The application of novel TEM techniques to the study of Pt catalysts

L Cervera Gontard[2*], D Ozkaya[1], L-Y Chang[3], A I Kirkland[3] , Hetherington C J D[3] and R E Dunin-Borkowski[2]

[1] Johnson Matthey Technology Centre, Blount's Court, Sonning Common, Reading RG4 9NH, UK
[2] Department of Materials Science and Metallurgy, University of Cambridge, Pembroke Street, Cambridge CB2 3QZ, UK
[3]Department of Materials, Oxford University, Parks Road, Oxford OX1 3PH, UK

Correspondence: lc358@cam.ac.uk

Industrial catalysts usually comprise crystalline particles of high atomic number that have sizes of between 1 and 20 nm and are supported or embedded in a lower atomic number matrix. Electron microscopy is a primary tool for the physical characterisation of their shapes, sizes and crystalline structures, which are in turn, important for understanding their catalytic properties. Here, developments in transmission electron microscopy (TEM) such as spherical aberration (C_s) correctors [1-2] and in scanning transmission electron microscopy (STEM) such as high-angle annular dark field (HAADF) electron tomography [4-5] are applied to the study of 5-10 nm platinum nano-particles supported on carbon. Indirect methods to remove lens aberrations using software for through-focal series exit-wave function restoration (TF-EWR) [3] are also applied. The aim of the work is to assess the degree to which an appropriate choice of spherical aberration provides an improvement to image quality and interpretability for such particles, both with and without the use of through-focal exit-wave restoration (TF-EWR).

FIG. 1 shows phase images obtained by applying TF-EWR to C_s-adjusted defocus series of high-resolution images of three different nanoparticles obtained using a JEOL 2200FS transmission electron microscope operating at 200kV equipped with a field emission gun, an objective lens spherical aberration corrector and an in-column energy filter, with a small value of the spherical aberration coefficient. An individual high-resolution image of a similar platinum particle is shown in FIG. 2(a). FIG. 2(b) shows the result of using an FEI F20 ST TEM operating at 200kV to perform HAADF STEM electron tomography.

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[2] Chen J H, Zandbergen H W and Van Dyck D 2004 *Ultramicroscopy* **98** 81-97
[3] Kirkland A I and Meyer R R 2004 *Microsc. Microananal.* **10** 401-41
[4] Weyland M 2002 *Topics in Catalysis* Vol. **21** No 4
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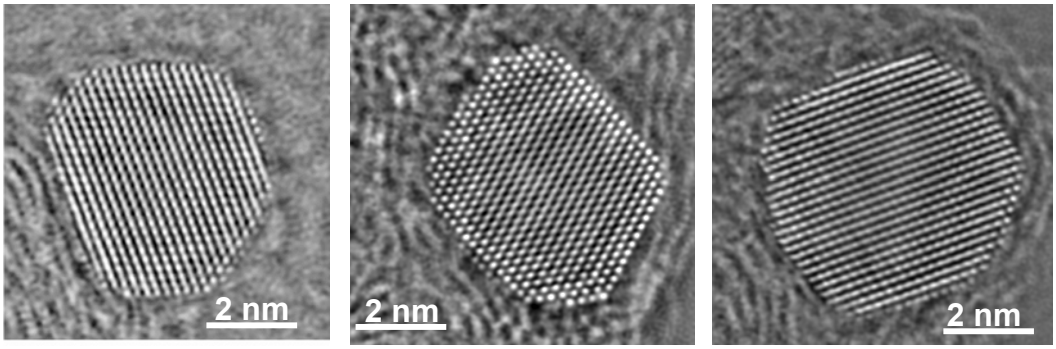

FIG. 1. Phase images obtained by applying TF-EWR to C_s-adjusted defocus series of high-resolution images of three diffeternt nanoparticles.

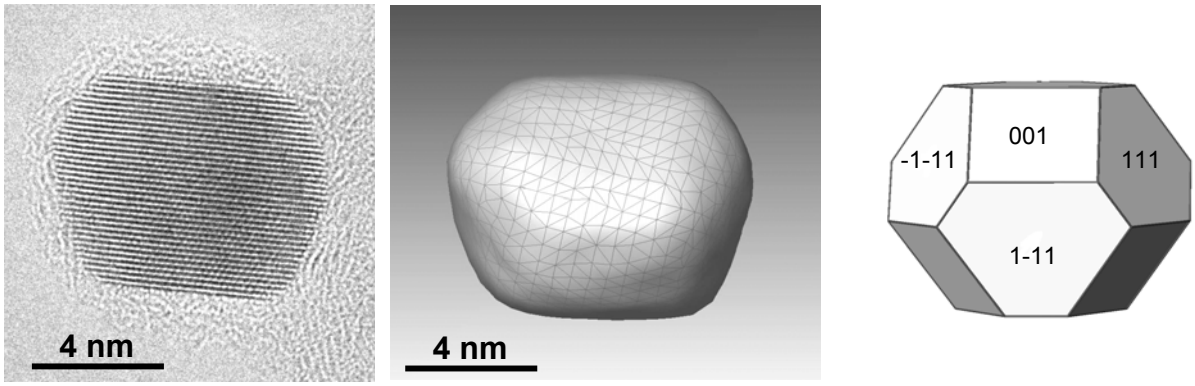

FIG. 2. (a) Individual C_s-adjusted high-resolution image of a 9nm platinum particle. (b) HAADF tomographic reconstruction of the three-dimensional shape of the same particle. (c) Schematic diagram showing the indices of the faces typically observed on such particles.