POSSIBILITIES WITH ARCI- HYDERABAD IN MATERIALS SCIENCES

P.K. JAIN

TEAM LEADER

CENTER FOR CARBON MATERIALS

INTERNATIONAL ADVANCED RESEARCH CENTER FOR POWDER METALLURGY & NEW MATERIALS (ARC-I)

HYDERABAD - 500 005

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INTERNATIONAL ADVANCED RESEARCH CENTRE FOR POWDER METALLURGY AND NEW MATERIALS (ARCI)

- An autonomous R&D institute of Department of Science and Technology, Govt. of India
- Employs about 160 people
  - ✓ 65 Scientists
  - ✓ 60 Technical Cadre
  - ✓ 45 Adm. & Supporting Cadre
  - ✓ Students (Around 100 Nos)
  - ✓ Services Out surced

ARCI'S MANDATE

- Development of High Performance Materials and Processes for niche market
- Demonstration of Technologies at Prototype/Pilot Plant Scale
- Transfer of Technologies to the Indian industry

CENTRES OF EXCELLENCE

Centre for Nano materials	Centre for Carbon Materials (Carbon Nano-materials)
Centre for Ceramic Processing	Centre for Non-Oxide Ceramics
Centre for Laser Processing	Centre for Engineered Coating
Centre for Sol-Gel Coating	Centre for Solar Materials
Centre for Characterization	

Centre for Technology Transfer

Center for Fuel Cells & Center for Automotive Materials

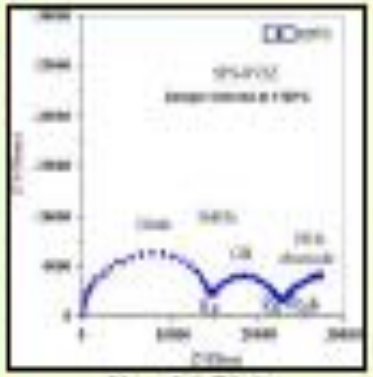
TECHNOLOGY TRANSFER TO INDUSTRIES

S.No	Technology	Status
1	Electro Spark Coating Technology	Transferred
2	Magnesia Aluminate Spinel	Transferred
3	Ceramic Crucibles for C & S Analysis	Transferred
4	Ceramic Honeycombs for Energy Efficient Air Heaters	Transferred
5	Detonation Spray Coating Technology	Transferred
6	Ceramic Honeycombs based Catalytic Convertors	Ongoing
7	Heat Pipes Heat Sinks	Ongoing
8	Evaporation Boats	Transferred
9	PM Grade Iron Powder	Ongoing
10	Sponge Iron Briquettes	Ongoing
11	Micro Arc Oxidation (MAO) Technology	Transferred
12	ESC Equipment Manufacturing Technology	Ongoing
13	Calcium Aluminate Cement & Insulating Aggregates	Ongoing
14	Ceramic Honeycomb Filters	Ongoing

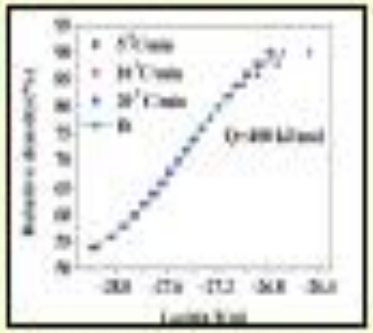
TECHNOLOGY TRANSFER TO INDUSTRIES

S.No	Technology	Tech. Transfer Status
15	Anti-bacterial Nanosilver Suspensions or Nanosilver Powder for Catheter Applications	Ongoing
16	Development and transfer of technology to manufacture nano-titanium dioxide based textile finishes for self-cleaning applications	Ongoing
17	Development and transfer of technology to manufacture nano-silver based textile finishes for antibacterial applications	Ongoing
18	Nanosilver impregnation of ceramic water filter candles to impart anti-bacterial function	Ongoing
19	**EXFOLIATED GRAPHITE & ITS VALUE ADDED PRODUCTS (Reinforced Graphite Sheets and Seals)**	Transferred
20	Evaporation Boats for Metallising Industries	Transferred

Center for Ceramic Materials

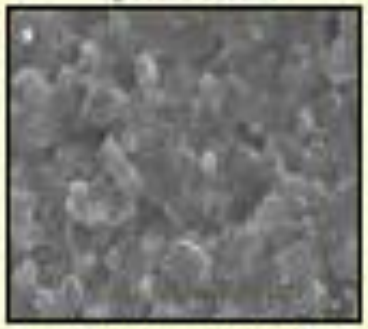


Nyquist Plot



Master Sintering Curve

Nano structured Spinel Powder



Fractographs of CNT-Alumina Composite

- Developing Innovative Processing Techniques for Technology Oriented Product Development
- Material Synthesis and Fabrication

- Characterization and Testing
- Prototype Development
- Technology Transfer

MAJOR PROCESSING CAPABILITIES

- Compaction Processing
- Extrusion Processing
- Thermal Gel Casting
- Gel Casting
- Slip Casting
- Pressure Slip Casting
- Spray Drying
- Sol-gel Processing
- Microwave Processing
- Combustion synthesis
- Spray Pyrolysis
- Isostatic Pressing
- Sol-gel/Slurry coatings
- Screen Printing
- Rate Controlled Sintering

Wall Flow Filter

Transparent Ceramics

Ceramic Foams

Radiant Porous Burner

Ceramic Honeycomb

Extruded Products

Alumina Balls

Alumina Spools

CVD Facility

Screw Extruder

Hot MOR

Impedance Analyzer

MAJOR FACILITIES

- Hot Isostatic Press
- Chem. Vap Deposition
- HT Vac/Air Furnaces
- High Shear Mixer
- Compaction Presses
- Ram-Screw Extruders
- Ceramography

CHARACTERIZATION

- Impedance Analyzer
- Hot MOR
- Microwave NDT
- Rheometer
- STA/Dilatometer
- Mercury Porosimeter
- Nano-Zeta sizer
- Powder flow analyzer
- FT IR Spectrometer

Pressure Slip Casting Machine

Hot Isostatic Press

CENTRE FOR NON-OXIDE CERAMICS (CNOC)

Uni-axial hydraulic press

High temperature vacuum sintering furnace

Large size cold iso-static press (CIP)

Vacuum hot-press

- *Developing Innovative Processing Techniques for Technology Oriented Product Development*
- *Materials Synthesis and Fabrication, Characterization and Testing.*
- *Prototype Development, Technology Transfer*

PROCESSING EXPERTISE

- Gelcasting
- Spray-freeze drying
- Pressureless sintering
- Chemical vapour deposited SiC
- Porous ceramics
- Extrusion processing
- Oxidation resistant SiC coating

Machined SiC parts

Light-weight foams

Reticulated foams

MAJOR FACILITIES

- High-tonnage hydraulic press
- Cold iso-static press
- High-temperature sintering furnace
- CVD system
- Conventional and ultrasonic machining facilities
- Extrusion press

Sintered SiC tubes

RTP SiC granules

SiC-SS brazed joints

Ultrasonic machining system

Hot-pressed SiC parts

Polished surface of CVD SiC

6-axis CNC machine

Freeze granulator

Rheometer

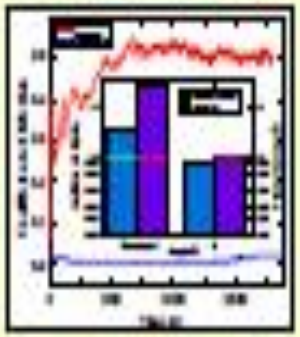
CVD system

Extrusion press

CENTRE FOR LASER PROCESSING OF MATERIALS (CLPM)

Promoting and providing laser-based materials processing solutions and technologies for industrial applications

Micro-Heater



Friction behavior of laser microtextured cast iron surface

Micropatterning of CNT forest

Microstructure of laser clad Metal-Ceramic coatings

MAJOR PROCESSING FACILITIES

- Ultrafast Ti-Sapphire based Laser Micromachining System
  - 12W at 10kHz, 100fs-50ps and 100ns
  - 5-axis CNC with nm resolutions
  - Micro machining, micro texturing, micro-cutting, engraving, ablation
- Fiber Coupled Diode Laser
  - 200 – 6000 W CW/pulsed , 900-980 nm
  - 6-axis Robotic System with Turn and Tilt Table
  - Hardening, Cladding, Alloying, Re-melting, Conduction Welding, Direct Metal Deposition, Plastic Welding and Brazing

Ti-Sapphire Ultrafast Laser (50 ps-100 fs, 12 W, 10kHz)

Additive Manufacturing

Pin Hole for Flash X-Ray

Grid for Pulsed Electron Source

Hemming bed Hardening

Crankshaft Hardening

Hardened steam turbine blade

High Pressure Nozzle Guided Vane

Aero-engine Combustion Liner

Die tool repair

Laser Welding of Solenoid Valves

Microwelding

Al-Steel laser brazed joint

Laser-MIG hybrid welding

CMT Welding

Diode Laser brazing system

MAJOR PROCESSING FACILITIES

- CO_2 Slab Laser
  - 100 – 3500 W (CW), 6 kW peak power (Pulsed)
  - 4-axis CNC (1500 mm X 3000 mm)
  - Welding, Cutting, Surface Modification and Hybrid Welding
- Pulsed Nd:YAG Laser
  - 400 W (Average) 20 kW (Peak), 1064 nm
  - 0.3 – 20 ms Pulse duration with shaping capability, Repetition rate (0.2 – 500 Hz)
  - 3- axis CNC (600 mm X 600 mm)
  - Precision Drilling, Micro-Welding, Cutting, Surface Texturing

High Power Diode Laser (6 kW, Fiber coupled)

Center for Engineered Coatings

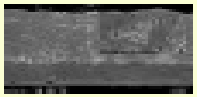
Providing a wide range of surface modification technologies and solutions to private and public sector industries and transferring state-of-the-art technologies to Indian market.

DETONATION SPRAY


Sea Harrier

- High velocity, moderate temperature
- Metals, ceramics and cermets
- Robust and economical

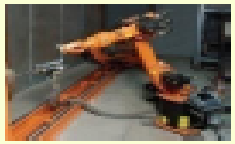
SOLUTION PRECURSOR PLASMA SPRAY

YSZ for TBC applications

- Nano coatings without nanopowders
- Metastable and novel composites
- YSZ, Al_2O_3, LSM, $LiFePO_4$, ferrites, TiO_2

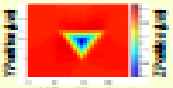
COLD SPRAY

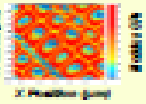



Sn coating on Al Bus Bars

- High Deposition Rate and Efficiency
- Retention of feedstock properties
- Cu, Ag,Sn,Al, Zn,Ta, Nb,Ti, Ni-Cr, HEA

ADVANCED CHARACTERISATION FACILITIES





Topography | In situ testing | Modulus mapping

- State of the art nanomechanical testing
- Tribological characterisation of coatings (Abrasion, erosion and sliding wear)

MAJOR FACILITIES

- Detonation Spray
- Solution Precursor Plasma Spray
- Cold Spray
- Micro Arc Oxidation
- Pulsed Electrodeposition
- Electron Beam Physical Vapour Deposition (EBPVD)
- Cathodic Arc Physical Vapour Deposition (CAPVD)
- Advanced Characterisation

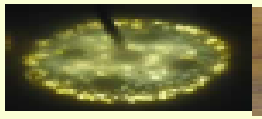
TECHNOLOGIES TRANSFERRED AND APPLICATIONS DEVELOPED

- Transferred 3 technologies to 17 entrepreneurs
- Successfully developed applications for a wide range of industries including, automotive, aerospace, defence, nuclear, energy, steel, textiles. etc.,
- Significant contributions to the strategic sector
- Healthy mix of basic research and technology / application development

TECHNOLOGIES AVAILABLE/TO BE AVAILABLE FOR TRANSFER

- Advanced Detonation spray (Mark II) with enhance Pulse Frequency
- Portable Cold spray Technology
- Advanced Micro Arc Oxidation technology for Industry and Academia
- Pulsed Electrodeposition will be shortly available for transfer

MICRO ARC OXIDATION




Coating in Progress | Wire-drawing pulleys

- Eco friendly & economically viable
- Excellent wear and corrosion resistance
- Can coat Al, Ti, Mg, Zr and their alloys

PULSED ELECTRODEPOSITION


Nano Ni coating for Helicopter Hinge Pin

- Environment friendly plating bath
- Control over composition and properties
- Ni, Zn, Ni-W, Fe-W, Ni-P, Ni-W-SiC

EBPVD


Aero Engine components

- High yield and wide range of thickness
- Can coat thin foils & heavy blanks
- TBC and oxidation resistant coatings

CAPVD



Solar thermal | Cutting tools

- Mono/multigradient coatings / thin films
- High adhesion, low temperature & clean
- TiN, CrN, TiAlN, TiCrN, M-DLC, no-TiAlN/a-

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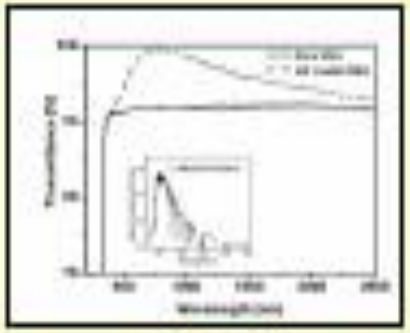
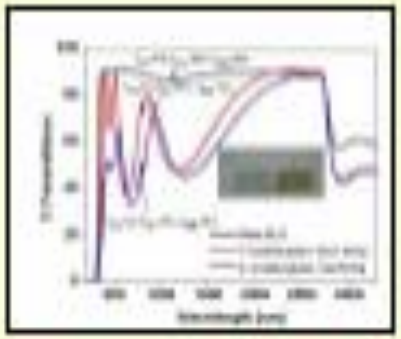
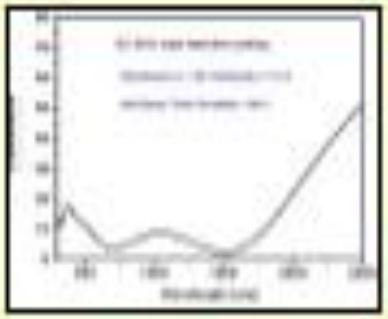
Center for Sol Gel Coatings



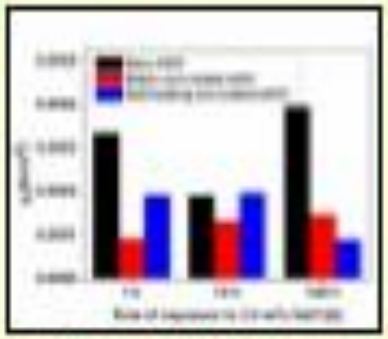
Transmittance spectrum of single layered antireflective coating on BSG



Transmittance spectra of fully dielectric solar control coating



UV-Vis-NIR reflectance spectrum of solar selective coatings on SS



Comparison of corrosion currents for bare and coated AZ91 substrates

- Developing Innovative Sol Compositions for Technology Oriented Product Development
- Sol Synthesis, Coating, Characterization and Testing
- Prototype Development
- Technology Transfer

PROCESS FACILITIES

- 10 l, 20 l and 100 l reactors

CLEANING AND PRETREATMENT OF SUBSTRATES

- Ultrasonic cleaning
- Flat glass cleaner
- Plasma treatment

COATING DEPOSITION

- Automated spray coating facilities (1 m x 1 m size)
- Dip coaters
- Spin coaters
- Screen printer
- Pad printer

Pilot Plant

Abrasion Resistant Coatings

Flame Retardant Coating

Hard Coatings on Plastics

Coloured coatings on glass

Bare & AR Coated Glass

Anti-corrosion Coatings

Scratch resistant coating

Solar selective coating

Easy-to-clean coating

Plasma treatment

Dip Coater

Flat spray unit

Batch furnace

CURING & DENSIFICATION

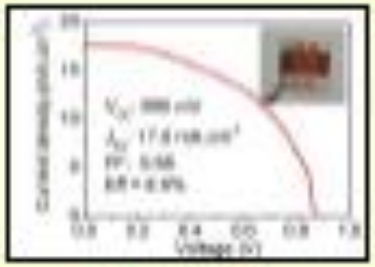
- UV, IR and LED curing
- Batch, belt furnaces
- Drying ovens

CHARACTERIZATION & TESTING

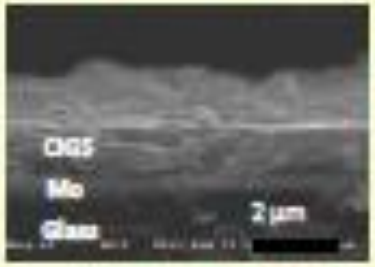
- Contact angle measurement
- Weathering resistance
- Haze meter
- Spectroscopic Ellipsometer
- Taber abraser
- Electrochemical workstation
- Viscometer
- Thickness gauge

Taber abraser

CENTRE FOR SOLAR ENERGY MATERIALS (CSEM)



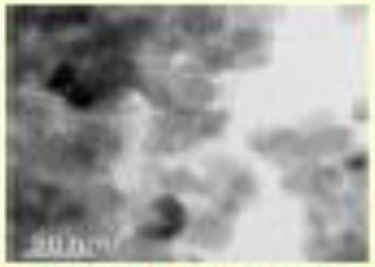
IV curve of PSC



Sputter deposited CIGS

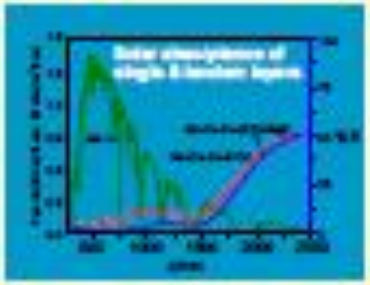
Electrodeposited CIGS

- Design and development of novel solar energy materials
- Film deposition and Device Fabrication
- Performance Assessment through Characterization and Testing
- Scale-up and Prototype Development
- Technology Transfer



Mesoporous MgF_2 Nanoparticles

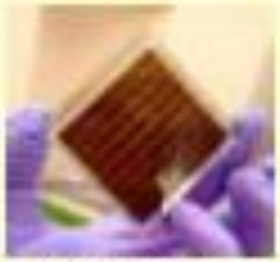
Mn-Cu-Co-ZrOx nanocomposites



MAJOR PROCESSING CAPABILITIES

- Nanoparticles & nanocomposites
- Thin film deposition
- Thick film coating
- Thermal evaporation
- Dip coating
- Chemical Bath Deposition
- Chemical Oxidation
- Electrodeposition
- Spray coating
- Chemical oxidation
- Sol-gel/Slurry coatings
- Screen Printing
- Solar Cell Encapsulation
- Laser scriber
- Long-term stability test

DSSC module



Prototype PSC

CIGS film on Flexi glass

Dust repellent coating on PV panel

Solar absorber tubes

Antireflective coating on PV & CSP glasses

MAJOR FACILITIES

- CIGS Pilot Line
- Evaporator-RTP
- Thermal Evaporator
- Glove Box
- Box &Tubular Furnaces
- Vacuum furnace & oven
- Pulse Power Supply
- Environmental Chamber

CHARACTERIZATION

- Solar Cell Tester
- Quantum Efficiency Unit
- X-ray Fluorescence
- UV-Vis-NIR spectrometer
- FTIR for thermal emittance
- Four probe
- Stylus Profilometer
- Contact angle & Tensiometer
- Electrochemical work station

Screen Printer

Evaporator-RTP

Ink-jet Printer

CIGS Pilot Line

UV-Vis-NIR spectrometer

TIR with Thermal Emittance Accessories

Quantum Efficiency

Solar Simulator

Thermal Evaporator

Environmental chamber

Center for Nano Materials

FACILITIES

RECENT PRODUCTS

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CENTRE FOR FUEL CELL TECHNOLOGY (CFCT)

Proven capability to build Fuel cell System (Fuel cell stack, Inverter, Controls) of capacity up to 20 kW modules for any grid Independant power requirement.

Use of Carbon nanomaterials for safe H_2 storage applications

FACILITIES

Development of rechargeable Metal-air secondary battery

XRD

TGA with MS

DMA

Porometry

Sieverts Apparatus

Surface area analyzer

FC Assembly

SEM

Electrochemical Test Station

Glove Box

Micro GC for field trips

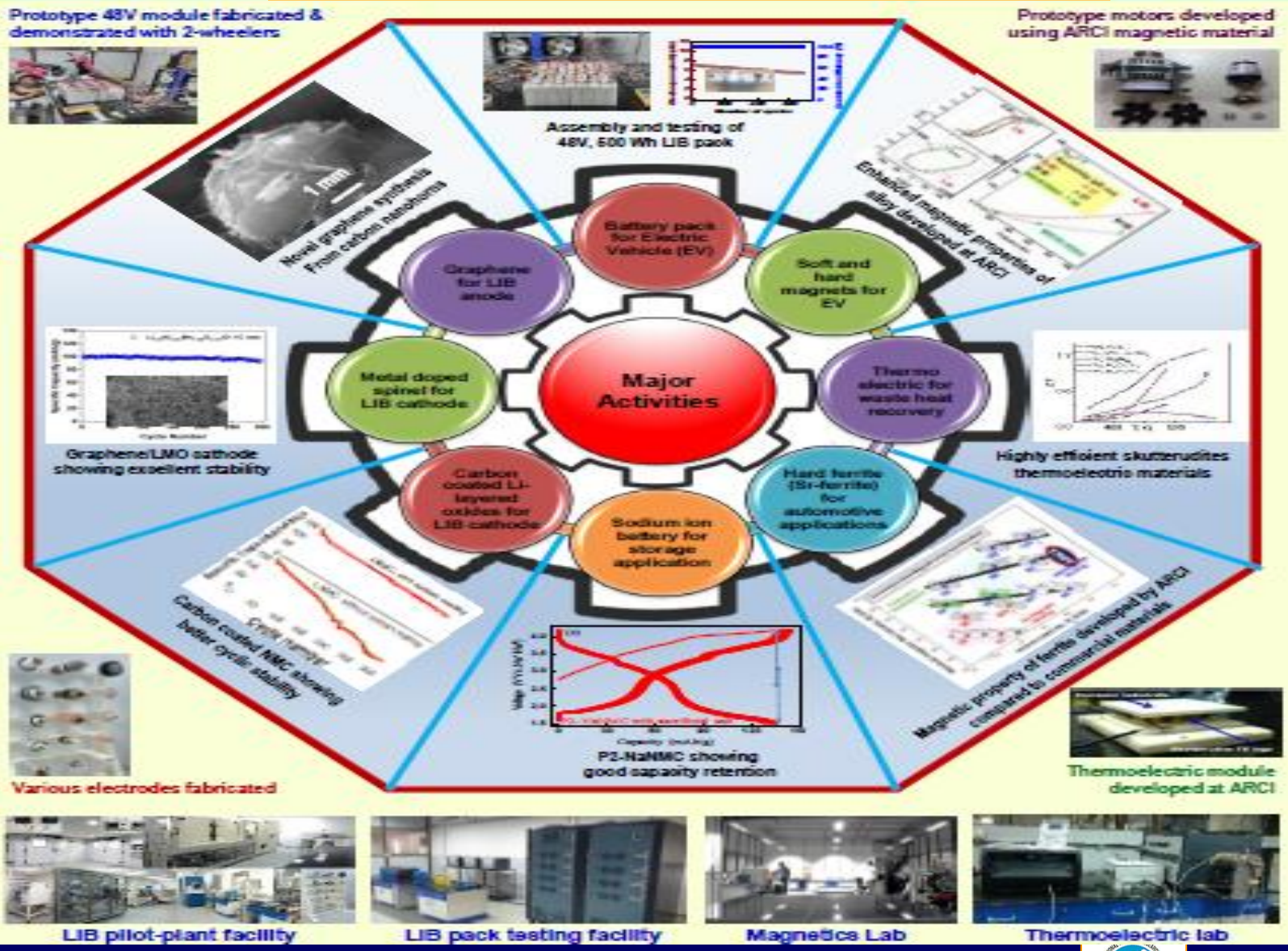
Hydraulic press

Screen printer

Fuel cell test station

Environmental chamber

Center for Automotive Materials



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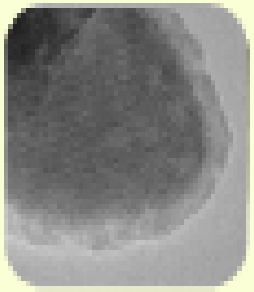
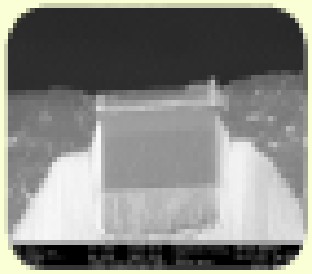
CENTRE FOR MATERIALS CHARACTERIZATION AND TESTING (CMCT)



Amorphous C on LiFeP



Multi-layer X-section

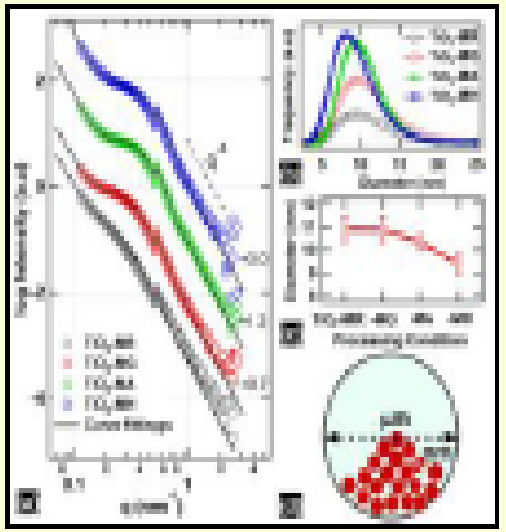
Characterization

Structural
- Residual stress
- X-ray diffraction
- Micro-XRD

Microstructural
- TEM , SAXS
- Dual Beam FIB-SEM
- FE-SEM / EBSD / EDS, SEM

Mechanical
- Nano-tribology (Scratch, Impact and Indentation)
- Creep and UTM (RT & HT)
- Macro/Micro Hardness

Electrochemical
- Impedance testing and Electrochemical analysis
- Cyclic corrosion



SAXS profiles of nano-TiO_2

OBJECTIVES OF THE CENTRE
- Offer a range of solutions for internal characterization needs
- Conduct basic research to support ARCI's technology development programmes
- Carry out multi-scale, multi property characterization for R&D laboratories, industries and academic institutions in project mode

CORE STRENGTHS
- Competent team to perform Structure-Property correlations
- State of art characterization tools to probe different types of materials such as metals, alloys and ceramics, covering all length scales (bulk, coatings and nanomaterials)
- Advanced Micromechanical testing facilities
- Comprehensive electrochemical characterization for testing materials for battery, solar cell, and other applications

Characterization facilities

Microscopy

Transmission electron microscope
Field Emission SEM with EBSD
Dual beam FIB-SEM
Conventional SEM with EDS
Optical microscopy

X-ray

Small angle X-ray scattering
X-ray diffraction
Micro-diffraction
Residual stress

Mechanical testing

Nano-tribology
Creep testing
Tensile and compression testing
Indentation testing (nano/micro)

Electrochemistry

Electrochemical analysis
Cyclic corrosion testing facility

Sample preparation

Metallography
Vibratory polishing
Multi-prep
Argon ion polishing (PIPS)
Twin-jet electropolishing
Dimple and disc grinders
Ultrasonic and mechanical disc punches for TEM specimens

Major facilities

TEM

SAXS

UTM

Residual stress

Dual beam

Nanomechanical testing system

Micro-XRD

Electrochemical

Electrochemical workstation

Cyclic corrosion chamber

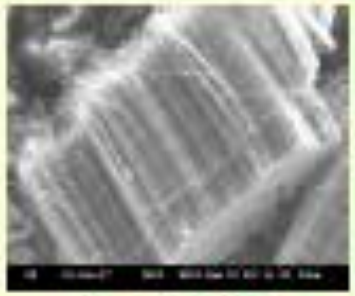
Optical microscopy & metallography

Optical microscope & micro hardness tester

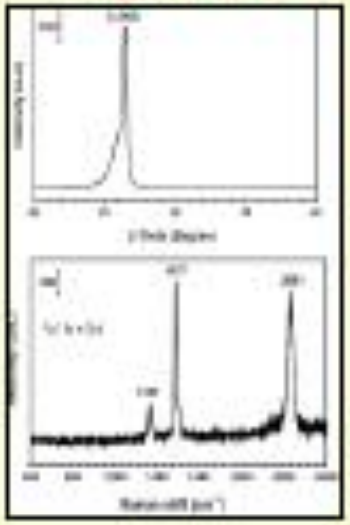
Center for Carbon Materials

Exfoliated Graphite Worm

Flexible Graphite Sheet



Aligned CNTs



Raman Spectrum

- Developing Innovative Processing Techniques for Technology Oriented Product Development
- Material Synthesis and Fabrication

- Characterization and Testing
- Prototype Development
- Technology Transfer

MAJOR PROCESSING CAPABILITIES

- Exfoliation of Graphite
- Flexible Graphite Sheets
- Graphite Seals
- Graphite Gaskets
- Bipolar Plates for Fuel Cell
- Graphite Boards
- Oil Adsorption
- Synthesis of carbon nanotubes
- Synthesis of Graphene
- Field Emitter (Aligned CNTs)
- Nano-electrodes for Supercapacitor
- CNTs based Nano-composites
- Conducting Polymers (CNTs)
- Nanofluids (CNTs)
- CNTs based Sensor

Exfoliated Graphite Products

Aligned Patterned CNT & Field Emiccion

GNP

CVD Set up

LFA

TMA

MAJOR FACILITIES

- Exfoliation of Graphite
- Pressing and Rolling
- Arc Discharge Set up
- Chemical Vapor Deposition
- Fluidised Bed Reactor
- Arc-under water
- Sputtering Unit
- Planetary Mill

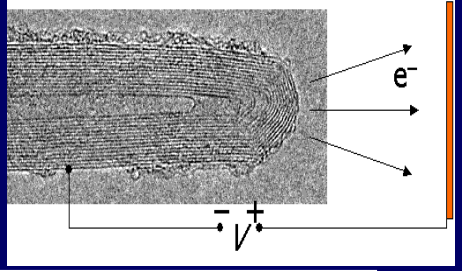
CHARACTERIZATION

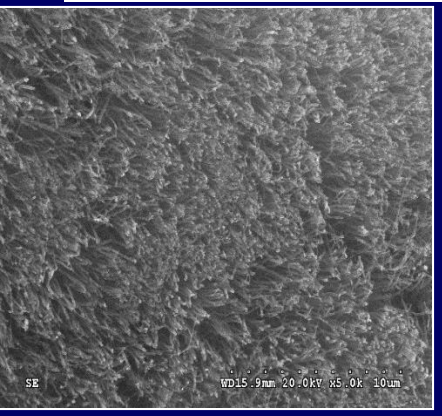
- Thermal Diffusivity (Cond.) Analyser (LFA)
- Simultaneous Thermal Analyser (STA)
- Thermo Mechanical Analyser (TMA)
- Zeta Sizer
- Rheometer
- UV Spectrometer

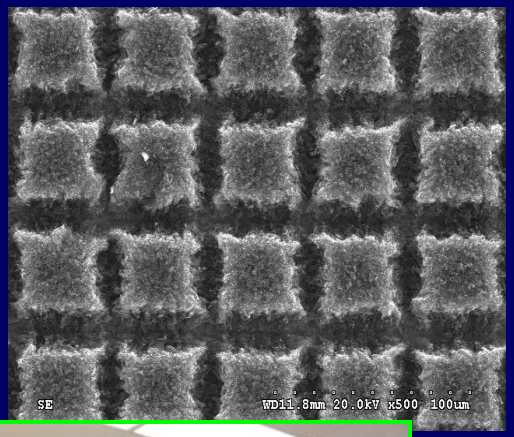
Arc discharge Set up

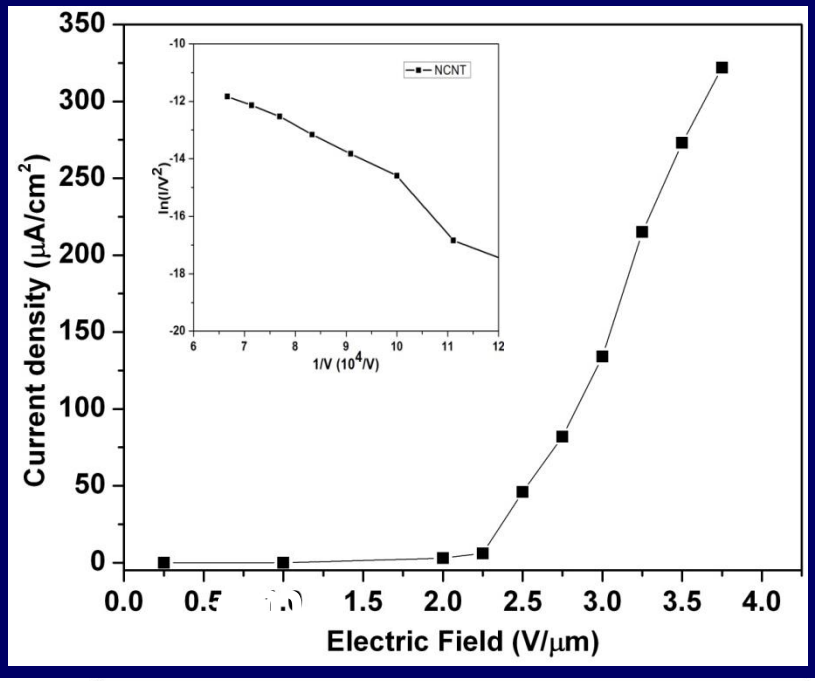
Sputtering Unit

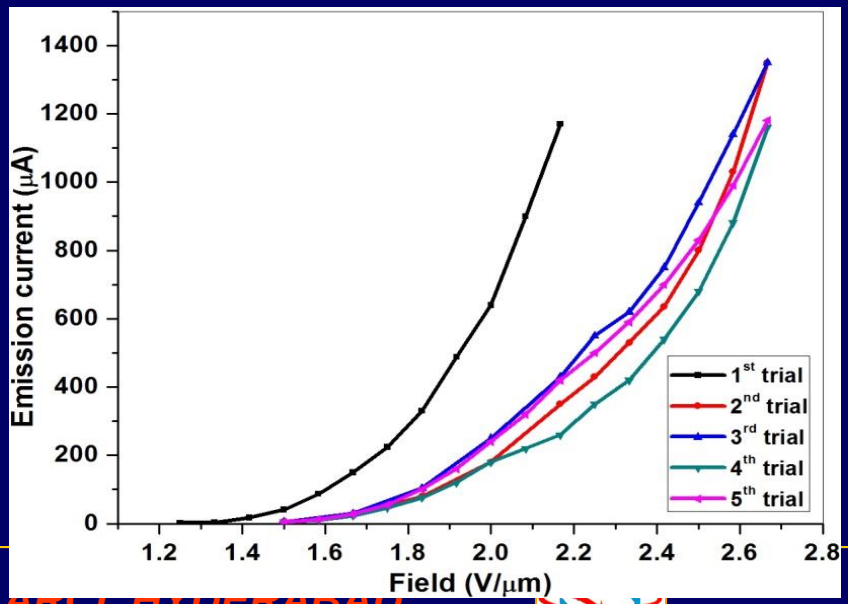
Field Emission Properties of CNT islands





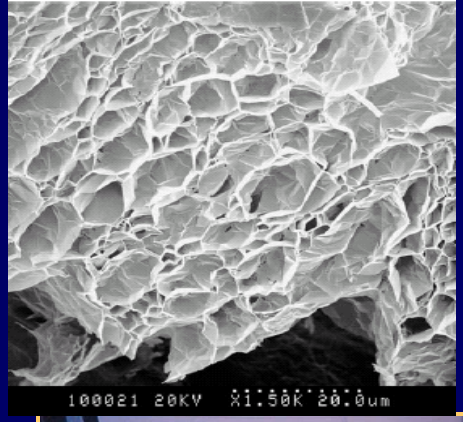






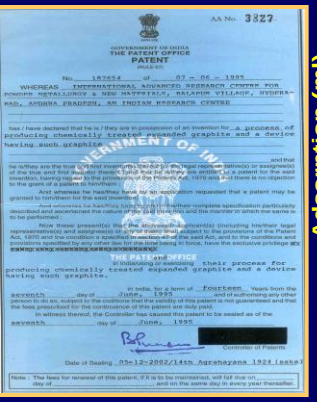
OILS ADSORPTION STUDIES

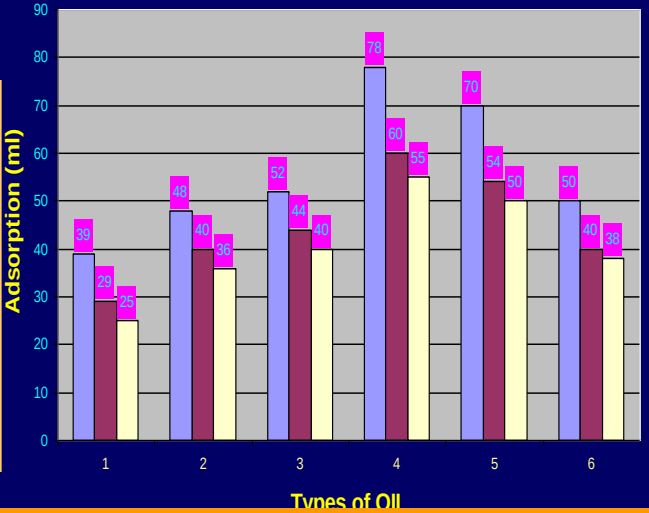
OILS	DENSITY (gms/cc)	VISCOSITY (C.P)
Diesel oil	0.8343	3.99
Hydraulic oil	0.8708	15.49
Transformer Oil	0.8376	19.68
Shell SAE-90	**0.8812**	**158.64**
Engine Oil	0.8794	206.99
Shell SAE 140	0.8928	517.67



OIL & WATER

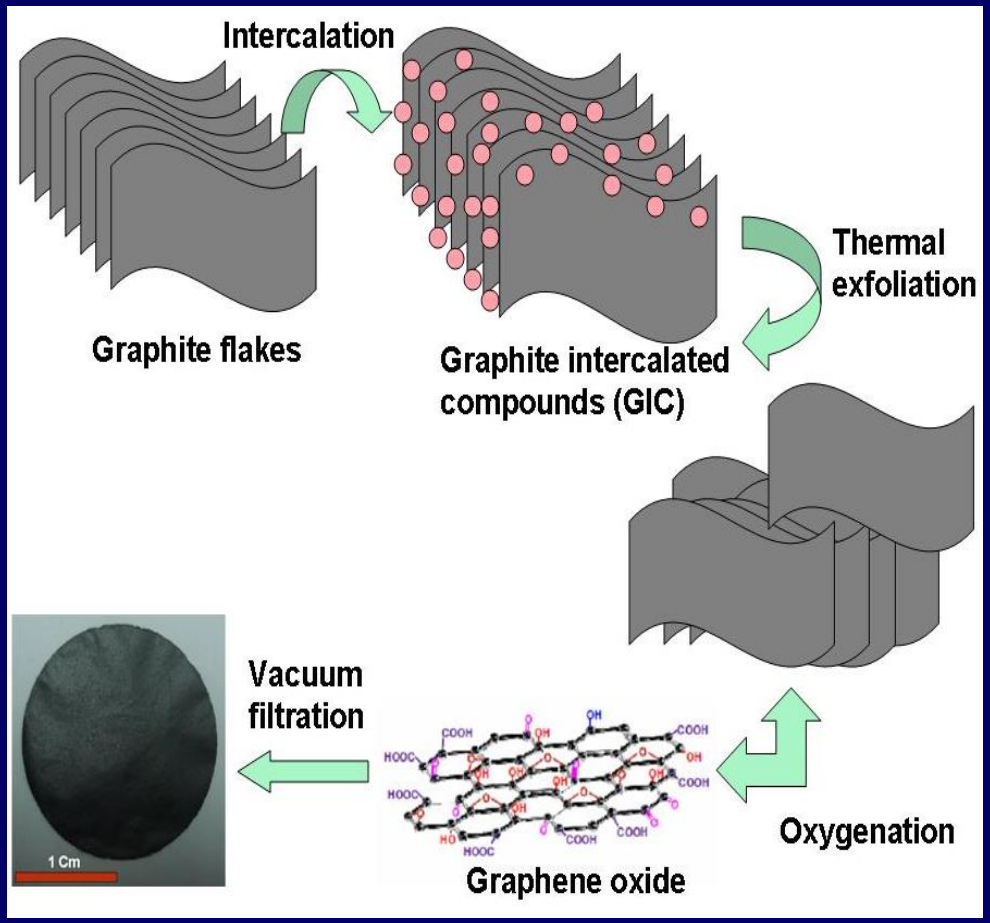
OIL SOAKED

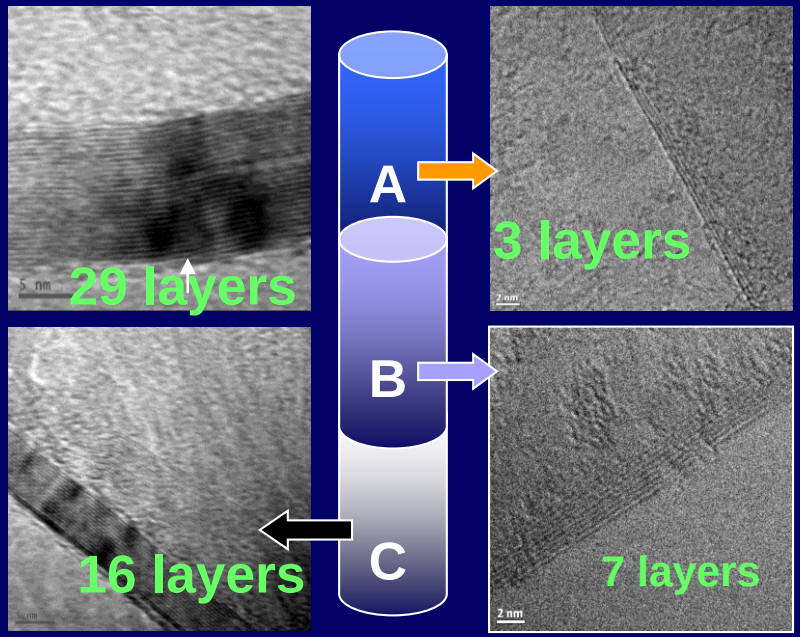


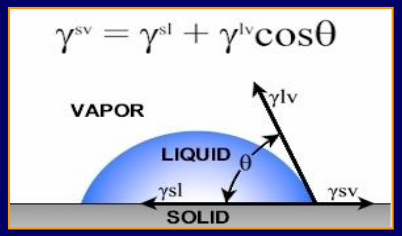


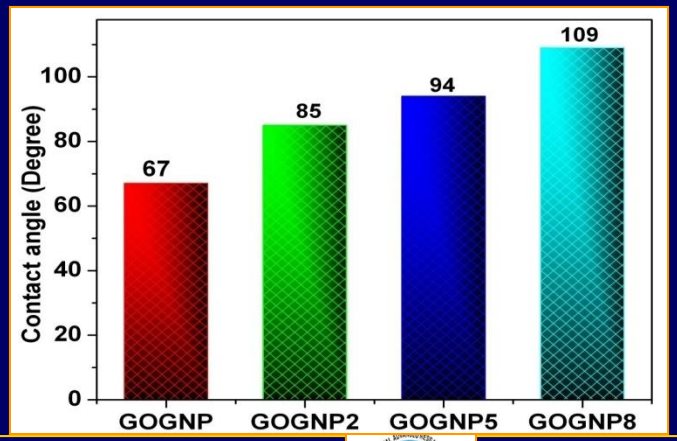
Oil adsorption behavior of Exfoliated Graphite powder shows that viscosity of oil plays an important role in adsorption (1 gram of Ex. Gr can adsorbs ~78 ml of Oil)

Flexible and free-standing Graphene paper









OPPORTUNITIES IN ARCI. HYDERABAD

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THANK YOU

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