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Complimentary Chemical Imaging of Au-Nanoparticles Embedded in MgO using Laser Assisted Atom Probe Tomography

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Ion beam implantation of heavy ions such as Au^{+} in oxides and post-implantation annealing treatments has been shown to result in in situ nanoparticle formation. It was proposed by earlier researchers that the embedded structures are of pure-Au, based on the electron microscopy and optical absorption analyses. However, the recent atom probe tomography (APT) analysis of the Au-implanted MgO samples questions these results and the first set of conclusions indicate that the nanoclusters formed within the MgO matrix may consist of a mixture of Au, Mg and O as opposed to 100% Au as reported.

Atom probe tomography, APT, is primarily a combination of point-projection microscopy and time-of-flight mass spectrometry. The three dimensional atomic structure of the sample tips can be obtained through a reconstruction of the experimental data generated by a progressive layer-by-layer evaporation of the atoms from the needle-shaped tip and accounting for the time-of-flight of the ions. Recently, the development of laser-assisted evaporation of materials has unveiled the great potential of atom probe tomography (APT) to analyze the insulating materials. APT is shown to provide chemical identity of the samples with atomic-scale resolution with a field-of-view better than 100 nm^{3}.

Here, we present the results of the detailed APT analysis of Au-nanoparticle embedded MgO single crystal samples. Iso-concentration surface analysis revealed that the Au-particle size is similar to that observed from TEM and STEM. While the size of the clusters is shown to vary with the implantation profile, 1D-compositional analysis indicates that the clusters may contain a maximum of up to 50 – 60 % in the largest cluster with the others having relatively lower concentration of Au. The interface between the nanoparticle and the MgO matrix is often rich with Mg and O. The merits of the results will be discussed with respect to the influence of laser energy, cluster size and will be put in perspective by comparing the results with electron microscopy and ion beam analysis. The presentation will emphasize the need for establishing optimum conditions before drawing conclusions from atom probe tomography analysis.