Equipment Name: Transmission Electron Microscopes: 2 TEM/STEMS (80-200 kV) SuperSTEM – 2 dedicated aberration corrected STEMs	**Category:** **C. Particle Characterisation in and ex-situ** **Institute: University of Leeds** **Location: IMR, Engineering Building, Leeds. LS2 9JT. UK** **Contact Details of Technology Expert:** **Name, Rik Brydson** **Phone, +44 113 3432369** **Fax, +44 1133432348** **E-mail mtlrmdb@leeds.ac.uk**

Short technology description/Overview *(approx 300 words)*:

The Transmission Electron Microscope (TEM) forms a parallel *projection image* of a thin (typically 30-100 nm) sample at magnifications in the range 10,000x – 1,000,000x. The limit of resolution is determined by imperfections in the objective (imaging) lens and is typically a few tenths of a nanometre. TEM electron sources are similar to those employed in the SEM and also require high vacuums, however, in the TEM the electrons are accelerated to much higher energies before they hit the specimen (typically 100 keV as compared to 10 keV in the SEM) – this is because we require the electrons to get through the thin sample in order to form the projection image.

The main advantage of the TEM over the SEM is the ability to view the internal (rather the surface/subsurface) microstructure at extremely high magnifications (and even view the atomic structure of a material !) and to easily form diffraction patterns from selected regions of the microstructure and so determine the crystal structure (in a similar fashion to XRD). As in the SEM it is also possible to analyse the chemical composition from the spectrum of X-rays generated in the specimen.

Scanning TEM (STEM) is analogous to SEM, however here the beam is focussed to a small probe and we measure the transmitted signal (not the backscattered signal or the signal from secondary electrons produced by the top surface as in SEM). We can measure both bright field and annular dark field (ADF) images, the latter provide Z-contrast images.

In conventional TEM imaging mode we can focus the beam on a selected region and record the spectrum of X-ray energies emitted by the sample at that point – this is known as the energy dispersive X-ray spectrum. Different elements in the sample produce X-rays of characteristic energies (or wavelengths), hence it is possible to determine the distribution of elements in the sample. If we scan the beam we can then X-ray maps and map out the different elemental distributions. Another analysis technique (Electron energy loss spectroscopy – EELS), which measures the energy lost by the transmitted electrons, can also provide detection and quantification of light elements as well as information on the chemical bonding.

Main Features (Equipment Capabilities):

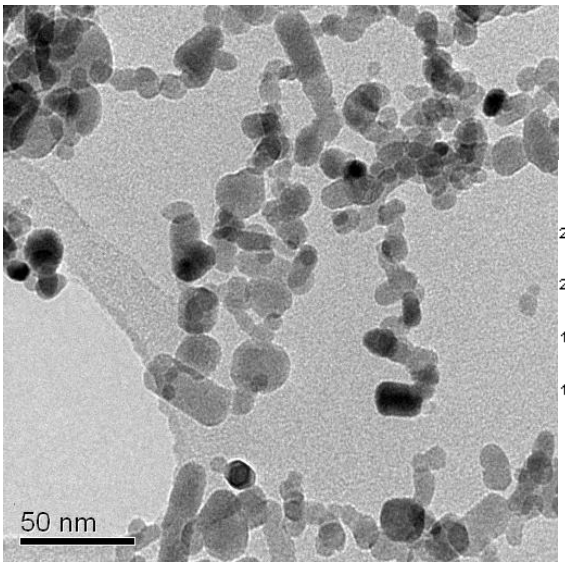
- Bright Field/ Dark Field Imaging
- Phase Contrast Atomic Lattice Imaging
- STEM High angle Annular dark field (Z-contrast images)

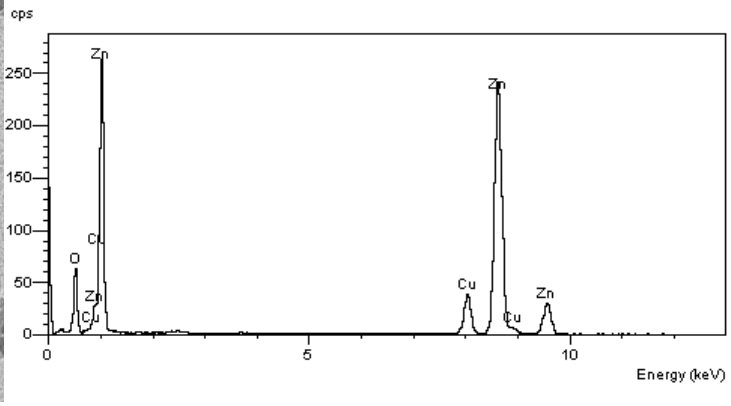
- Energy Dispersive X-ray spectra (composition)
- Electron Energy Loss Spectra (Light element Composition and Bonding)
- Heating Stage (up to 1273K) and Cooling stages (liquid nitrogen)
- Ex-situ Heating/Gas Atmosphere Holder for high temperature gas treatments plus vacuum transfer to TEM
- STM holder in-situ in TEM – useful for prodding particles or making 2 probe conductivity measurements

Typical Samples & Images:

Powders dispersed in suitable liquid, drop caste and dried onto a thin holey carbon support film.

Can also freeze dry dispersions and then allow to warm to view snapshot of the aggregation state in the dispersion.





Any further Information: