Abstract Number: abs#031

Characterization of metallic nanoparticles using synchrotron based analytical techniques

P. Kluth[1], B. Johannessen[1], R. Giulian[1], D. J. Sprouster[1], C. S. Schnohr[1], L. L. Araujo[1], A. P. Byrne[2], G. J. Foran[3], D. J. Cookson[4], M. C. Ridgway[1]

[1] Department of Electronic Materials Engineering, The Australian National University, Canberra, ACT, Australia
[2] Department of Nuclear Physics/Faculty of Physics, The Australian National University, Canberra, ACT, Australia
[3] Australian Synchrotron Research Program, Australian Nuclear Science and Technology Organization, Menai, NSW, Australia
[4] Advanced Photon Source, Argonne National Laboratory, Argonne, Illinois, United States

Metallic nanoparticles (NPs) embedded in SiO_2 show interesting linear and non-linear optical properties with a high potential for technological applications including optical filters, memories and switching devices. We have utilized advanced synchrotron based analytical techniques, in particular x-ray absorption fine-structure spectroscopy (XAFS) and small-angle x-ray scattering (SAXS) in combination with conventional methods such as transmission electron microscopy (TEM) to study the size, shape and structural properties of metallic NPs in SiO_2 formed/modified by ion implantation. XAFS provides a powerful tool for structural analysis of nanoparticles given their inherent lack of long-range order. We will present an overview of our recent results for a number of different materials systems. For example, elemental metallic NPs (Au, Cu, Co and Pt) reveal a size dependent bond-length contraction as a result of capillary pressure and increased structural disorder due to their considerable surface to bulk ratio. While pure Co NPs show a bond-length contraction, Co cores in Co-Au core-shell NPs exhibit a bond-length expansion with respect to the Co bulk reference. This is a consequence of strain induced by the Au shells. Our measurements are in good agreement with molecular dynamics simulations. Ion irradiation of metallic NPs can lead to a number of different effects depending on the irradiation conditions. At energies where nuclear stopping is predominant, amorphisation of the NPs was apparent attributed to their initially higher energy structural state as compared to bulk material and preferential nucleation of the amorphous phase at the NP/SiO_2 interface. In contrast, bulk elemental metals cannot be rendered amorphous by ion irradiation. With increasing irradiation fluence dissolution of the NPs due to ion beam mixing was observed. At high irradiation energies (swift heavy ion irradiation), where the energy loss is nearly entirely due to electronic stopping, a shape transformation of the NPs from spherical shapes to elongated rods is apparent.