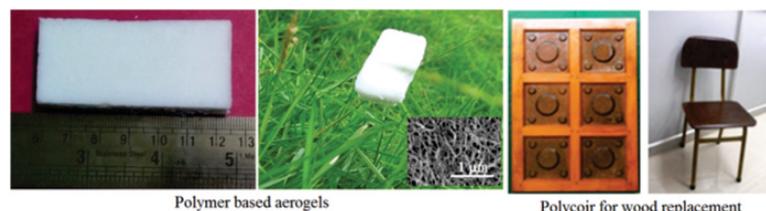


- Synthesis and characterization of rare earth magnets at lab scale using arc melting
- Development of cost effective and novel materials for magnetic refrigeration.
- Magnetic oxides for spintronic device applications
- Magnetic nanoparticles for biomedical applications
- New thermoelectric materials ( $ZT > 1.0$ ) for converting waste heat directly into useful electricity

### Polymers and polymer composites/nanocomposites

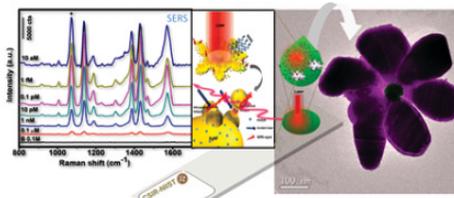
- Development of multifunctional nanofillers for semicrystalline polymers based on inorganic layered materials (Flame retardant additives and Nucleating agents)
- Generation of polymer based nanotemplates and their application
- Microstructure analysis of polymers/textiles (Using small- and wide-angle X-ray diffraction)
- Low dielectric polymer composites based on inorganic materials and EMI shielding applications
- Ultra-lightweight polymer aerogels
- Polycoir for wood replacement



- Indigenous and affordable technologies/products for early detection of diseases, smart displays, security labels, etc. based on the self-assembled soft materials
- Prototype responsive photonic crystals on flexible surfaces
- Transparent antibacterial coatings using white light active photoactive anatase  $TiO_2$  nanoparticles



Color changing photonic structures on flexible substrates for sensing pesticides & biomolecules



Biopolymer-derived noble metal platforms for the detection of analytes with exceptional sensitivity for early diagnosis of diseases

### Minerals and Metallic Materials:

#### Beneficiation of minerals and value addition to the industrial mineral wastes

- An environment friendly process for the production of high grade synthetic rutile from ilmenite.
- Physical, chemical and mineralogical characterization of ilmenite minerals.

- A plasma process for the production of synthetic rutile and pig iron from ilmenite concentrates- after successful feasibility studies, the process is got scaled up in the pilot plant (30 kg/hour).
- Process for the pyrometallurgical extraction and purification of rare earth metals and alloys.
- Studies on the characterization and utilization of ilmenite beneficiation by-products for value addition.
- Pilot plant studies on the laboratory data in collaboration with prospective user industries.

### Metals, Alloys and Composites

- High strength aluminium alloys and creep resistant magnesium alloys for automotive and aerospace applications.
- Magnesium based bio compatible and bio degradable alloys for implant applications.
- Metallic composites and functionally graded materials employing both micro and nano-scale reinforcements, for lightweight structural components, low-friction, wear and impact-resistant applications.
- Surface Engineering of Metals: Wear and corrosion resistance surface coatings through electroless, sol-gel and chemical conversion coating techniques for metallic substrates.
- Near net shape engineering component castings of light metals using low pressure, squeeze, and centrifugal casting techniques. Ultrafine and nanostructured light alloys and composites by severe plastic deformation.
- Fundamental solidification studies on grain refinement, hot tearing of aluminum and magnesium alloys to facilitate newer alloy design for improved mechanical and casting properties.



GSLV Al Mounting Frame



Al Piston



Mg Oil Strainer



Al-SiC Gear Housing

### Contact Details

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सीएसआईआर-राष्ट्रीय अंतर्विषयी विज्ञान तथा प्रौद्योगिकी संस्थान  
सीएसआईआर-एनआईआईएसटी

तिरुवनंतपुरम

CSIR-NATIONAL INSTITUTE  
FOR INTERDISCIPLINARY SCIENCE  
AND TECHNOLOGY

CSIR-NIIST  
THIRUVANANTHAPURAM



Material Science &  
Technology

# Materials Science and Technology

## Research Focus:

- Development of Advanced Functional Materials and Components for Strategic, Automobile, Energy and Societal Applications.

## The major research areas are

- Inorganic colorants with high NIR reflectance for energy saving applications
- Photoluminescent materials for white light emitting diode and bio-medical applications
- Porous ceramic materials for CO<sub>2</sub> adsorption for environmental applications
- Non-wetting ceramic materials
- Nano photo catalyst for dye-degradation
- New low temperature cofired ceramic substrates through tape casting
- Magnetic and magneto refrigeration materials
- Polymers and polymer nanocomposites
- Beneficiation of minerals and value addition to the industrial mineral wastes
- Aluminium and Magnesium alloys and composites for strategic and automobile applications.

## Functional Materials:

### Inorganic colorants with high NIR reflectance for energy saving applications

This innovative inorganic colorant material is processed using rare earth oxide and silica raw materials via a simple solid-state reaction at temperatures < 1000 °C. The chemical composition of this pigment has no toxic elements such as cobalt, lead, cadmium etc. This product has intense blue color [ $b^* \geq 45$ ] with 77% NIR reflectance. IR reflecting pigments have capability to reflect solar

heat energy and hence used as 'cool pigments' on metal and polymer roofing sheets. This rare earth silicate based blue pigment is highly competitive to the existing toxic cobalt aluminate blue.



## The CSIR-NIIST blue pigment can be used as:

- Cool-pigments for energy saving applications
- Solar heat control fillers in polycarbonate roofing sheets and powder coated metallic sheets

## This group also has the following capabilities:

- Pilot scale processing of IR reflective non-toxic ceramic colorants, synthesis of LaPO<sub>4</sub>/ ZnO/ CeO<sub>2</sub> based nano pigments for energy saving cool roofs, cool textiles and cool-paints.
- Processing of high temperature stable rare earth phosphate based ceramic colorants for energy saving emissivity coatings
- Adsorption and catalytic degradation of environmentally threatening industrial pollutants using low-cost activated porous silica/alumina aerogels
- Utilization of industrial wastes into multifunctional nanomaterials

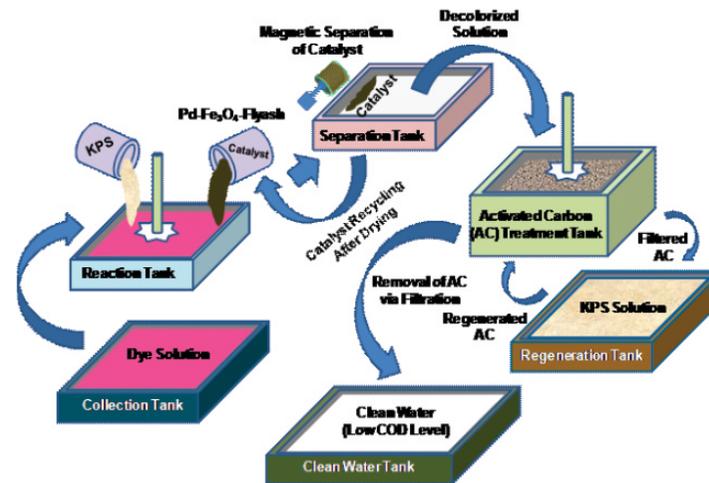
## Nano and micron sized materials for energy and environmental applications

Materials synthesised in nano and micron sizes by wet chemical approaches are processed to obtain sols and slurries that can be used for the development of coatings and monoliths. Applications ranging from self cleaning surfaces to ceramic membranes are demonstrated and process know how are developed for technology transfer.

- Development of photocatalytic self cleaning coatings (available for non exclusive transfer)
- Know how for the synthesis of photocatalytic titania from illmenite process intermediates (available for non exclusive transfer)
- Process for fabricating metal non-wetting crucibles (available for exclusive/ non exclusive transfer)
- Development of multi-channelled ceramic membranes with internationally competent specifications (DST-TSDP project with CGCRI as collaborating institute and HR Johnson as industrial partner)
- Development of high temperature ceramic absorbents for CO<sub>2</sub> capture (joint collaborative project sponsored by Noritake, Japan)



## Dye-degradation via dark-catalysis using magnetic composite (European Patent No. EP2885250, Granted on 3-August-2016)



- The dye removal technology is based on the attack of hydroxyl (OH<sup>•</sup>) and superoxide (O<sub>2</sub><sup>•-</sup>) radical ions generated in dark via the activation of strong oxidizers such as hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and persulfate anions (S<sub>2</sub>O<sub>8</sub><sup>2-</sup>) using palladium-magnetite-flyash (Pd-Fe<sub>3</sub>O<sub>4</sub>-FA) composite particles.
- The magnetic separation of catalyst particles is possible.

- The treated aqueous solution has very low COD level compared with that of initial dye solution.
- The technology does not need any radiation-exposure (ultraviolet / solar / visible / infrared) for the removal of organic synthetic-dye from aqueous solution.
- It is quicker, cost-effective, and safer than the existing technologies.
- It is applicable for the removal of variety of organic synthetic-dyes.
- No formation and handling issues associated with large amount of sludge.
- The treated water may be reused for agricultural and industrial purposes.

## Electronic Materials

- The electronic materials group in NIIST has a rich experience in the development of ultra-low loss microwave dielectric resonators that can be operated in TE, TM and TEM mode.
- Apart from this, high bandwidth dielectric resonator antenna (DRA) and fabric based printable antennas were also developed which have potential applications in defence sectors for navigation in remote battle fields.
- We are also developing several low temperature cofires ceramics (LTCC) having high thermal conductivity with a range of permittivities ( $5 \leq \epsilon_r \leq 20$ )
- Our current research focus is to develop screen printable functional inks, with insulating, semiconducting, conductive and piezo electric properties, for printed electronic applications. These inks will be employed in developing prototype devices like thin film transistors, dye sensitised solar cells and magnetic field sensors.
- We also develop several EMI shielding structures with high shielding effectiveness ( $SE > 40$  dB), which can shield 99.9% EM waves incident on them.

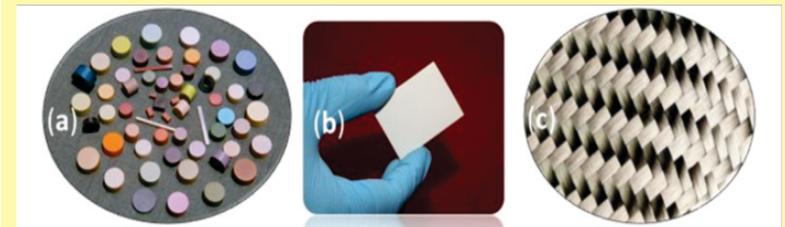


Fig. 1 Microwave materials developed at NIIST (a) high Q dielectric resonators, (b) microwave substrates and (c) EMI shielding structures

## Magnetic and magneto refrigeration materials

Group has excellent experience in nanomagnets, magnetic, superconducting and thermoelectric intermetallics and latest characterization techniques.