Variation of sub-10nm nanoparticle chemical composition in glass revealed by Atom Probe Tomography

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The study of amorphous Dielectric Nano-Particles (DNPs) smaller than 10 nm is a great challenge for the materials community. In conjunction with Transmission Electron Microscopy (TEM) and Electron-Probe Micro-Analysis (EPMA), we took advantage of a recent technology, Tri-Dimensional (3D) Atom Probe Tomography (APT) to investigate the variations of the chemical composition in sub-10-nm oxide nanoparticles, grown in silicate glass through heat treatments, at their early stages of nucleation. We provide here a comprehensive set of experimental data obtained from direct measurements of the concentration for P, Mg, Ge and Er within amorphous dielectric nanoparticles (DNP) of radii ranging from 1nm to 10nm. Most importantly, we report on the first observation of a plateau at the early stage of nucleation followed by an increase of the concentration of Mg and P with the size of the DNPs. We also demonstrate that the environment of erbium ions embedded in DNP changes with the size of the particles. These results have a profound impact on our understanding of amorphous phase separation mechanisms as well as spectroscopic properties of the luminescent ions and the design of (DNPs)-doped materials.