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Comparison of complementary techniques

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COMPARISON OF COMPLEMENTARY TECHNIQUES

	Method	Depth Profiling & Lateral resolution	Crystal-lography	Elemental Analysis
XRF	**X-ray fluorescence**: X-rays in, lower energy X-rays out. Works in real space. ***Direct competitor to PIXE***. XRF cross-sections are high near the exciting wavelength and fall (opposite to PIXE). Can be used (especially with tunable – synchrotron - source) to excite one species preferentially Quantification hard: no complementary signals	Depth sensitivity using microcapillary lenses and confocal techniques. Lateral mapping at ~um resolution with synchrotron source	No	ug/g sensitivity for many elements. Quantification often hard.
XRD	**X-ray diffraction**: X-rays in, same energy X-rays out. Works in reciprocal space, imaging Bragg reflections	Thin film sensitivity with glancing incidence	Yes, very powerful	Indirect
TEM	**Transmission electron microscopy**: Imaging electrons transmitted through *thin* samples. Elemental analysis: **energy dispersive X-ray** analysis (EDX) & **electron energy loss spectroscopy** (EELS). Analysed volume is always *very small*.	Intrinsically a **phase contrast** technique, but depth resolution with cross-sections or stereoscopy or confocal methods, **atomic resolution**	Yes, very powerful, with selected area diffraction	With EDX and EELS. Usually semi quantitive: representativeness always a concern
MEIS	**Medium energy ion scattering**: RBS with 100keV H beam (near maximum of energy loss curve for best depth resolution). Needs sophisticated position sensitive detector for angular resolution of scattered beam	Very high sensitivity to first few atomic layers	Detailed crystallography of first few atomic layers	As RBS. Uncertain ionisation state makes quantification hard
LEIS or ISS	**Low energy ion scattering** or **ion scattering spectroscopy**: RBS with noble gas ion of a few keV. Needs sophisticated position sensitive detector for angular resolution of scattered beam.	Very high sensitivity to first atomic layer	Detailed crystallography of first atomic layer	As RBS & MEIS
XPS	**X-ray photoelectron spectroscopy**: X-rays in, photoelectrons out. Photoelectrons can escape only from from first few atomic layers: :the *inelastic mean free path* is the critical quantity. Energy analysed with sophisticated spectrometers. Chemical bonding information. Sensitivity ~atomic%, absolute quantification (~10%, but much better in specific cases) . Mapping using confocal methods of electron extraction.	Only with sputtering. XPS is intrinsically very surface sensitive: can use angle resolved methods for depth resolution in first 10nm without sputtering. ~10um lateral resolution	No	Yes, traceability hard
AES or SAM	**Auger electron spectroscopy** or **scanning Auger microscopy**: Electrons in, Auger electrons out. Electron spectroscopy as for XPS. Use SEM technology for electron beam, thus very high lateral resolution. Less chemical bonding info since electron impact ionisation is a more complicated process.	as XPS. Mapping at sub-nm resolution	No	Yes, traceability harder than XPS. Often used qualitatively