Australian Government

ansto

Nuclear-based science benefiting all Australians

OPAL

AUSTRALIA'S WORLD-CLASS RESEARCH REACTOR

The Australian Nuclear Science and Technology Organisation (ANSTO) is Australia's national nuclear research and development organisation and the centre of Australian nuclear expertise. We deliver market-leading products and services to public and private sector organisations in medicine, mining, aerospace, minerals, agriculture, manufacturing and the environment.

OPAL

OPAL, Australia's new world-class research reactor, will help this country maintain its advanced position at the frontiers of international science.

OPAL will be the centre-piece of the facilities we offer at ANSTO, where our nuclear expertise supports health, environmental, industrial and national security objectives.

Similarly, it will enhance our ability to provide high-quality radiopharmaceuticals for nuclear medicine and produce radioisotopes and neutron beams for scientific and commercial uses.

To maximise the use of OPAL, ANSTO has established the Bragg Institute as a regional centre of excellence in neutron scattering science. The Bragg Institute is Australia's leading group in the use of neutron and X-ray scattering techniques to solve complex research and industrial problems. The Institute is named in honour of the Australian Nobel Prize for Physics winners, William and Lawrence Bragg.

OPAL will replace HIFAR, Australia's first nuclear reactor. It will perform in the top five per cent of more than 250 existing international research reactors, and at a similarly high level in its group of multi-purpose reactors. It can operate 340 days a year, a significant increase over the operating levels typically achieved by comparable overseas facilities.

PROFILE: Paul Metcalf

Science and engineering graduate Paul Metcalf says being trained as a reactor engineer has put him on a steeper learning curve than any he experienced at university – and he loves the challenge.

Paul is part of the team responsible for the safe commissioning and operation of OPAL, and will help to supervise a control and monitoring system that handles data from around 5 000 sensors.

PROFILE:

Design and construction

ANSTO has managed the design and construction of the reactor facility in a manner that meets all applicable health, safety, security, safeguards, environmental and quality standards, and relevant international obligations. The development process included a comprehensive environmental assessment and public consultations on safety issues. Every aspect of reactor siting design and construction has been overseen by the Australian Radiation Protection and Nuclear Safety Agency.

OPAL and the building that houses it have been designed to withstand major earthquakes and the impact of large aircraft. Its automated and highly sophisticated safety features include two independent safety control systems to quickly shut down the reactor and cool the reactor core in the event of an emergency.

Inside OPAL

The heart of the new reactor is a compact core of 16 radioactive fuel assemblies interspersed with control rods. In a process known as nuclear fission, uranium-235 in the fuel splits into smaller atoms that emit neutrons and energy. OPAL uses low enriched uranium fuel with around 20 per cent uranium-235. In terms of security and nuclear safeguards, this is a distinct advantage over earlier research reactors, some of which required as much as 95 per cent enriched uranium.

The fuel assemblies are cooled by demineralised light water (ordinary water) and surrounded by heavy water – deuterium (a stable heavy isotope of hydrogen) oxide – in a zirconium alloy ‘reflector’ vessel at the bottom of a 13-metre-deep open pool of light water. The sides of the pool are lined to help absorb unwanted radiation.

The open pool design makes it easy to see and manipulate items inside the reactor. The depth of the light water helps ensure effective radiation shielding of staff working in the area above.

Items can be irradiated in various locations inside the reflector vessel. These materials can be inserted into the vessel, either manually or with automatic equipment using compressed nitrogen, and, following irradiation, transported to a nearby building for further processing.

Size does matter

The Small-Angle Neutron Scattering (SANS) instrument will be one of OPAL's headline-making instruments. It will look at clusters of molecules and structures between one and 100 nanometres in size. SANS is an excellent technique for the study of nanotechnology applications such as the controlled release of pharmaceutical drugs.

ANSTO's 40 metre-long SANS instrument will be one of the best in the world. It will enable scientists to study real industrial processes, such as how polymer molecules change orientation as part of processing. Studying the nanostructure of polymer materials will enable scientists to see how different formulations and processing conditions can affect the structure and properties of everyday items such as high-integrity polymer components of cars.

Dr Michael James

PROFILE:

With qualifications in chemistry, Michael brings 10 years of ANSTO experience to his role as project leader for the construction of the Time-of-Flight Neutron Reflectometer. He works with a team of ANSTO engineers, technicians, computer programmers and scientists to facilitate the reflectometer's design and commissioning.

Michael's research interests are in investigating organic thin films for biosensing applications (detecting tiny amounts of organic molecules like proteins or DNA from very small samples). This complements his instrument building responsibilities, reflectometry being a primary technique used in his investigations.

Neutron scattering science

Neutrons and X-rays are complementary tools for investigating atomic and molecular structures, and the properties of matter. Structures can range in size from one nanometre to several hundred nanometres (one nanometre equals one millionth of a millimetre). Neutrons interact with the nucleus of an atom whereas X-rays interact with the electron cloud surrounding the nucleus of an atom. They are both used to solve complex research and industrial problems in a wide range of fields including plastics, minerals, engineering, pharmaceuticals, electronics and biology.

Neutrons have some advantages over X-rays as tools for determining the structure of both molecules and the arrangement of molecules within materials. For example, neutrons can be used to investigate and provide unique information about semiconductors and magnetic materials used in computers.

When a neutron beam hits a sample, 80 to 90 per cent of the neutrons pass through the sample, some 'scatter' and a very small number are absorbed. The angle at which the neutron beam hits the sample affects the 'scattering' and, hence, the type of information that can be gained.

As neutrons are highly penetrating they make it possible to study samples deep inside large pieces of equipment (such as aircraft engines), and inside vessels that have different conditions of pressure, temperature and environment.

Technetium-99m: the workhorse radioisotope

Technetium-99m, often referred to as the workhorse radioisotope, is the most commonly used radioisotope. It can help diagnose various heart, kidney, lung, liver and thyroid conditions, and some bone cancers.

One of the typical diagnostic applications of technetium-99m is in myocardial perfusion imaging (or heart imaging), which can also be undertaken with the radiopharmaceutical thallium-201.

The primary goal of heart imaging is to determine the adequacy of blood flowing to the myocardium or heart muscle. This is often done in conjunction with exercise and stress testing to detect and evaluate coronary heart disease.

Peter Lam

As one of three quality control supervisors that ensure ANSTO radiopharmaceuticals meet strict quality standards, approved by Australian and international agencies, Peter Lam is a busy man.

With qualifications in chemistry and information technology, Peter supervises the day-to-day, quality-control operations of ANSTO's radiopharmaceutical manufacturing facilities and contributes to continuous improvement of procedures and processes. Peter and his team work six days a week testing and releasing a wide range of radiopharmaceuticals.

"Our products have relatively short half-lives, so it's a constant challenge to make sure they are tested quickly and accurately to meet tight delivery schedules," Peter says.

PROFILE: Tatiana Karma

Tatiana Karma is the face behind ANSTO's multi-million dollar silicon irradiation business, with customers in Europe and Asia. A Russian-born nuclear engineer, Tatiana thoroughly enjoys the challenges of the job, including the important task of maintaining good long-term business relationships with international customers.

Tatiana says the new reactor will be able to handle silicon crystals up to 200 millimetres in diameter. It will produce irradiated silicon that meets the needs of a wide range of customers.

Radiopharmaceuticals and medical research

ANSTO supplies most of Australia's radiopharmaceuticals for use in nuclear medicine, as well to a number of overseas countries, especially in the Asia-Pacific region. On average, every Australian will use a radiopharmaceutical produced by ANSTO in their lifetime.

Radiopharmaceuticals contain radioisotopes that spontaneously produce specific amounts of radiation which can be used to safely diagnose and treat a wide range of human diseases and injuries. Radioisotopes are the essential parts of radiopharmaceuticals.

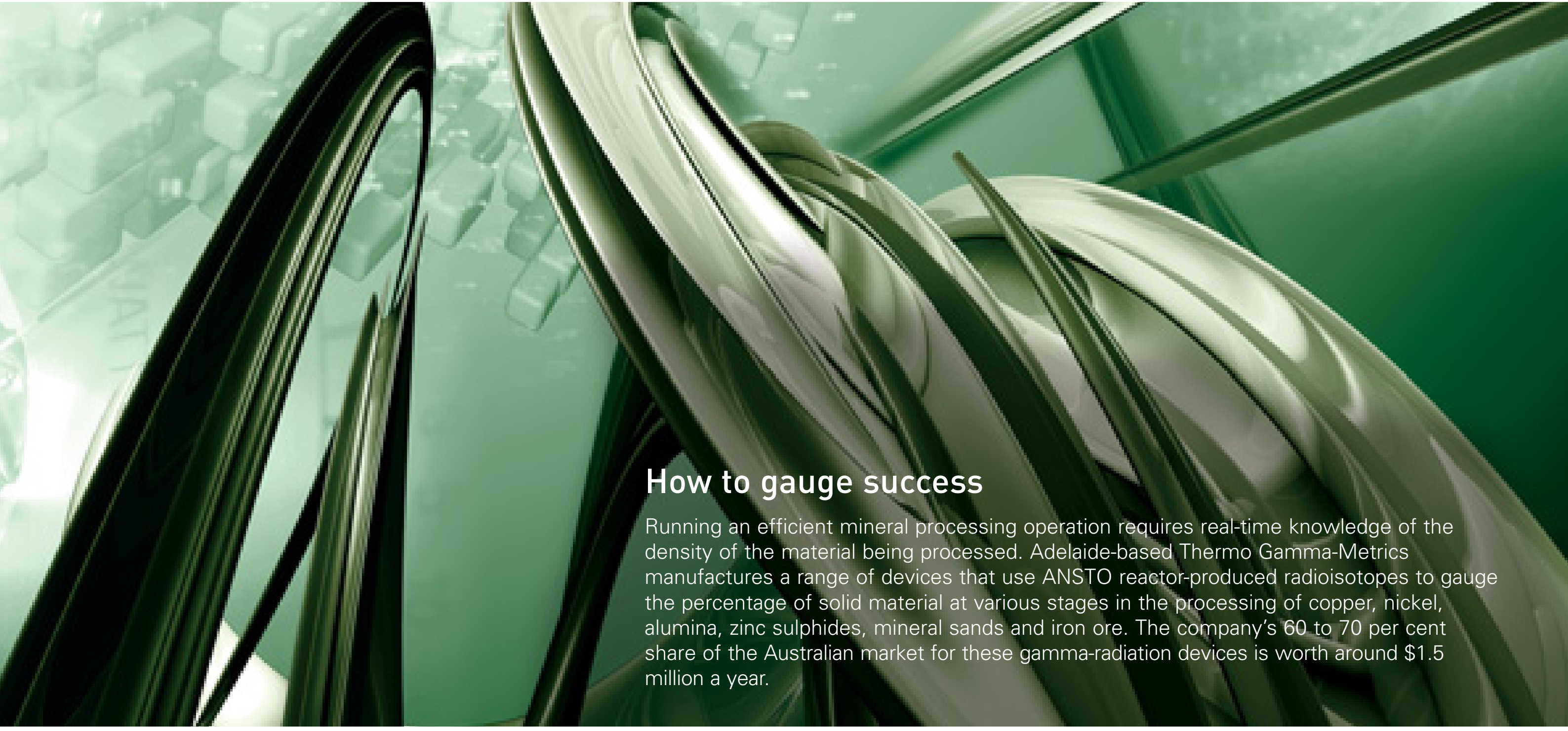
Diagnosis and imaging are the main uses of radiopharmaceuticals, but the nuclear medicine industry intends to expand the therapeutic uses of radiopharmaceuticals, which currently account for around 10 per cent of ANSTO's sales.

Most radioisotopes are produced in research reactors. A number, however, are also made in medical cyclotrons, which use high-energy protons rather than neutrons to effect transmutation. Transmutation changes the nature of an atom's nucleus, and therefore its chemical identity (for example, zinc to gallium).

Because radioisotopes have a limited shelf life, cost-efficiency is enhanced by producing them close to where they are used. Also, it is critical that radiopharmaceuticals reach nuclear medicine centres within a tight timeframe as they have a limited 'window' within which they can be used. This is due to medical radioisotopes generally having short 'half-lives' (i.e. the time in which the radioactive activity halves).

OPAL's increased production capacity will supply virtually all the radiopharmaceutical requirements of the Australian healthcare system for the next 40 years, and provide excellent opportunities for increased exports to overseas markets. The reactor also has the capability to produce a wide range of isotopes to assist medical research in the development of radiopharmaceuticals for new treatments and imaging of diseases.

These factors will help put Australia on the map as a world class supplier of radiopharmaceuticals and radioisotopes, as well as a centre of medical science excellence.



How to gauge success

Running an efficient mineral processing operation requires real-time knowledge of the density of the material being processed. Adelaide-based Thermo Gamma-Metrics manufactures a range of devices that use ANSTO reactor-produced radioisotopes to gauge the percentage of solid material at various stages in the processing of copper, nickel, alumina, zinc sulphides, mineral sands and iron ore. The company's 60 to 70 per cent share of the Australian market for these gamma-radiation devices is worth around $1.5 million a year.

How to find out more about ANSTO

ANSTO distributes regular updates on its science and technology, has available a range of publications and conducts free tours of its site. For bookings, information or to be added to ANSTO's database, please contact us.

+61 2 9717 3111
enquiries@ansto.gov.au
PMB 1, Menai NSW 2234, Australia
www.ansto.gov.au

Industrial products

ANSTO produces a range of radioisotopes and non-destructive testing equipment for industrial customers around the world. These radioactive sources can be used somewhat like a more powerful, more mobile form of X-rays to safely and reliably test the integrity of power station turbine blades, pipeline welds, aerospace structural components, railway tracks, bridges and heavy mining equipment. Other uses include checking the density of the rock on which bridges and roads are to be built, measuring the extent of subterranean oil resources, gauging refinery tank levels and assessing mineral flow on conveyor belts. From 2003 to 2005 ANSTO's sales of radioisotopes for non-destructive 'imaging' methods have tripled.

In addition to increasing the quantity and cost-effectiveness of these products, OPAL's capabilities will enable ANSTO to expand into new market sectors that require higher levels of radioactivity.

Silicon irradiation

ANSTO is one of the world's leading providers of irradiation services for silicon ingots of electronic grade for advanced electronic devices, integrated circuits and many other industrial applications. The new reactor will enable ANSTO to significantly increase its silicon irradiation capacity and produce irradiated material of the highest quality.

In its pure, natural state, silicon is an insulating material, so it does not conduct electricity. With the introduction of phosphorus atoms by a nuclear reaction, however, silicon acquires semi-conducting properties.

Silicon semiconductors are used for a wide range of applications in the power transmission, manufacturing, automotive, transport, military and space industries, and in scientific research. Devices manufactured from irradiated silicon are also used in appliances such as air conditioners, fridges and microwaves.

January 2006