Dynamic Observation of Catalysts in the Environmental Transmission Electron Microscope

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Transmission electron microscopy (TEM) has been used extensively in materials research, and especially in catalysis research [1]. Recent developments include monochromation of the electron source and aberration correctors for both the condenser system as well as the image forming objective lens. In the last few years, these developments have made their way into the environmental TEM as well.

The improved resolution of TEM resulting from the implementation of aberration correctors is beneficial for imaging surface structures of materials e.g. catalysts nanoparticles. Figure 1 shows transmission electron micrographs at different magnifications of a silver/ceria/silica based catalyst for selective liquid phase alcohol oxidation [2]. Figure 1a shows the catalyst after calcination. At this magnification, the size distribution of Ag particle appears to be bimodal. At higher magnification, the interplay between the various constituents of the catalyst is observed (Fig. 1b). At high magnification, the atomic arrangement at the surface of the Ag particle is clearly resolved (Fig. 1c).

Even though conventional high-vacuum TEM provides such unique information on morphology and atomic arrangements in materials, it is still far from monitoring the catalysts under working conditions. At the Center for Electron Nanoscopy, environmental TEM is used to investigate different types of materials and catalysts under gas exposure at elevated temperature. In this way, catalytic materials can be observed in a simulated working environment. Furthermore, dynamic phenomena such as sintering and growth can be observed.

In the presentation, various examples of dynamic phenomena observed in the environmental TEM will be presented. Specific emphasis will be on reduction of metallic precursors and morphological changes during redox cycles. The systems in question involve metallic nanoparticles on oxide supports for chemical reactions, such as Pd on ZrO_2 for methanol oxidation [3] and Ni-YSZ based anodes for solid oxide fuels cells [4].

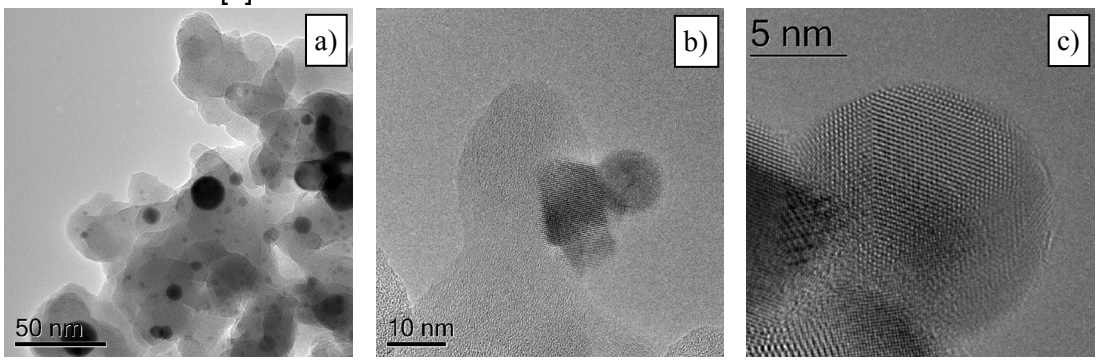

Figure 1: $Ag/CeO_2/SiO_2$ for selective liquid phase alcohol oxidation. See text for details.

References

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