

2024

CSIR-CGCRI

TECHNOLOGY COMPENDIUM



CSIR-Central Glass & Ceramic Research Institute, Kolkata

Editorial

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भारत का नवाचार इंजन
The Innovation Engine of India



2024

CSIR-CGCRI TECHNOLOGY COMPENDIUM

CSIR-Central Glass & Ceramic Research Institute, Kolkata

Foreword

CSIR system is widely recognized as the innovation engine of our great nation. It is believed that the core competence of CSIR-CGCRI is unmatched by many national labs worldwide in the area of ceramics and glass and the institute, being one of the first five national labs that were established, has grown from strength to strength from traditional ceramics like refractories to advanced ceramics like fiber optics, fuel cells, bioceramics, ceramic membranes, sensors, etc. When it comes to strategic sector, CSIR-CGCRI has a very special place in India and has continuously positioned and repositioned itself with the pressing challenges for technology denials in strategic sectors. Artificial intelligence and Machine learning are some of the emerging areas where CSIR-CGCRI is poised to venture into creating newer and better understanding of the structure-property-performance of ceramics and glasses. India is a country of 1.4 billion people and more than 80% of the biomaterials and implants are imported. CSIR-CGCRI has contributed significantly to this sector in developing biomedical implants for orthopedic applications.

Over 75 years of its glorious journey, CSIR-CGCRI has contributed significantly to strategic sectors, private stakeholders while having collaborations with academia, both nationally and internationally. With innovation hubs and companies investing more in translational programs, CSIR-CGCRI is aligned towards engaging itself among the frontrunners in translational research. Several technologies of CSIR-CGCRI have been commercialized to industries in the recent past and many are on the verge of commercial exploitation. This ‘Technology Compendium 2024’ represents to provide a glimpse of CSIR-CGCRI’s technology portfolio for connecting with key stakeholders.

I hope this compendium will serve the purpose in fulfilling our dream of making India self-reliant in technology arena globally.

Prof. Bikramjit Basu, FNA FNAE FNASc FASc FAMS

Director, CSIR-CGCRI

About Director




Bikramjit Basu

Education and Professional Career

PhD, Engineering Ceramics (2001) 
 Katholieke Universiteit Leuven, Belgium
Assistant/ Associate Professor, Indian
 Institute of Technology Kanpur (2001-11)
Associate/Full Professor, Indian Institute
 of Science, Bangalore (2011-2024) 
Director, CSIR-Central Glass & Ceramic
 Research Institute, Kolkata (2024 -) 

Elected Fellow of National Academies

Indian National Science Academy (2020) 
 Indian Academy of Sciences (2020) 
 National Academy of Medical Sciences
 (2017) 
 Indian National Academy of Engineering
 (2015) 
 National Academy of Sciences India
 (2013) 

Career Highlights

Research interests: Engineering Ceramics, Glass, Medical devices
[>300 research papers (Citation>19,500, H-index: 73), 5 textbooks, 4 tech transfers]

Major Honor/ Elected Fellow

Shanti Swarup Bhatnagar Prize, Engineering Science,
 Government of India (2013) 
Richard Brook Award and Fellow, European Ceramic
 Society (2021) 
Humboldt Research award
 AvH foundation, Germany (2022) 
World Academy of Ceramics (2024) 
 International Academy of Medical
 and Biological Engineering (2020) 
 International Union of Societies for
 Biomaterials Sci. and Engg. (2020) 
Elected Fellow, American Ceramic Society (2019), Coble award (2008) 
 Chartered Engineer/Fellow, Institute
 of Materials, Minerals & Mining, UK (2017) 
 American Institute for Medical and
 Biological Engineering, USA (2017) 

Key Appointments and Services

Associate Editor
 Biomaterials, Elsevier Journal
 (Impact Factor: 15.2) (2023-) 
Honorary Professor,
 Henry Royce Institute/ University
 of Manchester, UK (2017-) 
President,
 Society for Biomaterials and
 Artificial Organs, India (2021-24) 
Advisor, Medical Materials
 Business, TATA Steel (2017- 
Erasmus Visiting Professor,
 Univ. Polytech. Catalonia, Spain (2007)
 University of Ljubljana (2018/23) 
Chair, Bioceramics Division,
 International Strategic Planning
 Committee, Panel of Fellows 
Visiting Professor
 University of Lille; UPHF, France
 FUNGLASS Center, Slovakia (2021/22) 


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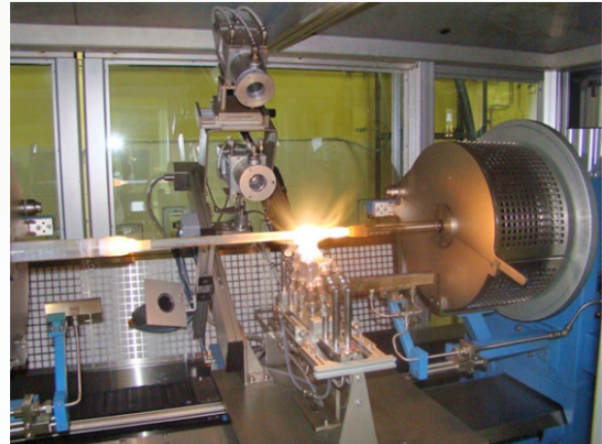
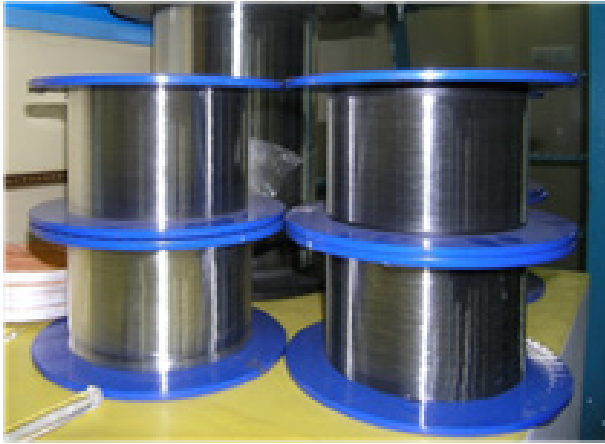
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**CSIR–Central Glass & Ceramic
Research Institute, Kolkata**

TECHNOLOGY

Specialty Optical Fibers



Salient Features

- » Er-doped fiber for CATV and C-band optical amplifier
- » Non-Linear Photonic Crystal Fiber (PCF) for Supercontinuum Source (500 – 2200nm)
- » Double-clad Yb-doped fiber for laser application @ 1 micron regime

Technology: Specialty Optical Fibers

Domain: Fibre Optics

IPR Status: Patented

Specification:

Fibre Parameters	Specifications
Cut-off Wavelength	900 - 950nm
Mode Field Diameter at 1550nm	$6.0 \pm 0.5 \mu\text{m}$
Absorption at Pump Wavelength (980 nm)	4.0 dB/m
Background Loss	<10 dB/Km
Fibre Diameter	$125 \pm 0.5 \mu\text{m}$
Coating Diameter	$245 \pm 2 \mu\text{m}$
Coating Type	Dual Acrylate

TRL: 8

Application/Uses: Optical Fiber Amplifier / Laser, Supercontinuum Source

Level/Scale of Development: Commercialized product, Commercialized through industrial partner

Line Ministry Mapping/ User Sector: Department of Telecommunications, MeitY/ Telecommunication and IT sector



Er-doped Fiber Amplifier (EDFA)



Commercial EDFA for Cable TV (CATV) Network

Salient Features

- » Output power up to 24dBm
- » Wide input dynamic range
- » Low noise figure
- » 1 U 19 inches Rack mount type

Technology: Er-doped Fiber Amplifier (EDFA)

Domain: Fibre Optics

IPR: Patented on Er doped fiber (produced by CGCRI) which is the key component of an EDFA.

Specification:

- » Operating wavelength: 1530 to 1565 nm (C-band)
- » I/P Signal Power: - 10 to +3 dBm
- » O/P Signal Power: 23 dBm (max)
- » Optical Gain: 20 to 30dB
- » Gain flatness: ± 0.5 dB
- » Noise Figure: < 6 dB

TRL: 8

Application/Uses: Cable-TV, Optical communication system

Level/ Scale of Development: Commercialized product/ Commercialized through industrial partner

Line Ministry Mapping/ User Sector: Department of Telecommunications, MeitY/ Telecommunication and IT sector



Specialty Glass Bead



Borosilicate Glass Frit



Borosilicate Glass Bead

Salient Features

- » Use of glass bead of desired sizes made out of the melted frits (as basic precursor towards the formation of glass bead) has enhanced the process throughput and hence facilitated the immobilization of radioactive nuclear waste being adopted in the Joule Melter
- » Spherical beads of dimensions in the range of 2-4 mm with stringent physical, chemical and mechanical properties have facilitated feeding into the Joule Melter and allow remote control of the entire operation. Technology is closely guarded and the material is critical for country's ambitious nuclear programme.

Technology: Specialty Glass Bead

Domain: Specialty Glass

IPR: Patented

TRL: 8

Application/Uses:

- » Immobilization of high level radioactive liquid waste containing radioisotopes (which remain active for prolonged period) for safe disposal without threat to the environment.
- » Strong impact on sustaining country's ambitious three-stage nuclear recycle program and significant contribution to power requirement

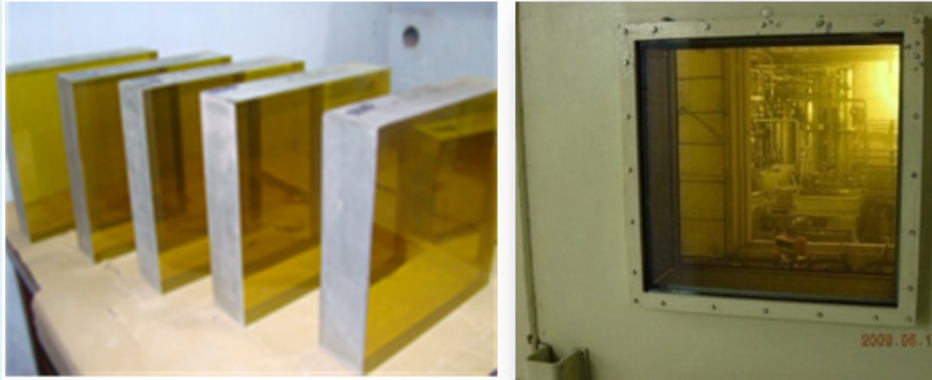
Level/ Scale of Development: Commercialized product.

Commercialized through Industry partner

Line Ministry Mapping/ User Sector: Department of Atomic Energy/ Nuclear Power establishments



Radiation Shielding Window (RSW) Glass



Salient Features

- » Involves cullet making in 310 lit refractory pot, final melting in 40 lit platinum pot, casting through bottom pouring technique (cast block size is $425 \times 425 \times 130$ mm³), annealing and final processing
- » Windows of dimensions $550 \times 550 \times 50$ mm and $700 \times 700 \times 35$ mm from the same melt size through slumping technique in order to increase the viewing area has been developed

Technology: High Density Radiation Shielding Window Glass for Nuclear Hot Cell Application

Domain: Specialty Glass

IPR: Trade Secret

TRL: 9

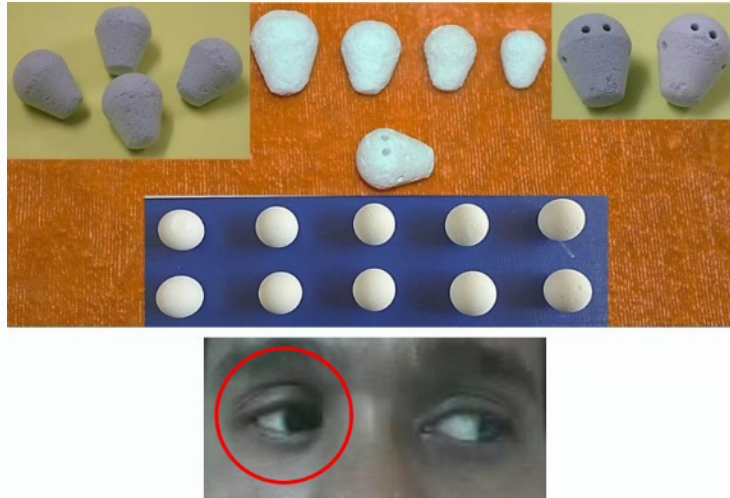
Application/Uses: Nuclear Hot cell, X-ray room, Operation theatre, Radiation therapy room

Level/ Scale of Development: Pilot scale facility established. Technology for producing homogeneous and defect free high density RSW glass blocks up to $400 \times 400 \times 100$ mm³ sizes successfully demonstrated

Line Ministry Mapping/ User Sector: Department of Atomic Energy



Hydroxyapatite Based Integrated Orbital Implant



Salient Features

- » Light weight, highly porous orbital implant made using bioactive hydroxyapatite.
- » The implant comes in different sizes to suit different patients.
- » Implants are made highly porous using innovative and economical process developed by CSIR-CGCRI.
- » The high porosity of the implant enables tissue ingrowth thereby provides natural eye movement that is synchronized with other natural eye.

Technology: Hydroxyapatite based integrated orbital implant

Domain: Bio ceramics

IPR Status: Patented

Specification:

- » Bulk density = 0.61 g/c.c.
- » Total weight = < 2 g;
- » Porosity: ~ 60%;
- » Pore size: 100-300 m;
- » Compressive strength: 5-6 MPa

TRL: 9

Application/Uses: Healthcare; Ophthalmology

Level/Scale of Development: Commercialized through industry partner.

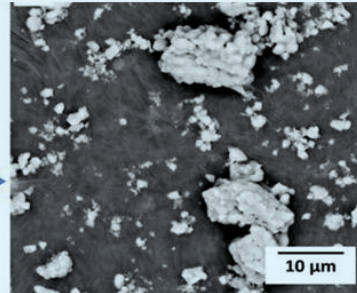
Line Ministry Mapping/ User Sector: Ministry of Health & Family Welfare



Hydroxyapatite/ β -tricalcium Phosphate from Biogenic Resource



Dried raw fish scales



**Nano crystalline
Hydroxyapatite**

Salient Features

- » Multi ion containing phase pure calcium phosphate powder/ granules synthesized from fish scale
- » Low cost raw material, process can be upscale able easily – product (calcium phosphate) will be much cheaper
- » The main advantage of the naturally derived calcium phosphate ceramics containing trace elements like Na, K, Mg, Sr, etc which are very useful for bone regeneration.
- » Most importantly, these trace elements are present in optimum concentrations fixed by nature.

Technology: Hydroxyapatite/ β -tricalcium phosphate from biogenic resource

Domain: Bio ceramics

IPR Status: Patented

Specification: Phase pure calcium phosphate ceramics containing trace elements like Na, K, Mg, Sr,

TRL: 6

Application/Uses: ceramic is suitable for use in the repair of infected or aseptic bone defects in a wide variety of orthopaedic, dental and maxillofacial abnormalities as a substitute for natural bone material.

Level/Scale of Development: Preclinical trial completed

Line Ministry Mapping/ User Sector: Ministry of Health and Family Welfare



SrTiO₃ Based Composite as Spherical Granules and Porous Scaffolds for Dental and Orthopaedic Applications



Salient Features

- » The porous SrTiO₃ sample found to be biocompatible and gradually release of Sr²⁺ ions in body fluid
- » Monolithic SrTiO₃ sample showed 3 times higher compressive strength than Hydroxyapatite (HAp)
- » In vivo study showed more new bone formation in SrTiO₃ composite scaffold than the HAp scaffold

Technology: SrTiO₃ based Composite as spherical granules and porous scaffolds for dental and orthopaedic applications

Domain: Bio ceramics

IPR Status: Patented

Specification: customized size spherical granules with porosity more than 40%, SrTiO₃ material showed good biocompatibility, osteoconductivity and high load bearing capability

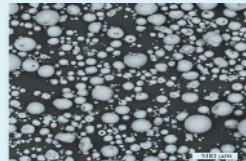
TRL: 6

Application/Uses: new ceramic is suitable for use in the repair of infected or aseptic bone defects in a wide variety of orthopaedic, dental and maxillofacial abnormalities as a substitute for natural bone material.

Level/Scale of Development: Preclinical trial completed

Line Ministry Mapping/ User Sector: Ministry of Health and Family Welfare

Plasma Spray Grade Hydroxyapatite (HAp) Granules and Plasma Spray Coating on Metallic Biomedical Implants



HAp granules



Plasma spray HAp coated
finger joint



Plasma sprayed hydroxyapatite coating
on hip stem and acetabular shell



Plasma spray HAp coated
dental implant

Salient Features

- » This technology offers a complete solution for plasma spraying of pure HAp coating on metallic implants including preparation of free-flow plasma spray grade HAp granules.
- » Free flow, nearly spherical shaped plasma spray grade phase-pure HAp granules prepared by a simple, economical wet chemical synthesis and spray fabrication technology.
- » These granules are used to deposit highly crystalline coating of HAp on metallic implants through industrially popular air plasma spraying technology for variety of orthopaedic and dental applications.

Technology: Plasma spray grade hydroxyapatite (HAp) granules and plasma spray coating on metallic biomedical implants

Domain: Bio ceramics

IPR Status: Patented

Specification:

- » Composition: Phase pure HAp (as per ASTM F1185)
- » Granule Characteristics: 20-100 m, porous, freely flowable.
- » Coating thickness: 100-200 m; Degree of crystallinity: ~ 70%
- » Bonding/ adhesive strength: 15-25 MPa; Porosity: 8-12%
- » Roughness: 7-12 m (as per ISO 13779)

TRL: 7-8

Application/Uses: Healthcare; Orthopaedic, dental; Orthopaedic – THR, spinal implants, metacarpophalangeal (MCP) joints, etc.; Dental: Filler, cement, implant, etc.

Level/Scale of Development: Commercialized through industry partner (Granules)

Line Ministry Mapping/ User Sector: Ministry of Health & Family Welfare



Technology for Manufacturing Alumina Ceramic Based Femoral Head and Cup (alumina ceramic or PE) for Total Hip Replacement (THR)



Salient Features

- » Affordable and state-of-the-art healthcare solution
- » Both femoral head and cup are biologically and chemically inert, non-toxic, biocompatible and needs almost no replacement while the conventional metallic ones give rise to local infection occasionally, prone to chemical corrosion in body fluid, need replacement after regular intervals of 10 years.
- » The articulating surfaces being harder than conventional ones would offer better wear resistance and therefore longer service life when used in different combinations of ball and cup.
- » Different designs of commercially available stems (made of either SS 316 L or Ti-6Al-4V alloy) can be safely used with this ceramic femoral head and cup.

Technology: Technology for manufacturing alumina ceramic based femoral head and cup (alumina ceramic or PE) for total hip replacement (THR)

Domain: Bio ceramics

IPR Status: Patented

Specification:

- » Ceramic head: In compliance with ISO Spec.
- » Density: > 3.90 g/cc; Hardness: ~ 19 GPa;
- » Compressive strength: ~ 1200 MPa;
- » Burst strength: ~ 60 kN;
- » Fracture toughness: ~ 3 MPa.m^{1/2};
- » Surface finish (Ra): ~ 0.05 m

TRL: 9

Application/Uses: Healthcare; Total hip replacement (THR) implants based on ceramic head and ceramic/ polymer acetabular cup

Level/Scale of Development: Commercialized product (ceramic-to-polymer); Commercialized through industry partner Completed single-centric clinical trials (ceramic-to-ceramic)

Line Ministry Mapping/ User Sector: Ministry of Health & Family Welfare



Technology for Manufacturing New ZTA Ceramic Based Femoral Head and Cup (alumina ceramic or PE) for Total Hip Replacement (THR)



Salient Features

- » Affordable and state-of-the-art healthcare solution
- » Range of new compositions of ZTA with tailored mechanical properties and enhanced fracture toughness without compromising other mechanical properties, such as, hardness
- » Due to surface wettability characteristics, it provides low coefficient of friction and therefore squeaking is expected to be reduced post implantation
- » New ZTA composite composition enhances interaction with physiological environment forming lubricious tribofilm leading to low coefficient of friction
- » The composite composition helps in effective sintering without grain growth and form high aspect ratio phases that can improve fracture resistance

Technology: Technology for manufacturing new ZTA ceramic based femoral head and cup (alumina ceramic or PE) for total hip replacement (THR)

Domain: Bio ceramics

IPR Status: Patented

Specification:

- » Patented Composition
- » Hardness: Upto 2100 HV
- » Fracture toughness: Upto 10 MPa√m

TRL: 7

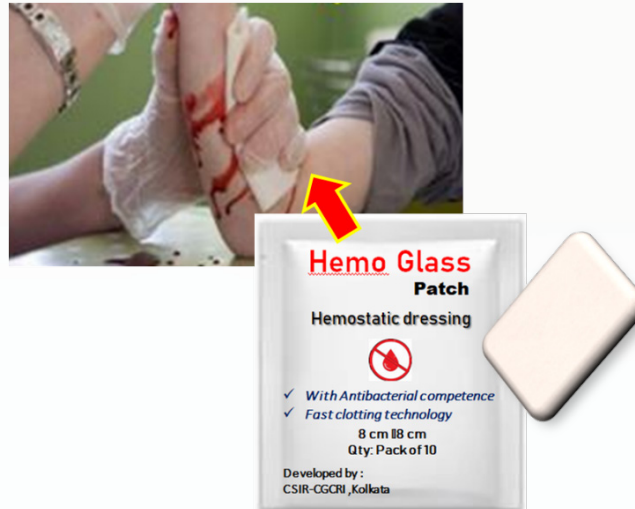
Application/Uses: Healthcare; Total Hip Replacement (THR) implants based on new ZTA ceramic head and new ZTA ceramic/ polymer acetabular cup

Level/Scale of Development: Commercialized through industry partner

Line Ministry Mapping/ User Sector: Ministry of Health & Family Welfare



Mesoporous Antibacterial Bioactive Glass Based Hemostatic Dressing for Profusely Bleeding Military Wounds



Salient Features

- » Rapid action hemostasis
- » Affordable cost (1/8th of the imported brands, 1/2 of indigenous brand)
- » Easy to use for soldiers in remote battlefields
- » Complete indigenous development

Technology: Mesoporous antibacterial bioactive glass based hemostatic dressing for profusely bleeding military wounds

Domain: Bio ceramics

IPR: Patented

Specification: Composition- $\text{Al}_2\text{O}_3\cdot\text{ZnO}\cdot\text{CaO}\cdot\text{SiO}_2$ based bioactive glass, PT ($26.00\text{-}28.00 \pm 0.68\text{sec}$) /APTT ($21.00\text{-}24.00 \pm 1.25\text{sec}$), Post treatment blood loss $1.5\text{-}1.7 \pm 0.31\%$, Bleeding time-120-127 sec

TRL: 7-8

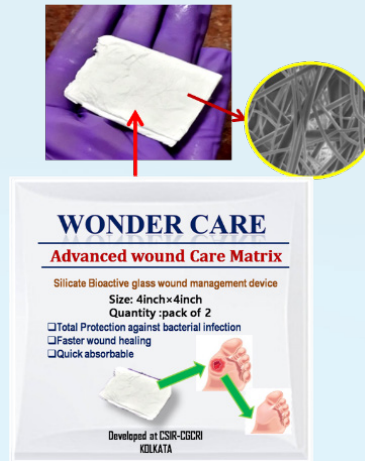
Application/Uses: In healthcare, Stops profuse arterial bleeding due to military combat/fatal accidents, rapidly

Level/Scale of development: Lab level (Phase 1 clinical trial awaited)

Line Ministry/User sector: Ministry of Health and Family Welfare, Ministry of Defence



Antibacterial Bioactive Glass Micro Nanofibre Based Advanced Wound Care Matrix



Salient Features

- » Fast healing of chronic wound within 10-14 days
- » Applicable to low to high exudating wounds
- » Prevents bacterial contamination at the wound bed
- » Easy to use at affordable cost
- » Complete Indigenous development with NO competitor

Technology: Antibacterial bioactive glass micro nanofibre based advanced wound care matrix

Domain: Bio ceramics

IPR: Patented

Specification: Composition-Ag.CaO-SiO₂ based bioactive glass, water solubility-10 to 1 g/L , Tensile strength-13-17 MPa, stability at 25°C and 75% humidity is 1-3 months, at 0°C, 6-8 months, Minimum Inhibitory Concentration (MIC): 0.4 to 0.5 µg/ml

TRL: 7-8 (Phase 1 clinical trial being initiated)

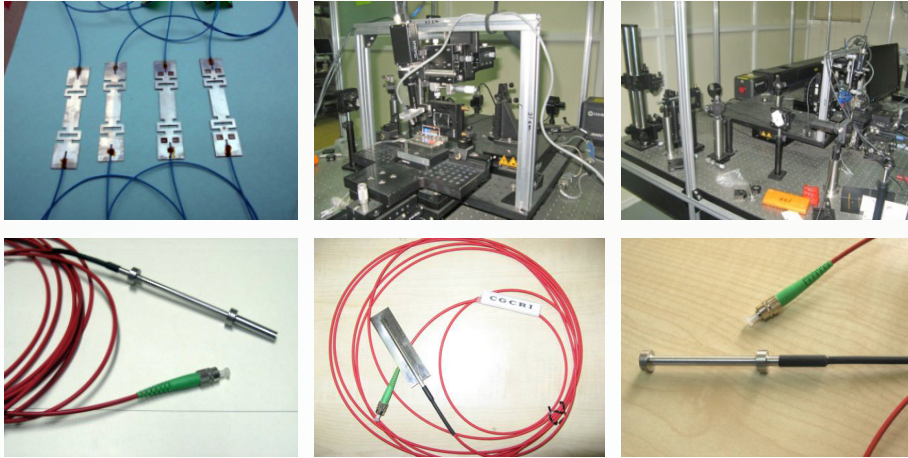
Application/Uses: In healthcare, for treatment of chronic/nonhealing wound, fast wound closure without a scar mark

Level/Scale of development: Lab level (Phase 1 clinical trial being initiated)

Line Ministry/User sector: Ministry of Health and Family Welfare



Optical Fiber Bragg Grating (FBG) Based Sensors



Salient Features

- » Optical fiber based sensing devices
- » Free from electromagnetic interference
- » Operable in harsh environments where conventional sensors are unusable
- » Can be used in distributed form i.e. over hundreds of sensors in a single optical fiber
- » Tiny sensors so easily embeddable in structures during fabrication of structures leading to development of intelligent infrastructure

Technology: Optical fiber Bragg grating (FBG) based sensors for smart infrastructure and industrial process monitoring

Domain: Fibre Optics & Photonics

IPR: Patented

TRL: 6

Application/ Uses: Structural health monitoring and industrial process control

Level/Scale of Development: Prototypes of FBG based strain, temperature, pressure and vibration sensors developed and deployed.

Line Ministry Mapping/ User sector: Ministry of Telecommunications/ Ministry of railways/ Ministry of Urban Development



Electrochromic Coatings- A Trendsetter for Smart Devices



Electrochromic Smart Window

Electrochromic Smart Display

Salient Features

- » Fabrication process is very simple and cost effective
- » Fast Switching Response time
- » Quick Recovery to initial state
- » Battery operable and hand held
- » High color efficiency
- » Easily upscalable
- » Indigenised development

Technology: Electrochromic Coatings- A Trendsetter for Smart Devices

Domain: Coatings/ Smart Electronics

IPR Status: Patented

Specification:

- » Colouration time < 5 s and Bleaching time < 3s with repeatability
- » Optical contrast (> 80% at 633 nm)
- » Colouration efficiency in the order of $3 \times 10^2 \text{ cm}^2 \text{ C}^{-1}$
- » Alternative of existing LED/ECD devices and substitute for the existing smart window PDLC glasses

TRL: 4

Application/Uses: Adaptive brightness in information display, glare-free automotive rear-view mirrors, sunroofs, smart windows in buildings and aircrafts, smart sunglasses are few examples where such coatings are used

Level/Scale of Development: Lab level Prototypes of Advanced Electrochromic Assembly

Line Ministry Mapping/ User Sector: Automotive, Aerospace, Infra structures, Energy sectors etc.



Moisture Sensor in Transformer Oil (5-100 ppm moisture)



Sensor dip in transformer oil
with data transmitter system



Sensor data receiver system
from transformer (500 m)



Moisture meter

Salient Features

- » Sol-gel derived cost-effective ceramic capacitive sensor;
- » Online detection of transformer oil trace moisture in the range of 5-100 ppm;
- » Wireless communication up to 800 m in free air;

Technology: Moisture sensor (5-95%RH) Moisture meter (5-100 ppm moisture)

Domain: Functional Materials, Sensor

IPR: Patented

Specification:

Description	Trace moisture sensor
Measuring Range	5 -100 ppm
Accuracy (at 300C)	± 1 ppm
Temperature Limits	100 – 100°C
Response Time (90%)	10 s
Powder Supply/Consumption	9 Volt DC, <10 mA
Weight	200g
Options	Digital/LCD OR LED Display

TRL: 6

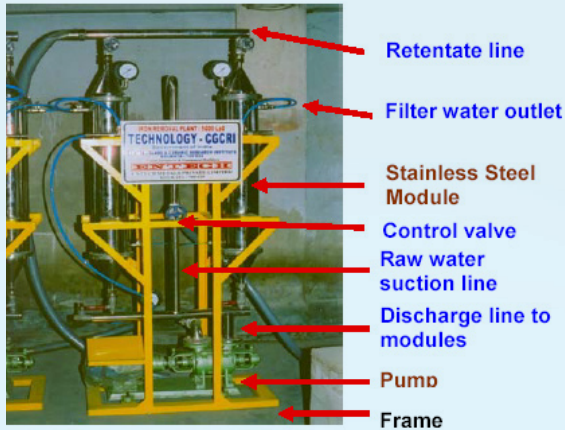
Application/Uses: Moisture detection in any system or environment

Level/Scale of Development: Lab Scale

Line Ministry Mapping/ User sector: Ministry of Power/
Ministry of Steel/ Department of Commerce etc.



Water Purification through Ceramic Membrane Based Process



Salient Features

- » Technology is essentially a hybrid type comprising of two steps
 - Adsorption of arsenic by the colloidal media particles suspended in water; and
 - Application of membrane based separation technique for solid-liquid separation using ceramic micro-filtration membrane modules
- » The level of purification achieved is as per WHO recommended limits for arsenic (<0.01 ppm) and iron (<0.3 ppm) in drinking water

Technology: Water Purification through Ceramic membrane-based process

Domain: Membrane separation technologies

IPR: Off Patent

TRL: 8

Application/ Uses:

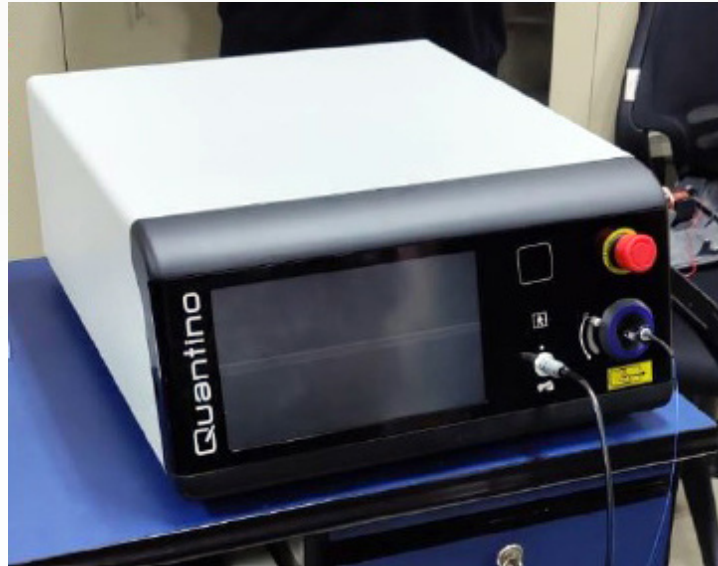
- » Removal of arsenic and iron from contaminated groundwater for production of Quality Drinking Water
- » Pretreatment of river water for removal of colloidal material to produce drinking water by Ceramic Membrane based process

Level/ Scale of Development: Developed and deployed through licensees at multiple locations

Line Ministry mapping/ User Sector: Department of Public Health Engineering/ Ministry of Rural Development etc.



Continuous Wave (CW) Thulium Fiber Laser (TFL)



Salient Features

- » Thulium fiber laser at operating wavelength of $1.94\mu\text{m}$
- » Average power: 30 W, Modulated for frequency 10-1000 Hz, Pulse width $40\mu\text{s}$ -90 ms, Energy upto 2.7 J

Technology: 30 W Continuous Wave (CW) Thulium fiber laser (TFL) at 1.94 micron & 2 micron

Domain: Optoelectronics, Laser Surgery

Specification:

CW Avg. Power	30W
Cooling	Air
Operating Temp.	20-25°C
Termination	SMA905

IPR: Patented

TRL: 6

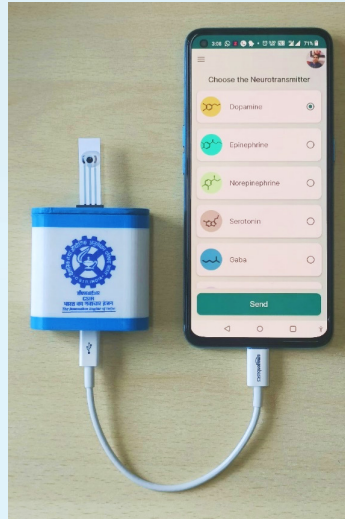
Application/Uses: Lithotripsy Coagulation Thin tissue ablation

Level/Scale of Development: Ready tested Pilot Unit, Yet for certification and clinical validation

Line Ministry Mapping/ User Sector: Ministry of Health & Family Welfare (MoHFW)



Point-of-Care Sensor for Non-invasive Detection of Neurotransmitters



Salient Features

- » IoT-enabled ultraportable Sensor device
- » Rapid detection (<1 minute)
- » User-friendly
- » Point-of-care Testing

Technology: Point-of-Care Sensor for Non-invasive Detection of Neurotransmitters

Domain: Healthcare/ Point of care Diagnostics

IPR: Patented/ Trademark

Specifications:

- » Prototype dimension: 5.8 cm x 5.8 cm x 2 cm
- » Interface type: USB OTG
- » Test format: Non-enzymatic electrochemical detection
- » Detection range: 1 μ M – 200 μ M
- » Limit of detection (LoD): 1 μ M
- » Detection time: < 1 min

TRL: 4

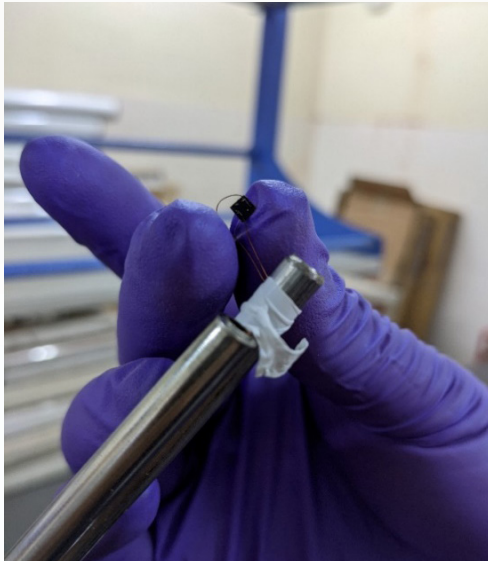
Application/ Uses: Painless screening of Neurotransmitters from a drop of urine sample

Level/ Scale of development: Lab Prototype

Line Ministry mapping/ User sector: National Health Mission, Ministry of Health and Family Welfare



Ammonia Gas Sensor at Very Low Temperatures



Flat sensor for *in-situ* ammonia sensing Low temperature ammonia sensing set-up

Salient Features

- » Cheap chemi-resistive material with reusability and long self-life
- » Can be made into sensors for detecting decay of meat-based food; robust and easy to use

Technology: A Novel Metal Oxide-Polymer Nano Composite for Very Low Temperature Sensing of Low Ppm Ammonia Gas in a Range below Room Temperature to Sub-Zero °C

Domain: Sensor, Food Safety

IPR Status: Patented

Specification:

- » Extended microporous semiconductor metal oxide nanomaterial based chemiresistive sensor
- » Selective ammonia sensor (with other VOCs generated during food decay like iso propanol, ethanol, etc.) with self-life of ~10 months
- » Suitable for ammonia sensing (sensitivity ~4 times) under sub-zero degree Celsius temperature (including dry ice sublimation temperature) with quick response and recovery
- » Multiple use cost effective sensor with safe chemical components for use as handheld food decay sensors
- » Both in-situ and ex-situ sensing feasible

TRL: 4/5

Application/Uses: Detect meat and meat product spoilage under cold storage; decay of stored body organs/transplants

Level/ Scale of development: Lab level of material development

Line Ministry mapping/ User sector: Ministry of Food Processing Industries



Fiber Bragg Grating Based Vibration and Temperature Monitoring System



Salient Features

- » Provide multipoint vibration and temperature measurement for stator end windings of a generator, over frequency range 30 Hz to 500 Hz, displacement range 10 μm (p-p) to 1 mm (p-p) at 100 Hz, and temperature upto 75°C
- » Sensors tested to withstand high voltage upto 60 KV and Hydrogen pressure upto 5 Bar

Technology: Fiber Bragg grating based vibration and temperature monitoring system for stator end windings of Generator

Domain: Fiber Optic Sensors

IPR: Patented

TRL: 6/7

Application/Uses: For health monitoring of electric generators

Level/ Scale of development: Field trial done

Line Ministry mapping/ User sector: Ministry of Power/ Power industry



Low Temperature Maturing Vitreous Sanitary Ware Body & Matching White Opaque Glaze Formulation



Salient Features

- » Low temperature maturing Sanitary Ware Body & Matching White Opaque Glaze having maturing temperature range of 1160°C-1175°C.
- » Suitable for firing cycle of 16 - 17h.
- » Low energy cost (Natural Gas, power etc.) by reducing both firing temperature and /firing time.
- » Reduced production cost.

Technology: Low Temperature Maturing Vitreous Sanitary Ware Body & Matching White Opaque Glaze Formulation

Domain: Traditional Ceramics- Sanitary ware body and glaze

IPR Status: Not Patented

Specification:

Properties of Sanitary ware body	CGCRI-Body	IS 2556 : 1994
Litre Wt. of Slip (g/L)	1745-1750	-
Flow of Slip (secs.) using B4 ford cup	57-63	-
1h Cast thickness (mm)	8-9	-
Dry Linear Shrinkage (%)	2.50-3.00	-
Dry Modulus of Rupture(kg/cm ²)	25-30	-
Maturing temperature (°C)	~1160-1175	-
Rate of heating 2.5°C/minutes- Soaking 40 minutes)	~16-17h	-
Total Linear Shrinkage (%)	12.00-12.50	-
Fired MOR (Kg.cm ⁻²)	>1000	≥ 612
Water Absorption (%)	≤ 0.5	≤ 0.5
Bulk Density (g.cm ⁻³)	2.35-2.37	-

Properties of white opaque Glaze applied on developed Sanitary ware Body	
Maturing temperature (°C)	1160 -1175
Gloss (GU)	94 – 96
Whiteness Index	82-83
L value	93-94
Thermal expansion (%)@ 550°C	0.340
Properties of Glazed Sanitary ware Body	
Crazing resistance test as per IS 2556:1994	Passed
Stain resistance as per IS 2556:1994	Passed
Chemical resistance as per IS 2556:1994	Passed

TRL: 4

Application/Uses: Sanitary ware industries.

Level/Scale of Development: Technology developed at Lab level

Line Ministry Mapping/ User Sector: Sanitaryware Industries, Ministry of MSMEs, Ministry of Petroleum & Natural Gas, Ministry of Power.



Pottery and Low Cost Earthen Wares



Salient Features

- » Quality Assurance of Raw materials.
- » Development of Lead-Free body, engobe and glaze for blue pottery
- » Development of Ultra High Strength & Leak-proof blue pottery
- » Waste Minimization & Cleaner Production
- » Product Diversification
- » Human Resource Development
- » International Market Promotion through RUDA

Technology: Pottery and Low Cost Earthen Wares

Domain: Rural Industrialization

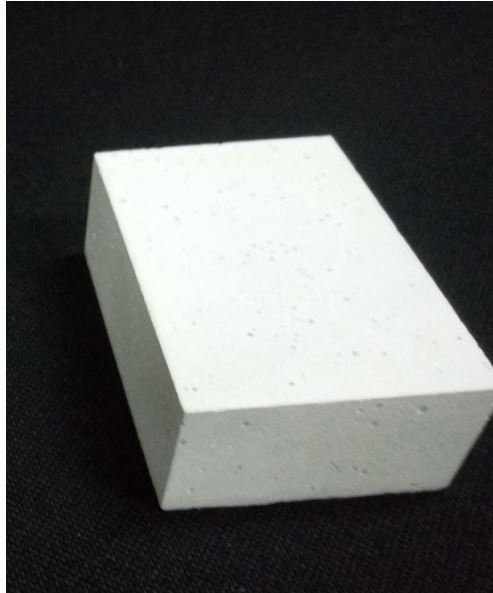
IPR: Not Patented

Application/ Uses: High strength eco-friendly blue pottery glaze and the technology

Level/ Scale of Development: The technology lead to high strength eco-friendly blue pottery glaze and the technology was transferred to the artisans in several clusters around Jaipur through series of T&D programs as well as implementation at units' level by CGCRI. The blue pottery technology was also highlighted in "TURNING POINT" programme of Door Darshan several times.

Line Ministry Mapping/ User sector: Ministry of Skill Development and Entrepreneurship, Ministry of Rural Development, MSME

Low Moisture Castable ($45-75\% \text{Al}_2\text{O}_3$)



Salient Features

- » Unshaped refractory, joint less construction
- » Moisture requirement $< 5 \text{ wt}\%$

Technology: Low moisture castable (45-75% Al_2O_3)

Domain: Refractory

IPR: Off Patent

TRL: 9

Specification:

- » Al_2O_3 : 45-75 wt%
- » Moisture requirement < 5 wt%
- » Service temperature: 1350-1600°C (based on Alumina content)

Application/Uses: High temperature refractory in steel, cement, petrochemicals, thermal power plants etc.

Level/Scale of Development: Technology transferred and commercialized

Line Ministry Mapping/ User sector: Department of Steel/ Steel Industry, cement industry/ Ministry of Power

Mag-Chrome Refractory Aggregates from Friable Chrome ore



Salient Features

- » Developed from friable Chrome ore
- » High corrosion resistance
- » High Refractoriness under load (RUL : 1700°C)

Technology: Mag-Chrome refractory aggregates from friable chrome ore

Domain: Refractory

IPR: Patented

Specification:

- » Bulk Density: 3.20 g/cc
- » Apparent Porosity: 14%
- » CCS: 700 kg/cm²
- » PLCR at 1600°C: +0.20%
- » RUL, ta : 1700°C

TRL: 9

Application/Uses: Refractory for steel ladle, copper smelter, cement rotary kiln

Level/Scale of Development: Commercialized

Line Ministry Mapping/ User Sector: Ministry of Steel/ Ministry of Mines

Mullite Refractory Aggregates from Bauxite



Salient Features

- » Mullite aggregates from inferior quality Bauxites of Indian origin
- » Innovative phase modification technique to utilize low quality bauxite

Technology: Mullite refractory aggregates from Bauxite

Domain: Refractory

IPR: Patented

Specification:

- » Al_2O_3 : ~ 70 wt%
- » Bulk Density: 2.8 g/cc
- » Apparent Porosity: 10.1 %
- » RUL, ta : 1600 – 1630°C

TRL: 8

Application/Uses: Refractory for Blast furnace stove, Bosh, Shuttle kiln lining, Rotary kiln, Tunnel kiln

Level/Scale of Development: Commercial trial completed in refractory unit at a level of 30 Tons

Line Ministry Mapping/ User Sector: Ministry of Steel/ Ministry of Mines



Mag-Al Spinel Refractory Aggregates



Salient Features

- » High corrosion resistance
- » High RUL
- » Eco friendly alternative of Mag Chrome refractory

Technology: Mag-Al spinel refractory aggregates

Domain: Refractory

IPR: Patented

Specification:

Properties	Al ₂ O ₃ content, wt %		
	66	78	90
Bulk Density, g/cc	3.2-3.3	3.22-3.25	3.37-3.40
App. Porosity, %	1.6-4.8	1.5-2.0	3.4-4.2
Water absorption %	<1.0	<1.0	<1

TRL: 9

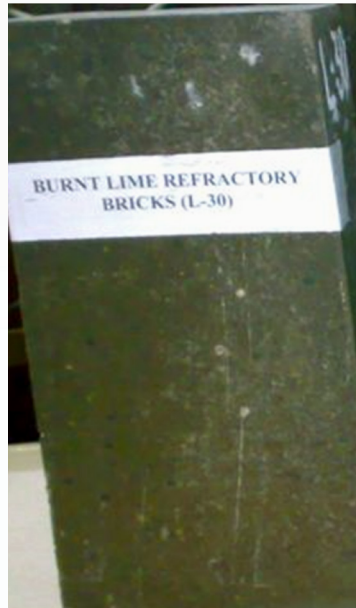
Application/Uses: Refractory for steel ladle, burning zone of cement rotary kiln

Level/Scale of Development: Successful Plant Trial (100 Tons)

Line Ministry mapping/ User sector: Ministry of Mines/ Ministry of Steel/ MoRTH, Ministry of Heavy Industries



Lime Refractory



Salient Features

- » Thermodynamic stability at high temperature
- » Improved hydration resistance
- » High corrosion resistance at moderate basicity

Technology: Lime refractory

Domain: Refractory

IPR: Patented

Specification:

- » Bulk Density: 2.83 g/cc
- » Apparent Porosity: 15.3 %
- » CCS: 959 kg/cm²
- » Shelf life: 4 weeks

TRL: 8

Application/ Uses: Refractory for AOD vessel for secondary steel refining, Rotary kiln Level/Scale of Development: Successful plant trial (100 Tons)

Line Ministry Mapping/ User sector: Ministry of Steel



70-90% Alumina Cement Free Dense Self Flowing Castable



Salient Features

- » Easy installation
- » Self flow -no vibration during application
- » Less inventory
- » Quicker and controlled cold setting property

Technology: 70-90% Alumina cement free dense self flowing castable

Domain: Refractory

IPR: Patented

Specification:

- » Al_2O_3 : 70-90 wt%
- » Bulk Density > 3.0 g/cc
- » Cold Compressive Strength > 1000 kg/cm²
- » MOR > 200 kg/cm²
- » Service temperature > 1600°C

TRL: 9

Application/ Uses: High temperature refractory for steel, cement, petrochemicals, thermal power plants etc.

Level/Scale of Development: Technology transferred and commercialized

Line Ministry Mapping/ User sector: Ministry of Chemicals & petrochemicals/ Ministry of Steel/ Ministry of Power



Solid Oxide Fuel Cell (SOFC; Vertical - H₂ Utilization)



Salient Features

- » 1 kW Class SOFC Stack (Maximum Power: 1015 W and Power Density 0.58 W/cm² using H₂ as a fuel)
- » 500W Class SOFC Stack (Maximum Power: 563 W and Power Density 0.25 W/cm² using Reformed NG as Fuel;
- » CO + CH₄ + H₂ = 30:10:60)
- » Indigenous interconnects and stack integration with CSIR-CGCRI
- » 10 kW prototype of SOFC @ TRL – 5 for application in Oil Industries, Remote powering with BoPs and CHP including power electronics

Technology: SOFC Technology (Vertical - H₂ Utilization)

Domain: Energy Materials

IPR: Patented

Specification:

- » Maximum Power 1015 W (1kW class of SOFC stack)
- » Power Density: 0.58 W/cm² with SOFC Stack Reformed NG as Fuel; CO + CH₄ + H₂ = 30:10:60 (500W Class SOFC Stack)
- » Power Density: 0.25 W/cm² with H₂ as a fuel
- » Operating temperature = 800°C

TRL: 5

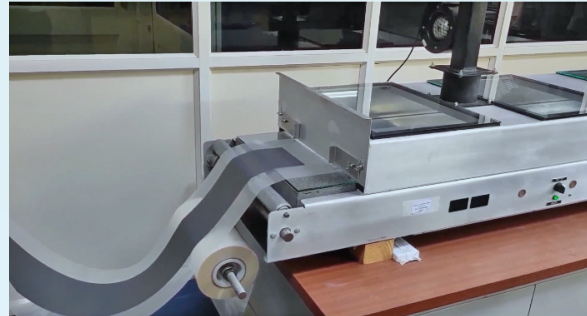
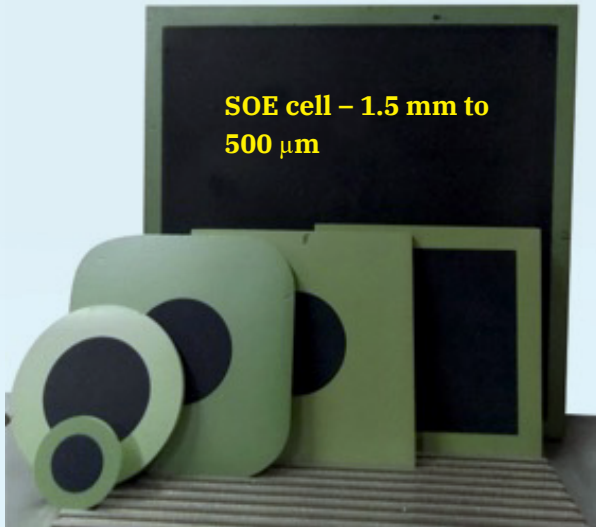
Application/ Uses: Oil Industries, Remote powering with BoPs and CHP including power electronics

Level/Scale of Development: Technology transferred

Line Ministry Mapping/ User sector: ARCI and HPCL



Solid Oxide Electrolyser Cell (SOEC; Vertical - H₂ Generation)



Co-casting technology
at CGCRI

Salient Features

- » High performing cells – $13\text{--}1.5 \text{ A.cm}^{-2}$ @ 800°C $1.4\text{--}1.5 \text{ V}$
- » Thermally cyclable sealants with rigid and newly developed composite sealants (≥ 20 numbers of cycles)
- » 2 kW module – 1 kg/day H₂ – $< 35 \text{ kWh/ kg of H}_2$ generation having through put – $0.5 \text{ Nm}^3/\text{hr/kW}$

Technology: SOEC Technology (Vertical - H₂ Generation)

Domain: Energy Materials & Devices Division

IPR: Patented

Specification:

- » Current Density: 13-1.5 A.cm⁻²@800°C 1.4-1.5 V
- » 1 kg/day H₂ – < 35 kWh/ kg of H₂ generation having through put – 0.5 Nm³/hr/kW
- » Thermally cyclable sealants with rigid and newly developed composite sealants (≥ 20 numbers of cycles)
- » High temperature operation with indigenous design

TRL: 4

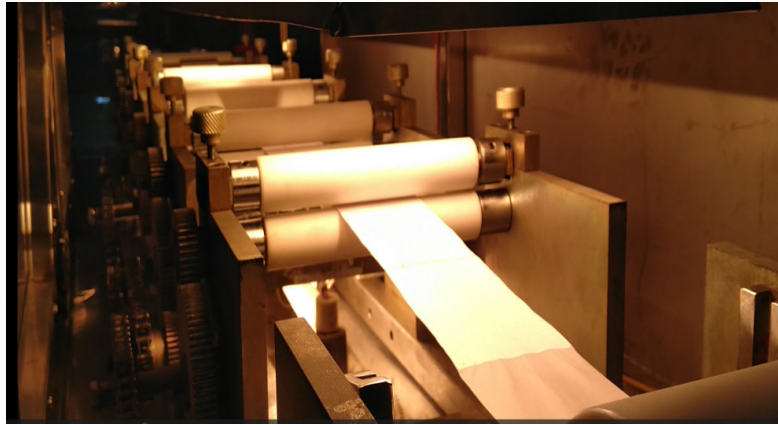
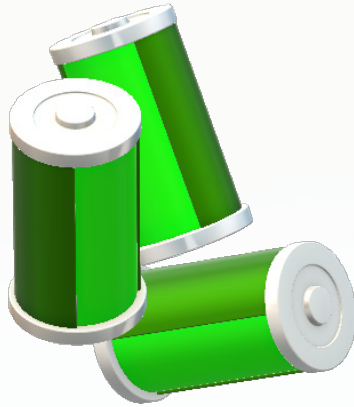
Application/ Uses: Oil Industries, Remote powering with BoPs and CHP including power electronics

Level/Scale of Development: Technology transferred

Line Ministry Mapping/ User sector: Ministry of New and Renewable Energy (MNRE), Ministry of Petroleum and Natural Gas (MoPNG), Ministry of Power, Ministry of Steel



Paper Based Ceramic Separator



Salient Features

- » PAPERATOR- Paper based Ceramic Separator for Lithium-ion/Sodium ion/Supercapacitors
- » Battery and Supercapacitor grade Carbon anode from biomass
- » Engineered LIB cathodes and anodes
- » Pseudo-Solid State Lithium Metal Batteries
- » Paper Cell for curved Surfaces
- » Cellulosic Ion Exchange Membrane (IEM) for Redox Flow Batteries

Technology: Paper based Ceramic Separator

Domain: Ceramic separator for LIBs/MIBs/SCs

IPR: Patented

Specification:

- » High electrolyte wettability
- » Excellent chemical stability in cell environment
- » No dimensional shrinkage at elevated temperature
- » No thermal softening up to 250°C
- » Comparable electrochemical performance to that of PP/PE
- » Flame retardant

TRL: 6

Application/ Uses: Energy Storage Devices, Li and Na ion batteries, electric vehicle.

Level/Scale of Development: Technology transferred

Line Ministry Mapping/ User sector: Ministry of New and Renewable Energy (MNRE), Defence, Department of Space (DOS)





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