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Institute of Materials Engineering- General

The Institute of Materials Engineering (IME) is a major centre of materials engineering expertise in Australia with a multidisciplinary team of scientists and engineers. The Institute plays a significant role in maintaining Australia's international profile in the field of nuclear science and technology. The Institute's core mission is to:

Develop, manufacture, characterise, model and ultimately, utilise Materials in support of the Advanced Nuclear Fuel Cycle and next generation Nuclear Power generation systems.

It undertakes a number of other research activities through sponsored collaborative research programs and is home to other research activities that enhance our contribution to ANSTO and the wider community. It performs its mission by undertaking:

Outcome focussed targeted research and development

The Institute has three main themes: ***Advanced Nuclear Systems*****,** ***Structural Integrity,*** **and** ***Facilities and Commercial Activity*****.**

The ***Advanced Nuclear Systems*** programme undertakes research into the fundamental scientific aspects and industrial applications of nuclear materials relevant to the Advanced Nuclear Fuel Cycle. It includes groups working on:

Waste Form Science: the design and development of new waste forms and technologies and the development of processing technologies to support the commercial opportunities implemented through *synroc*ANSTO.

Nuclear Materials Chemistry: the development of novel separations materials that can be deployed in advanced nuclear energy systems and includes Pyro- and electrochemical radioactive material re-processing undertaken as part of the European Commission FP7 project ACSEPT: Actinide reCycling by SEParation and Transmutation.

Functional Materials: the design and synthesis of novel organic and inorganic functional materials for applications such as light harvesting and molecular separation

*Materials Physics and Modelling****:*** enabling the development of new nuclear materials through a basic understanding of structure/property relationships using validated atomistic and molecular modelling.

The ***Structural Integrity*** programme undertakes research underpinning the assessment of structural integrity of advanced nuclear power system components. It is also the home to the National Security Research function within ANSTO. It thus includes groups working on:

Advanced Nuclear Structural Materials: the development and assessment of structural materials and design methodologies for advanced nuclear power generation systems including the use of advanced structural materials for use in high stress, high temperature and high radiation environments.

*Nuclear Structural Integrity Modelling****:*** the use of advanced structural materials modelling to predict both weld residual stress and high temperature structural integrity. A critical capability is the ability to fully validate both model outputs and the materials constitutive data produced. Undertakes significant modelling activity in support of the Defence Materials Technology Centre.

National Security Research: the application of ANSTO expertise in nuclear and material sciences to enhance national and regional counter terrorism capabilities and to design and implement novel classes of radiation detectors for medical physics, radiation protection and radiobiological research.

Material Challenges: is Nuclear the new Nano?

The world is undergoing a nuclear power renaissance using current technology. Next generation nuclear power systems are designed to address global energy needs later this century. The materials community will need to identify, design and produce materials that can withstand the extreme conditions of radiation, temperature, chemical environment and stress inherent in these advanced nuclear systems if they are to be successful. Meeting these requirements is both challenging and exciting. We then must understand and develop predictive models of the failure mechanisms so that we can develop design codes and defect-assessment criteria that ensure structural integrity.

The Institute is actively addressing these issues and welcomes collaborations with scientists and engineers committed to solving these exciting problems. The following facilities are available to enable such collaboration. New facilities are currently being developed to enable the study of irradiated materials and researchers interested in developing programmes of research specifically concerning nuclear materials are encouraged to contact the Institute Head to discuss possible collaboration.

Microstructural Characterisation Facilities

A comprehensive range of equipment for determining the microstructures of materials particularly metals and ceramics. Experimental facilities are as follows:

5605 Metallographic and electron microscopy specimen preparation

Preparation of samples for SEM and TEM using specialised techniques.

5610 Transmission electron microscope JEOL 2010F

Transmission electron microscope fitted with a Scanning Image Observation Device (a STEM), bright field and high angle dark field detectors, a hollow cone illumination device, a Gatan Imaging Filter (GIF 2001) and an EmiSpec E Vision EDX system.

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5625 Scanning electron microscope JEOL JSM 6300 SEM

Noran Voyager Series IV EDS system with stage automation.

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5630 XRD - PANalytical X'pert Pro X-ray diffractometer

The PANalytical X'Pert Pro Diffractometer is used for the identification and quantification of unknown phases in a mixture as well as the acquisition of data for crystal structure studies. In conjunction with the heating and cooling stages, it can also be used for phase transformation studies. It comprises a X'Celerator detector, multi purpose stage, 45 position sample changer, Cu anode ceramic X-Ray tube, Data Collector and Highscore software. Also available is an Anton Parr HTK16 hot stage (to 600°C in vacuum or 1200ºC in air), Anton Parr HTK 450 cryo furnace (-190°C to 450°C) and a capillary spinner.

Applications

Routine examination of metallic and ceramic specimens. The microscopes are suitable for the determination of lattice site preferences by ALCHEMI and for microanalysis of precipitates, including carbides, in metals.

Crystal structure determinations can be carried out by X-ray diffractometry at temperatures up to 1200^{o}C.

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5750 Instrumental Indentation Facility

Description

A Nano Indenter Model IIs from Nano Instruments Inc for making instrumented indentations to probe near-surface material properties. Vickers, Berkovitch and spherical indenter tips are available. Conversion of data to hardness measurements is standard, while elastic moduli can be obtained under suitable conditions.

A new option is now available allowing the elastic modulus to be measured throughout the loading curve.

Support Services and Facilities

Some support for data interpretation.

Applications

Hardness measurements of treated or coated surfaces as a function of depth.

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5760 Scanning Probe Microscope

Description

The Scanning Probe Microscope from Digital Instruments makes available high resolution surface imaging through a variety of modes - contact AFM, intermittent mode AFM, scanning tunnelling microscopy, lateral force microscopy and magnetic or electrostatic force microscopy. Maximum scan area is 100mm x 100μm with an inspection area of approximately 100mm^2 disc. Samples may be in air or under liquid. Some image analysis is also possible.

Applications

It can map and quantify sample-tip force interactions such as friction, magnetic fields and electrostatic forces at sub-micron dimension, especially for samples which are unsuitable for imaging under vacuum conditions.

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5770 Spectroscopic Ellipsometer

Description

The Spectroscopic Ellipsometer facility is a GESP5 made by SOPRA. It performs ellipsometric measurements as a function of wavelength from 250nm to 900nm. The incident and reflected angles are also adjustable. From this data the optical properties of samples can be determined.

Extensive data analysis routines are available to model the ellipsometric data and hence extract further information about the properties/structure of the measured sample.

Applications

Measurement of optical properties of bulk material - real and imaginary refractive index verses wavelength.

Optical response of multi-layer structures - determination of layer thickness, porosity, interface structure, etc.

Support Services and Facilities

Support and instruction on data modelling.

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5920 Cold and Hot Isostatic Pressing Facilities

Description

Powders of ceramics and metals can be (cold) isostatically pressed (CIP) in rubber bags using two CIP machines. The maximum sample size for the larger CIP is 300mm diameter and 750mm length. The maximum sample size for the smaller CIP is 75mm diameter and 300mm length. The maximum pressure that can be applied for the larger CIP is 200 MPa and for the smaller CIP is 400 MPa. Metals, ceramics and composites can be hot isostatically pressed (HIPed) up to maximum temperature of 2000^{o}C and at a maximum pressure of 200 MPa. It is also possible to sinter in the same cycle prior to HIPing. There are two HIP machines available. The maximum sample size for the larger HIP is 300mm diameter and 500 mm length. The maximum size for the smaller HIP is 70mm diameter and 110mm length.

Support Services and Facilities

Ceramic or metal powders have to be encapsulated in a metal can before HIPing. The necessary facilities are available.

Extensive facilities for powder processing, fabrication of parts, sintering and heat treatment are available (Section 5100 and 5300).

Also facilities for microstructural characterisation and mechanical testing of processed materials are available (Section 5600 & 5450 respectively).

Applications

HIPing can be used to remove closed porosity in metal castings and ceramics, thereby producing higher quality castings or ceramics. Diffusion bonding of similar or dissimilar materials can be carried out.

Superalloys (eg aircraft turbine blades) may be rejuvenated in the HIP. Consolidation by HIPing produces a fine microstructure and a very dense material with superior mechanical properties.

5921 Encapsulation

5925 Hot Isostatic Press LARGE (<1750 deg)

5930a Hot Isostatic Press LARGE (>1250 deg<1750 deg)

5930b Hot Isostatic Press LARGE (>1750 deg)

5935 Hot Isostatic Press SMALL (<1750 deg)

5940 Hot Isostatic Press SMALL (>1750 deg)

5945 AIP Cold Isostatic Press - Small

5950 AIP Cold Isostatic Press- Large

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5970 Nuclear Functional Materials Laboratories

Description

The Institute of Materials and Engineering has a number of radiochemistry and chemistry laboratories with expertise and capabilities in design, preparation and characterisation of functional materials and nuclear probes for studying the engineering of new materials and their properties. Research areas of interest include the investigation into the surface chemistry, transport properties and adaptive response materials and their solid-liquid and solid-gas interfaces.

These facilities include a gamma counter, alpha and beta scintillation counter, gamma and alpha spectrometer, inductively coupled plasma-mass spectrometry (ICP-MS), N_2 gas adsorption, particle size measurement, radioanalytical HPLC (R-HPLC) and associated equipment for handling of radioisotopes. In addition, there are clean room facilities for the preparation of functional surfaces using classical solution based techniques such as spin and dip coating methods and vapour based techniques such as atomic layer deposition.

Support Services

Experienced professionals are available to assist in the design and development of functional materials, nuclear probes, as well as execution of radiotracer studies. Assistance in collection and analysis of data, development of routine methods and training in use of relevant techniques is also available.

Applications

The design and characterisation of novel materials and radiotracers for monitoring nano and micro particles, thin-films and interfaces for use in industrial, medical and environmental applications.

Some well established techniques in our laboratories include

1. Sol-gel processing of organic-inorganic hybrid materials
2. Surface functionalisation using atomic layer deposition
3. Metals binding affinity, stability and loading on novel materials in various media.
4. On line monitoring of controlled release materials in particles and films.
5. Determination of available functional groups in particles and films.
6. Radiolabelling of a range of nano and microparticles for nanotoxicology applications.

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5980-5990 Detector Lab - General

Description

Experimental facilities for the design, characterisation and testing of radiation detector technologies.

Specific capabilities are as follows:

5980 Detector Instrumentation Characterisation.

Available techniques include current-voltage, capacitance-voltage, noise analysis, response testing to alpha, beta, gamma and neutron radiation. Large volume experimental vacuum chambers with multipin electrical feed throughs supported by a diverse range of nucleonics instrumentation.

5990 Geant4 Computing Cluster.

A 43 node computing cluster dedicated to the Geant4 application. Used for simulating the transport of most forms of ionising radiation types in materials and detectors.

Applications

Design, characterisation and testing of radiation detector technologies for applications in medical physics, radiation protection, nuclear science and nuclear technology.

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