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Z-Contrast Scanning Transmission Electron Microscopy of Nanometer-Scale Coated Particulate Materials*

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Z-CONTRAST SCANNING TRANSMISSION ELECTRON MICROSCOPY OF NANOMETER-SCALE COATED PARTICULATE MATERIALS

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Particulate materials with unique functional properties have been the focus of much attention in recent years. Of particular interest, due to their considerable scientific and technological importance, are particles coated with nanoparticles. These have greatly stimulated interest for their novel structure and properties. In these kinds of particulate materials, the interface structures between the support particle and the nanoparticle play a crucial role in controlling their properties. Consequently, imaging of the atomic structures at the interfaces can provide deep understanding of the relationship between the particulate and the corresponding properties. Z-contrast scanning transmission electron microscope (STEM) provides a new view of materials on the atomic scale, a direct image of atomic structure composition which can be interpreted without the need for any preconceived model structure. Therefore it is a powerful tool in the study of particulate materials. In this report, we will present the structures of 18 micron diameter alumina particles coated with Ag nanoparticles.

Particulates were prepared by a laser ablation technique, which involves laser ablation of the target material (Ag) onto a fluidized bed of core particles (alumina). The core alumina particles were fluidized inside the deposition system using a mechanical vibration method. For the STEM analysis, the particulates were lightly crushed in water using a pestle and mortar, then diluted in ethanol and deposited on a TEM grid coated with an amorphous carbon thin film.

Fig. 1 presents bright field and dark field images of the crushed nano-Ag coated alumina. From the dark field image, one can clearly see the small bright Ag particles attached to the substrate alumina. To further investigate the behavior of the interfaces between the nanoparticles and the alumina, as well as their atomic structures, we tilted the sample and observed the interesting area where the Ag nanoparticle just connects with the substrate. In Fig. 2, the low magnification (A), and high magnification (B) dark field images, and the high magnification bright field image (C), clearly show the interface with a distinct facet structure, which implies that there is no significant intermixing. Fig. 3(A) presents the multiply twinned structure of another laser ablation deposited Ag nanoparticle on alumina. Fig. 3 (B) and (C) gives the atomic structure of the Ag nanoparticle. From the image (C) the distances of AB, BC, and BD are 0.30 nm, 0.43 nm, and 0.26 nm, respectively, which are consistent with crystalline Ag in the <110> projection. It is clear that the Ag atomic structure is maintained right to the surface of the nanoparticle, i.e., that there is no significant layer of Ag-oxide on the surface of the particle. Our experimental results indicate that the STEM can be a powerful tool in the characterization of engineered particulates.

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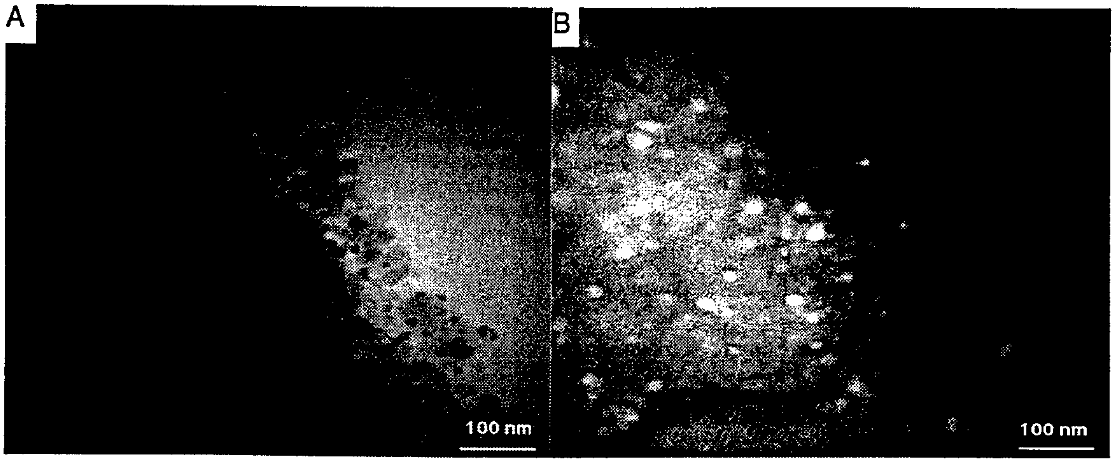
1



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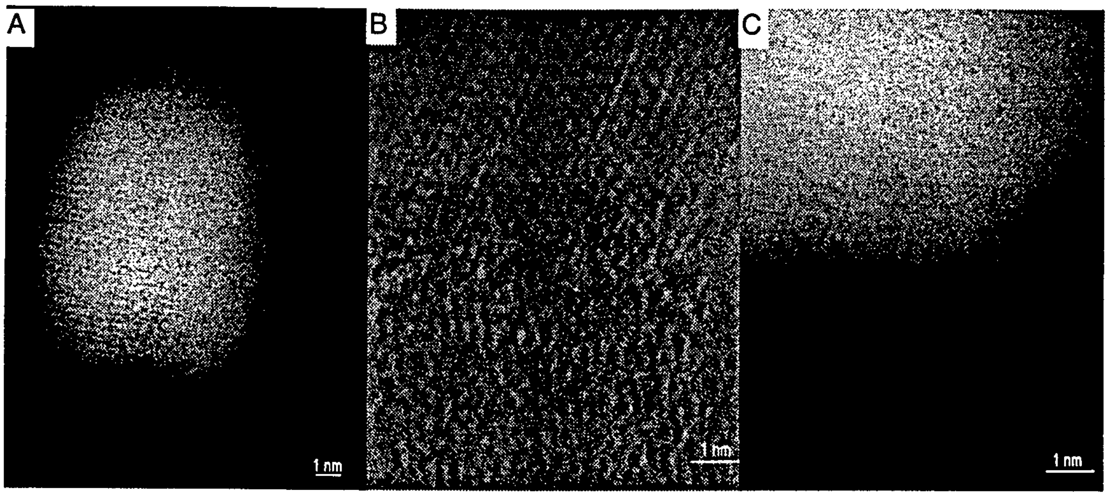

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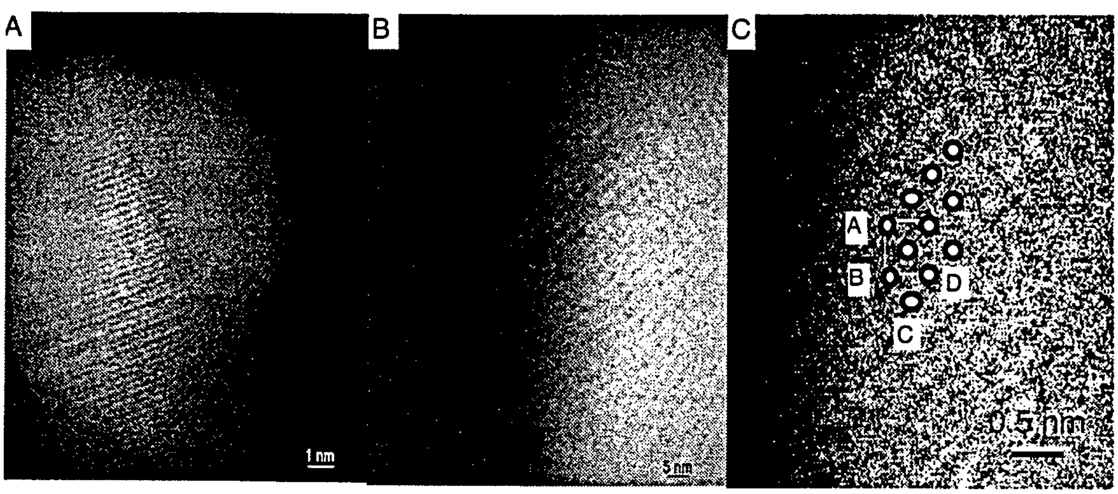

FIG. 1 Low magnification bright field (A) and dark field (B) images of Ag nanoparticles on an 18 micron alumina support particle.
FIG. 2 Images of a faceted Ag nanoparticle on alumina support particle.
FIG. 3 (A) Multiply twinned particle. (B) and (C) Atomic resolution dark field images showing Ag lattice structure at the particle surface.

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