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The 3-D Pore Structure of Pd Nanoparticles as a Function of Temperature

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With the increasing interest and usage of alternative energy sources, the need for reliable and efficient energy storage methods is likewise increasing. Porous nanoparticles, and in particular Pd, are being investigated for their potential use in catalysis, hydrogen storage, and electrochemistry [1]. For all of these applications, a very high surface area is desirable, with every point in the material ideally being within a few atoms of an interface. This would facilitate attributes such as high double-layer capacitance, higher reaction rates in kinetically limited interfacial reactions, and rapid charging with hydrogen [2, 3]. However, in order to ensure the reliable performance of these materials for such applications, the pore connectivity, diffusion, migration, and collapse must be understood for a variety of thermal treatments. As 2-D images only provide a projection of the structure of the nanoparticles, 3-D imaging is necessary to completely describe the complex pore structure and its age-dependent evolution.

Here we investigate porous nanoparticles of Pd using a combination of STEM tomography and in-situ heating experiments. Our previous results show that the pore structure begins to change as low as 100°C, and complete pore collapse occurs at 400°C. The particles in this study are heated to various temperatures and then cooled, thus "freezing in" the pore structure. This pore structure is then studied with STEM tomography and reconstructed in 3-D. Figure 1 shows results from the untreated sample used as the control. Figure 1(a) is one of 141 STEM images illustrating that porosity is visible. Figure 1(b) is a 1nm slice through the reconstruction showing that the porosity is very complex, with some pores connecting within the slice, some pores going through the slice, and some pores going to the surface. Figures 1(c) and (d) show volume and surface renders, respectively, further illustrating that the pores go through the particles and to the surfaces. Results will be presented from the heat treated samples comparing the 3-D pore structure to these control results [4].

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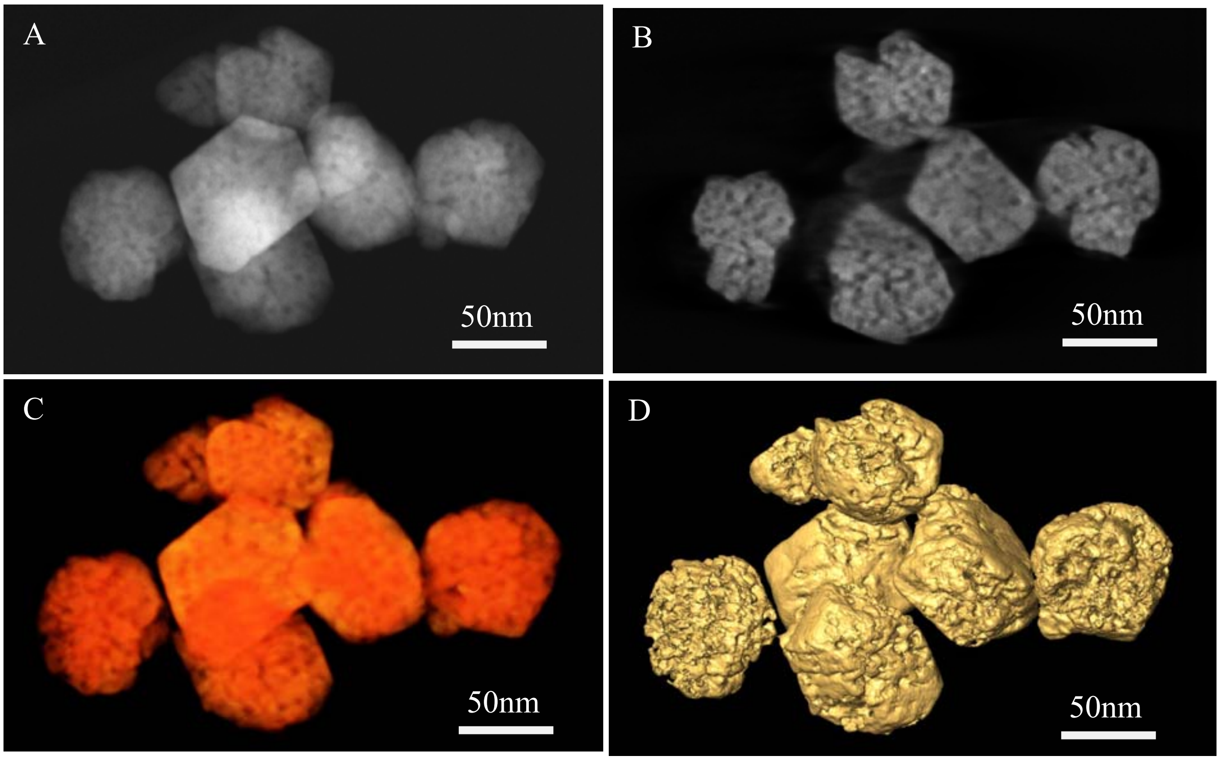

Figure 1: Image and reconstruction from an untreated Pd nanoparticle sample using STEM tomography. A is one of 141 STEM images illustrating that porosity is visible. B is a 1nm slice through the reconstruction showing that the porosity is very complex, with some pores connecting within the slice, some pores going through the slice, and some pores going to the surface. C and D show volume and surface renders, respectively, further illustrating that the pores go through the particles and to the surfaces.

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