Characterisation

Transmission Electron Microscopy

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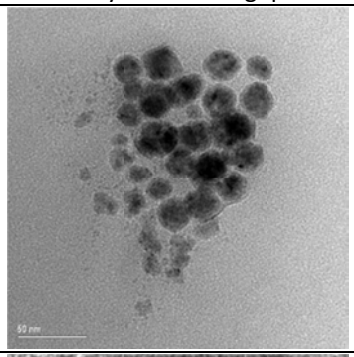
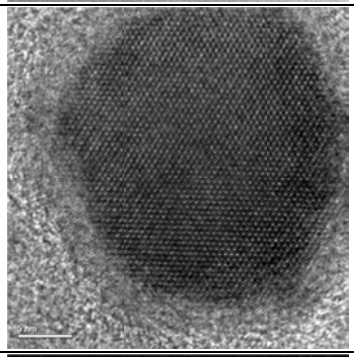
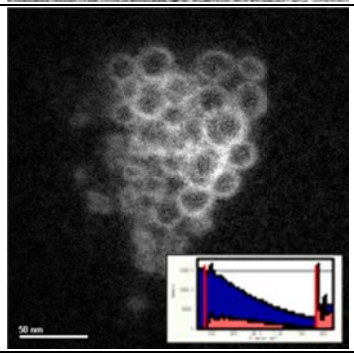
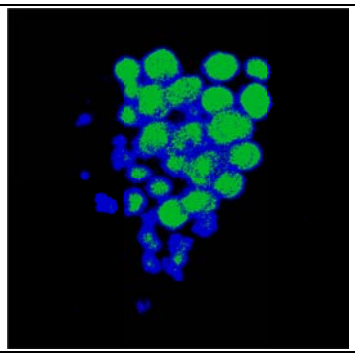
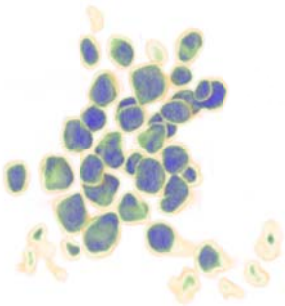
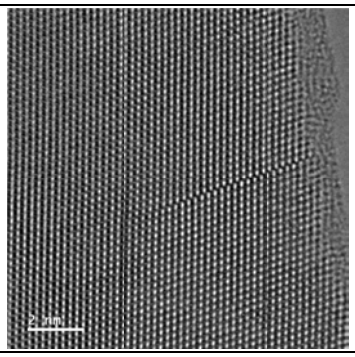
Material class:	Silicon	Polymer	Metal	Ceramic	Glass	Organic	Other
	X	X	X	X	X	X	X

Equipment:	Titan 80-300 aberration corrected
Short technology description:	Transmission electron microscopy enables characterization of powders and thin films (which can be prepared in a target preparation from bulk materials) by direct imaging with up to atomic resolution. The image information can be locally correlated with spectroscopic techniques (EELS/EFTEM and EDX) to provide semi-quantitative elemental composition/maps with up to sub-nanometer resolution. All of these techniques can also be performed during in-situ heating or tensile testing of the material. For complex three-dimensional structures, electron tomography can be used to generate a 3D representation of the material with a spatial resolution of 1-2 nm, which can be used to quantitatively measure e.g. particle distributions, surface areas and faceting.
Typical structures and designs:	 **BF-TEM image of Co/CoO core/shell particles with a diameter of ~30 nm**
	 **HRTEM image of Co/CoO particles showing the atomic arrangement in the single crystalline Co core and the polycrystalline CoO shell**
	 **EFTEM image of oxygen distribution in Co/CoO particles and local EELS spectrum of a CoO shell**

		**Multivariate analysis of Co and O EFTEM maps revealing the Co und CoOx distribution**
		**Volume rendering of 3D tomographic reconstruction of Co/CoO particles**
		**Atomic resolution TEM image of a partial dislocation in nanocrystalline palladium**
Special features:	– FEI Titan 80-300 – (aberration corrected TEM) – Resolution: – 0.08 nm information limit TEM – 0.14 nm resolution in STEM – 0.7 eV energy resolution EELS – Techniques: – BF-TEM, aber. cor. HRTEM – HAADF-STEM, HRSTEM – EFTEM, EELS, EDX – Electron diffraction – Lorentz imaging – (S)TEM tomography – Low-dose techniques – In-situ heating holder (up to 900ºC) – In-situ straining holder	
Limitations, constraints:	– Sample has to be a solid at RT and stable under vacuum conditions – Maximum sample thickness: 10-2000 nm (depending on resolution and technique) – Except in tomography, the TEM always provides an image/analysis of the projected structure of a sample – Depending on the chemical composition, the sample might be sensitive to the electron beam – H, He und Li can not be detected by analytical techniques	
Material examples:	– Thin films or nano powders can be directly imaged. All other materials need to be prepared for the TEM analysis – Target preparation by FIB lift-out (field of view typically 25x10 µm) – Classical preparation by cutting, grinding, argon ion milling or microtomy	