., more than 1500°C. The exercise was undertaken with participation of industry wherein the green coated crucibles were biscuit fired at 900°C followed by 1400°C and finally sintered at 1520°C. Two such crucibles have been fired and more than 72% mullite was formed at this temperature with significantly lower cristobalite and corundum phases. Two numbers of in-house fabricated 60L scale stirrer biscuit fired at 960°C was also successfully carried out.

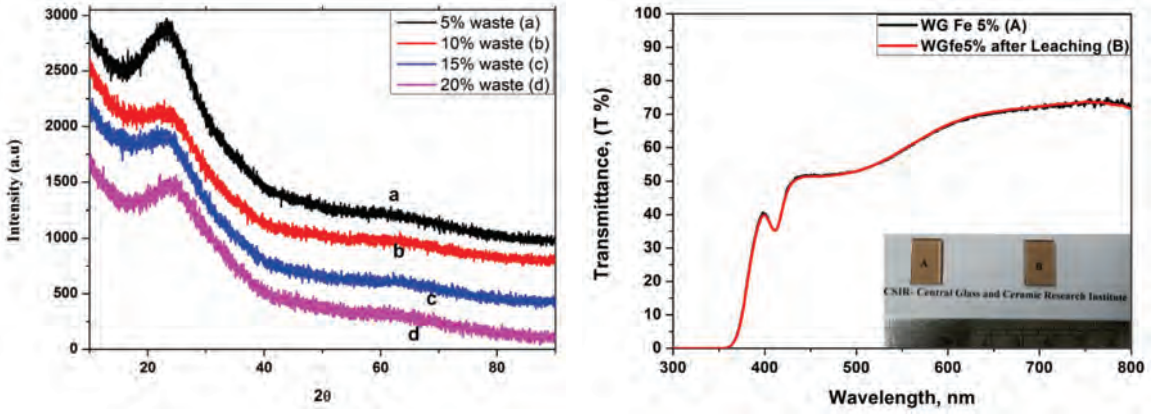

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

## Utilization of toxic waste in glass making

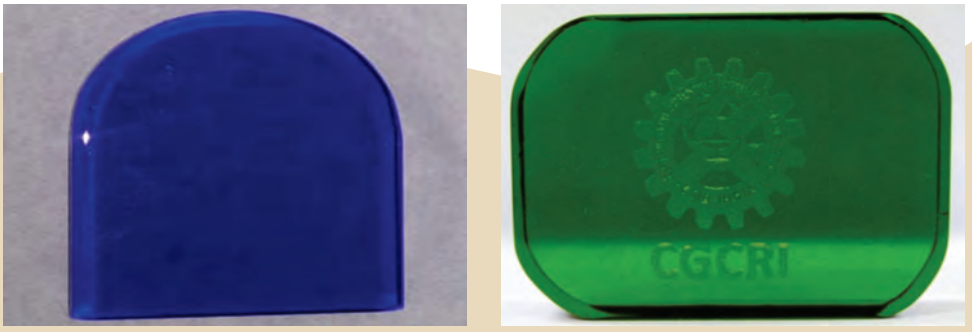
Arsenic contamination of groundwater is a major challenge causing serious arsenic poisoning to large numbers of people. There are several ways to remove arsenic from the ground water in order to make suitable for human consumption. However, arsenic contaminated sludge after treatment followed by filtration is discharged in land creating serious contamination of surface water. Similarly, toxic effects of tannery solid waste (TSW) and effluent on plants, animals and human are mainly reported with chromium toxicity. Hexavalent chromium is a powerful agent that induces mutations and causes cancer in animals and human. The effluents and sludge from tanning operations as well as from biological treatments are discharged into water bodies and onto land creating serious pollution problems. Electrical and electronic waste (e-waste) also accounts for one of the largest growing waste stream. E-wastes contain over 1000 different substances many of which are toxic and potentially hazardous for environment and human health. Although the metals like cu, Ag, Au are recovered, glass part of E-waste is most often dumped into landfills. Over time, the e-waste leads to certain amount of chemical and metal leaching. This can very often lead to ground water contamination.

CSIR-CGCRI investigated feasibility of utilization of all the above waste in glass making. Preliminary study has been undertaken and encouraging result obtained with the incorporation of As contaminated sludge obtained from water filtration, e-waste glass and tannery solid waste into glass matrix to develop various glass products. Incorporation of TSW into glass matrix may be used to produce filter glass particularly green filter glass and decorative glass article. Optimization of composition yield UV transmittance 70% at ~370 nm and no significant visible transmission is recorded up to 750 nm. Similarly, As containing sludge is also incorporated into glass matrix and brown color glass is obtained. Significant chemical durability has also been observed in both the cases under submerged in distilled water at 75°C. No

leaching of hazardous element (As, Cr, Fe, Co, Ni, Pb etc.) is detected in distilled water from the glass. The potential use of the glass containing As sludge can be in window panel significantly reducing electricity load in the building. The glass containing TSW can be used for development of different glass product such as green filter glass, decorated glass, table ware glass etc. In another study, 90% of e-waste glass can be reutilized as culet or raw material in glass making and various glass products glass particularly color glasses could be produced.




*XRD profile of glass containing 5-20 wt.% of As contaminated sludge obtained from filtration of contaminated ground water; (Right) UV-Vis spectra of glass prepared with 5% As sludge before and after leaching study. (Inset: A – Polished Glass prepared with 5% As sludge; B-Glass after submerged in water for 14 days at 75°C).*

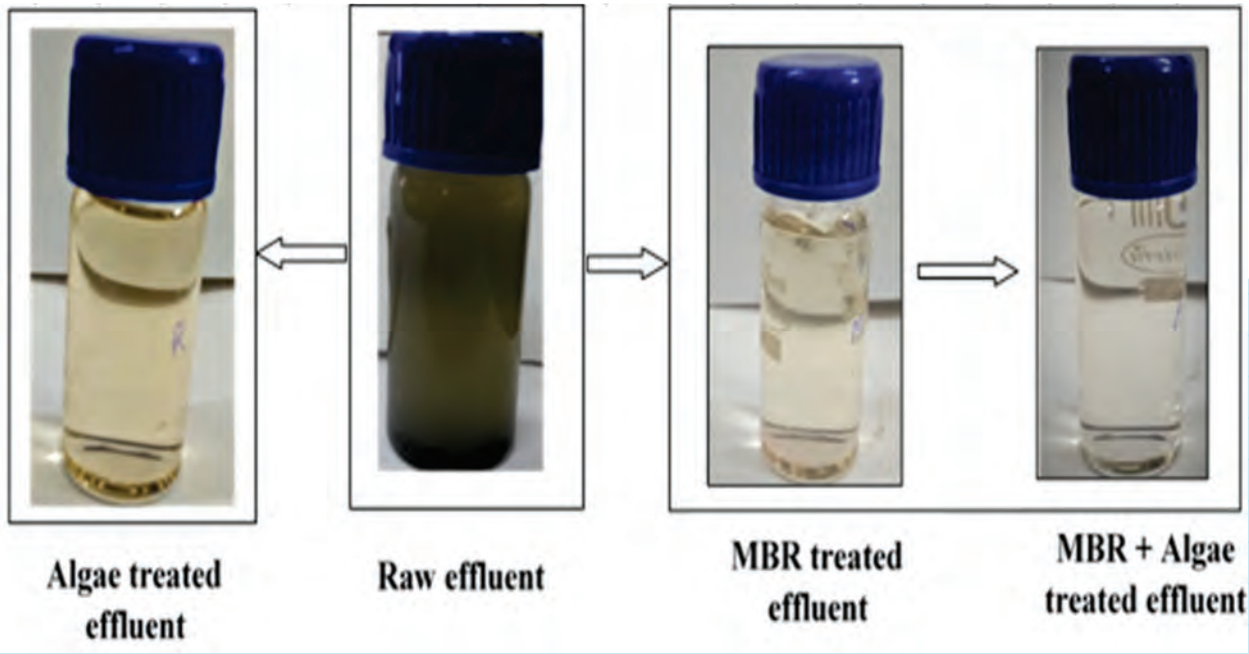



*Blue colored glass utilizing tube light/fluorescent glass waste (Left); Glass souvenir prepared from Tannery solid waste (Right)*

6 CLEAN WATER AND SANITATION

## Tannery waste water treatment using membrane bioreactor

Tannery effluent was collected from a leather processing unit located at Bantala leather complex, Kolkata and characterized in detail. The effluent showed typical value of COD 6500 mg/L, $BOD_5$ 1000 mg/L and $Cr^{+6}$ content of 70 mg/L. Batch mode bioreactor studies were done with tannery effluent and an effective bacterial consortium was identified and selected depending on the removal of COD, $BOD_5$ and hexavalent chromium. Microorganisms responsible for biodegradation were preliminary identified as *Bacillus* sp., *E. coli* (by Gram staining method, lactose fermentation test, EMB agar test). Bentonite clay was used to prepare ceramic ultrafiltration membrane on clay alumina based tubular support.



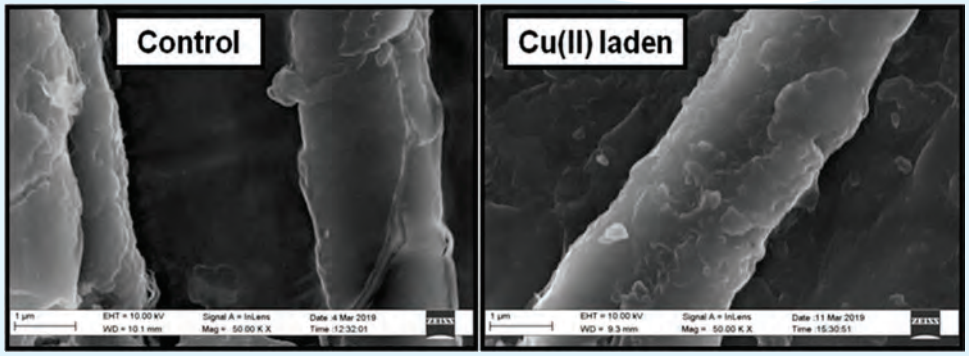
# WATER TECHNOLOGY

6 CLEAN WATER AND SANITATION

## An integrated technology development forbiosorption with ceramic membrane based microfiltration treatment of toxic metal containing wastewater

The spent biosorbent generated after multi-metal (Ni(II), Co(II), Zn(II) and Cd(II)) biosorption using dried activated waste tannery sludge were applied for glyphosate removal. The removal efficiency could be enhanced from 26.18 % to >92% after increase in the multi-metal loading on the sludge. The process showed a gradual removal at wide pH range within 24-28 h of contact time. Similar biosorption efficiency (91.7%) was observed for treatment of simulated agricultural wastewater.

The biochar developed from jute industry waste commonly known as jute caddies was proposed as low cost, easy to prepared, efficient and suitable adsorbent for removal of Cu(II) metal ions from synthetic as well as from simulated jute industry wastewater. Feasibility study for real effluent treatment exhibited comparable adsorption efficiency as the synthetic Cu(II) solution. The studies showedabout 98.74% removal at pH 5.1 and 97.15% removal of Cu(II) at without adjusted pH of the Cu(II) simulated jute industry wastewater. The maximum adsorption capacity for Cu(II) ions onto the developed biochar was found 588.25mgg-1 at original pH of the metal solution within 4h of the contact time.

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