Synchrotron-based Spectroscopy techniques available at Diamond

Type	What is it?	What does it enable/provide?	Benefits/what it's best for	Applications	Beamlines
X-ray absorption Spectroscopy (XAS)	Oscillatory variation of X-ray absorption as a function of photon energy beyond an absorption edge.	Understanding of the local structure of materials with chemical specificity. Information on the electronic properties and oxidation state of the studied element.	• Enables investigations into the relationship between chemical structure and reactivity • Capable of studying solids, liquids and even gases • Perfect for *in situ*, operando studies, using different sample environments (eg. pressure/temperatures) to probe materials under real industrial processes. • Can be combined with other techniques for complex studies. • Ideal for studying biochemical processes.	• Catalysis • Microelectronics • Batteries/fuel cells. • Cancer therapies • Lubricants • Healthcare • Food • High density visual displays • Memory storage devices under environmental control, (eg. temperature, magnetic field.)	I06 B18 I18 I20 B07 I08 I14
X-ray Fluorescence (XRF)	Elemental analysis by measurement of its characteristic X-ray emission energy.	Powerful tool for the qualitative and quantitative estimation of all elements with an atomic number greater than 8.	• Non destructive rapid technique of chemical analysis. • Elemental distribution across the selected area of interest with very high precision and accuracy.	• Process control • Mining • Geochemical exploration • Environmental • Lubricants • Pigments • Food processing • Cancer screening	I08 I18 B18 I14
Scanning X-ray Microscopy (SXM)	Microscopic and spectroscopic imaging of a thin section of a sample with nm scale spatial resolution.	Information on the elemental distribution, the local chemical state of an atomic species, the local structure of studied elements across various materials. Information on the alignment of molecular orbitals and magnetic properties when using polarised light.	• Can be combined with an array of techniques to examine the elemental distribution of the material and identify different chemical species • Enables transmission imaging with simultaneous acquisition of absorption, differential phase contrast and dark field imaging • Provides access to L and M-edges for some metals • Provides access to C, O and N K-edge XAS by exploiting the natural absorption contrast in the water window • Allows low energy XRF mapping using a lower radiation dose when compared to transmission electron microscopy • Provides the flexibility for NEXAFS microspectroscopy.	• Catalysis • Energy storage • Pharmaceutical research • Medicine • Polymer science • Environmental chemistry • Biomaterials.	I08 I14
X-ray Photoelectron Spectroscopy (XPS)	Semi-quantitative analysis of surface material	Understanding of the physical and chemical interactions that occur at the surface or at the interfaces of a material's layers. Understanding of the corrosion rates and catalytic activity of various processes. Provides information on adhesive properties, wettability, contact potential and failure mechanisms.	• Applicable for use across a broad range of materials • Perfect for *in situ* studies of surface modifications (of organic and inorganic materials) to determine composition and chemical state and alter or improve the performance and behaviour • Capable of depth-profiling (e.g. cross section and absorption edge) of a material or element being researched • Provides fast data acquisition times when compared to lab-based X-ray sources. • Allows for ambient pressure XPS operational up to 100 mbar pressure • Provides *in situ* capabilities to study the chemical processes under more industrially relevant conditions (water vapour, various gases, temperatures)	• Nuclear waste materials • Pharmaceutical • Catalysis • Thin-film electronics • Bio-active surfaces • Corrosion • Electrochemistry	I09 I06

Type	What is it?	What does it enable/provide?	Benefits/what it's best for	Applications	Beamlines
Infrared (IR) Microspectroscopy	The analysis of infrared light interacting with a molecule.	Enables studies of organic and biological material in condensed matter. Allows spatial resolution studies to understand the physio - chemical properties of materials and surfaces at a microstructural level.	• Allows high spatial resolution IR studies extending from the near-IR up to the far-IR (or THz) region • The combination of IR with X-ray microspectroscopy techniques allows the complementary characterisation of samples both at molecular and atomic levels • Enables biomedical samples like tissue sections or single cells to be mapped in plots showing molecular composition versus position.	• Pharmaceutical products • Catalysis • Advanced materials • Cancer screening • Medical diagnostics • Polymers • Ancient artefacts, • Processed food products • Biomedical samples such as tissue sections and live cells.	B22

Angle-Resolved Photoemission Spectroscopy (ARPES)	Probe of electronic band structure and electron-electron, electron-phonon interactions	A direct measure of electrons live in bands.
		
		Enables you to follow changes in band dispersions and quasiparticle lifetimes during electron-electron and electron-phonon interactions.
			• The momentum parallel to the surface allows studies on layered low-dimension materials
			• The three-dimensional momentum distribution in the photoelectron features allows studies of metallic single crystals to be undertaken
			• Provides the most direct probe of electronic band dispersion in crystalline solids
			• Enables the study of the following phenomenon:
			  • Brillouin zones
			  • Fermi surfaces
			  • Band dispersion
				• Graphene, molecular electronics, carbon nano tubes, BN nanostructure
				• Transition metal oxides
				• Quantitative analysis of electron interactions, fermi surfaces, renormalisation, energy gaps;
				• Heavy Fermions
				• Ultra small bandwidth dispersions
				• New materials
				• Molecular adsorbates, ultra thin films, stepped surfaces, epitaxially grown nano-wires
				• Topological insulators, Dirac semimetals and the Weyl fermions. High-temperature superconductors
					I05

UV and Visible Circular Dichroism	The differential absorption of left and right-handed circularly polarised light.	Enables you to determine the optical isomerism and secondary structure of molecules. Allows studies on chirality of various biologically important materials.	• The combination of high photon flux and small spot size allows: i) the measurement time for CD time resolved experiments ii) smaller amounts of chiral material to be used • Enables investigations on protein/ligand binding interactions, such as those involved in signal transduction of normal and tumour cells, without the need for labelling or immobilising any of the components.	• Applicable to large or small biomolecules • Structural, functional and dynamic interactions between elements in proteins, nucleic acids and chiral molecules • Protein folding, macromolecular interactions, conformational changes, enzyme mechanisms, and secondary structure determination • Fold recognition for structural genomics and complex formation for proteomics. • Ligand and drug screening for functional genomics.	B23
X-ray Magnetic Circular Dichroism	The differential absorption of left and right circularly polarised light in a magnetic field to examine magnetic materials and properties.	Used alongside X-ray absorption spectroscopy it can provide complementary information on the electronic structure of various materials	• Provides a research method that is element-specific and sensitive to the orbit and spin properties of matter • Enables fingerprinting studies to study specific ground state • Instrumental resolution allows you to capture the multiplet structure and charge-transfer satellites. • Provides X-ray spectroscopy and scattering measurements sensitive to magnetic X moments	• 3D transition metal, lanthanide and actinide systems. • Magneto-electronics, chemistry, organo-metallic compounds, spinels, geomagnetism and metalloproteins, biomagnets • Thin films, multilayers, magnetic nanostructures, clusters and spin transport systems.	I06 I10 I16