Infrared Spectroscopy

The infrared (IR) spectroscopy beamline uses the unique characteristics of synchrotron radiation to extend the scope of this popular technique. The facility can locate and analyse individual components in samples with dimensions of only a few microns, producing high spatial resolution chemical images. The IR beamline also offers high spectral resolution IR spectroscopy for characterising samples in the gas phase.

Features

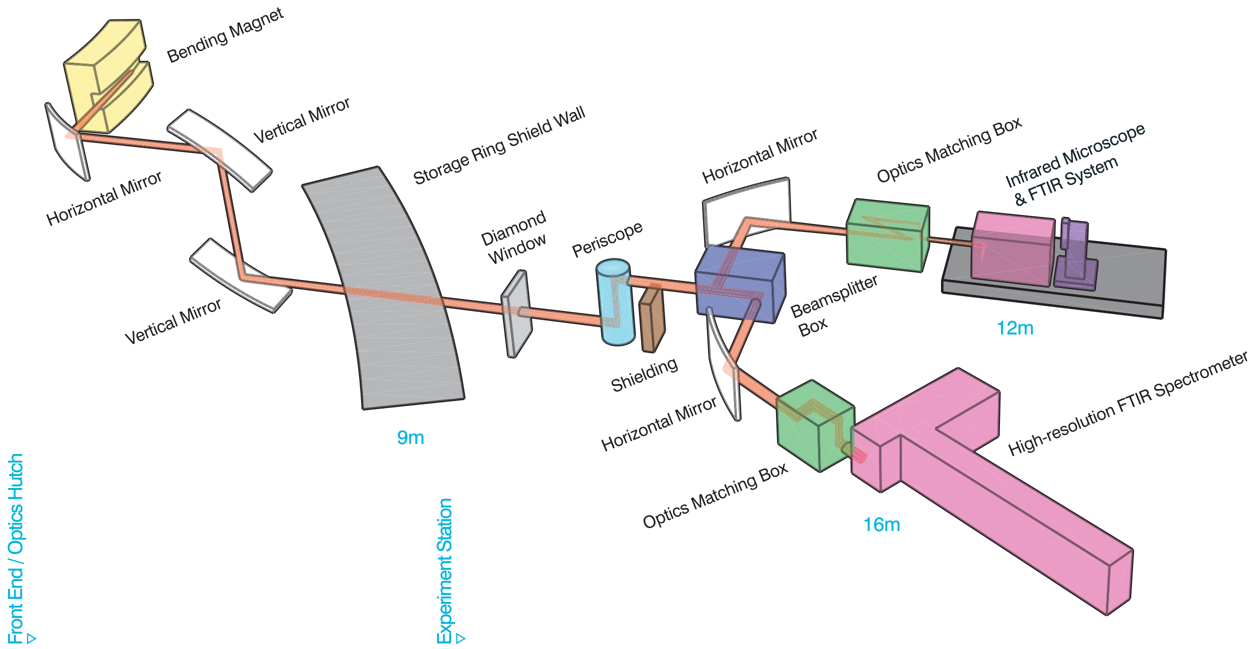
- highly-collimated, polarised infrared beams up to 100 times more intense than conventional IR sources, offering spatial resolution down to 3 microns in the mid-IR
- chemical mapping of diverse materials including biological tissues, composite materials and surface coatings
- high spectral resolution gas-phase spectroscopy.

Applications

Infrared spectroscopy is widely used in research, analytical and industrial laboratories. The technique is applied in many fields, including the life, environmental, physical and earth sciences, and in forensic investigations and in the study of cultural artefacts.

A relatively new development, synchrotron infrared facilities are currently only available at a handful of synchrotrons.

Synchrotron light greatly enhances the potential of infrared techniques, especially in microspectroscopy, in the far infrared and at high spectral resolution. Examples include the microanalysis of surface contaminants, chemical imaging of biological cells and the study of minerals at very high pressures. The high intensity of the synchrotron IR light enables fast throughput of this diverse range of samples.



Examples

- studies of cellular changes in tissues affected by diseases such as Alzheimer's and multiple sclerosis; real-time studies of conformational changes in proteins (to complement protein crystallography studies)
- detection of mineral species with limited specimen preparation; separation of real from artificial diamonds
- studies of combustion processes; monitoring of atmospheric and exhaust gases
- studies of industrially important processes such as yeast fermentation, surface corrosion and the build-up of engine deposits
- forensic science studies of fibres, dyes, paints, pigments and gunshot residues; *in situ* studies of paintings, manuscripts, textiles and statues
- band-gap studies of new classes of semiconductor materials and non-linear optical materials.

Case study 1

Research to improve IVF success rate

Professor Don McNaughton and Dr Bayden Wood from Monash University are using synchrotron IR microscopy to study the maturation of mammalian egg cells (oocytes) and better assess their viability for use in in-vitro fertilisation (IVF) techniques. The work will ultimately help to improve the success rate of human IVF procedures. Using a synchrotron enables the researchers to study the oocytes at subcellular level, which is not possible with laboratory-based equipment. Dr Wood and his colleagues also use synchrotron techniques for other medical research projects, including screening potential new cancer drugs, assessing the compatibility of organ donors and studying heart disease.

Case study 2

Conserving our written heritage

Professor Dudley Creagh and Alana Lee from the University of Canberra are using the IR beamline at the Australian synchrotron to study how inks and pigments such as iron gall ink can degrade old parchment and paper. Made from iron sulphate and tannins extracted from wasp galls on trees, iron gall ink is quite acidic and can eventually eat into the parchment. The work will lead to better conservation methods for important documents held in museums and national archives, and assist the development of improved forensic techniques for criminal investigations. The researchers are also using synchrotron techniques to study the deterioration of other heritage items such as bark paintings, historical aircraft and motion picture film stock.

Case study 3

Far-IR sheds light on atmospheric interactions

Professor Don McNaughton, Dr Evan Robertson and Dr Christopher Thompson from Monash University are using far-infrared high spectral resolution IR spectroscopy to investigate gases that could harm the ozone layer.

The group has been studying chlorine-containing refrigerant gases such as CFCs that are being phased out of worldwide use due to their high ozone-depletion potential. They are also studying possible replacement gases such as fluorinated hydrocarbons, which are relatively harmless to the ozone layer.

Storage rings provide much brighter far-IR light than standard thermal laboratory sources, making the far-IR spectral region more accessible for high-resolution gas-phase studies. The detailed analyses provide essential data for modelling the spectra under the varying conditions found in the earth's atmosphere, a necessary step in identifying and quantifying these man-made atmospheric gases.

Beamline specifications

Source	edge radiation and bending magnet radiation from the first dipole of sector two of the storage ring
Energy range	0.4 µm to 100 µm
Energy resolution	• microscope resolution (mid-IR) = 0.2 cm^{-1} • high resolution FTIR resolution (far-IR) = 0.001 cm^{-1}
Nominal beam size at sample (microscope)	8 x 8 µm to 3 x 3 µm

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