Australian Government

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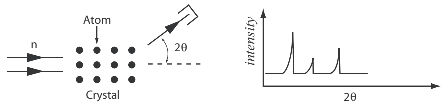
WOMBAT

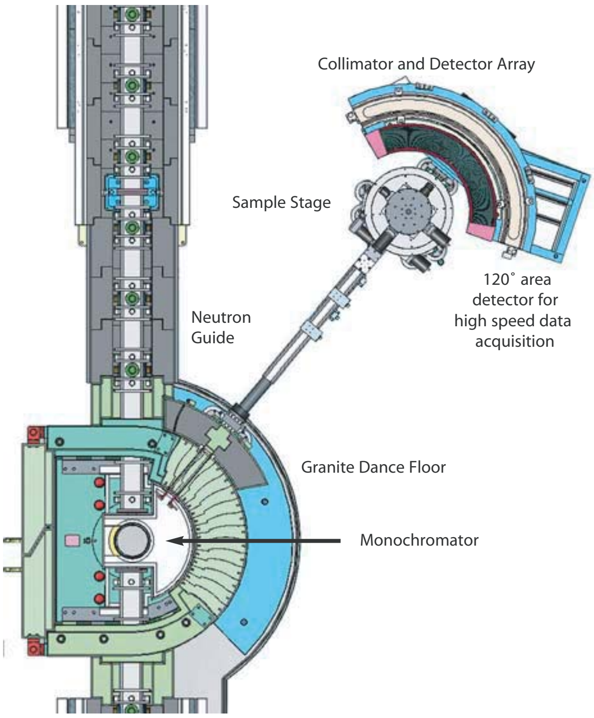
High-intensity powder diffractometer

Wombat is the most powerful high-intensity powder diffractometer in the world. It has the power to detect a million neutrons a second and to produce data on the structure of materials in a matter of milliseconds.



Diffraction

A neutron beam is scattered within a crystalline material creating diffraction patterns to determine the arrangement of atoms and molecules within the material.



What makes Wombat special?

- Able to determine crystal structures quickly for phase transitions, chemical reactions and kinetic studies with rapid real time measurements (down to 30 μs)
- Able to analyse very small samples (approx 10 mg).
- Able to analyse samples in complex sample environment(s), eg: in pressure cells

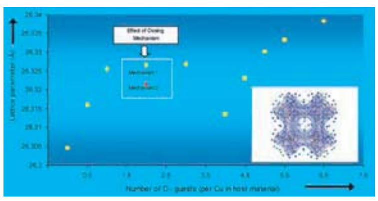
Applications:

Wombat can be used to study a range of materials including, novel hydrogen-storage materials for clean energy storage of the future, pharmaceutical molecules, negative-thermal-expansion materials (materials that contract upon heating) and materials for fusion reactors.

The properties of a material are linked to its atomic structure, which can be influenced by its environment. The effects of temperature, pressure, applied fields (magnetic or electric) on the atomic structure can affect the material's properties and can be measured by Wombat.

For example:

- Phase transitions – by varying one or more of the temperature, applied magnetic/electric fields, or applied pressure, the properties in a material can be created or destroyed.
- Material formation – many materials undergo one or more chemical reactions as a function of time as they are formed e.g setting of cement
- Cyclic variations – materials periodically exposed to applied fields resulting in changes to the atomic structure.
- In-situ studies to observe chemical reactions and other dynamic phenomena as they occur

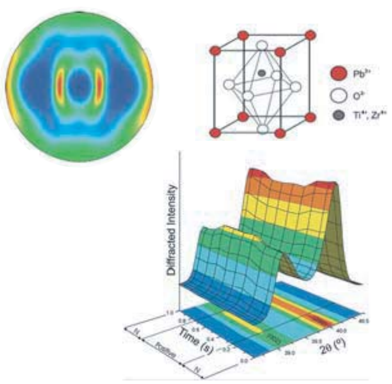


Range of new materials which can be studied.

Case Study 1: *In situ* chemical physics

Recently, a new class of porous materials has been developed in which the structure (and properties) can be changed through the absorption of other molecules, called 'guests'.

The way in which a change is applied can also affect structure. Recent research on a porous framework material indicates a structural change dependant on the rate of guest sorption. Wombat will be able to uncover the mechanisms for such perturbations in structure.



Phase transition in PZN-8.5PT

Case Study 2: Piezoelectric materials

Ceramic lead zirconate titanate (PZT) is a very popular material for electromechanical transducer applications due to its large piezoelectric response and low cost. Devices such as ultrasound generators, hydrophones, high-voltage generators, impact sensors, and micro-positioning systems are just a few which take advantage of the exceptional properties of PZT. There are a whole range of piezoelectric materials based on the PZT structure, with the potential for applications to be explored.

Wombat will be used to perform rapid stroboscopic measurements to determine how these materials change structure with the application of an electric field, combined with longer duration measurements to study fatiguing effects over time which can lead to device failure.

Instrument specifications:

Wombat is located on the thermal neutron guide TG1
Wombat was built as a flexible modular instrument which can exploit the advantages of:

- focussing neutron optics in the monochromator system over a wide range of incident wavelengths
- a large solid angle detector with position sensitive detection capabilities
- an advanced data acquisition electronics system
- a re-configurable collimation system which optimises the background reduction in each experiment.
- Wavelength ranges
  0.9 - 2.4 Å (Ge monochromator)
  2.4 - 5.8 Å (PG monochromator with Be filter for >4 Å)
- Resolution Dd/d > ~ 2 x 10^{-3}
- Beam size max. 20 mm (wide) x 60 mm (high)
- Sample weight ~10 mg to 10 g
- Typical sample size 1 cm^3
- 1s acquisition for 10 mm^3 (17 min for 1 mm^3) in one shot irreversible experiments
- 30 μs acquisition in stroboscopic mode (reversible experiments)
- Estimated flux at sample position >10^8 $ncm^{-2}s^{-1}$
- Detector area: continuous detection over 120° x 200 mm high

For more information contact:
Andrew Studer: +61 2 9717 3602
Email: andrew.studer@ansto.gov.au

Margaret Elcombe: +61 2 9717 3611
Email: margaret.elcombe@ansto.gov.au

Vanessa Peterson: +61 2 9717 9401
Email: vanessa.peterson@ansto.gov.au

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