NANO HIGHLIGHT
Temperature-induced nanoparticle-host interactions in natural samples

NSF NIRT Grant EAR-0403732

Udo Becker, Rodney C. Ewing, Lu-Min Wang, Martin Reich and Satoshi Utsunomiya
University of Michigan, Ann Arbor, Michigan

Natural nanoparticles have recently attracted much attention due to their potential role in the geochemical transport and dispersion of trace metals in the environment. Paradoxically, there is a complete lack of information on the stability and thermal behavior of these natural nanoparticles, although their synthetic analogues have been studied extensively due to their unique properties and technological applications arising from size-confinement effects.

By studying natural gold nanoparticles (AuNPs), our research team at the University of Michigan has discovered that when embedded in a solid-state host, these particles react rapidly to increased temperature. By capturing *in-situ* transmission electron microscopy (TEM) "movies" of temperature-dependent nanoscale processes, we show that the thermodynamic behavior of AuNPs is not only dependent on particle size, but also on the surrounding pyrite matrix. Isolated AuNPs melt, with the melting temperature being a function of size[1]. Here we describe that when these particles are embedded in a sulfide host, they react rapidly to increased temperature by diffusing into the matrix and forming larger particles in an Ostwald-type ripening process. These findings indicate the important role of the nanoparticle-host interface during high-temperature solid-state processes.

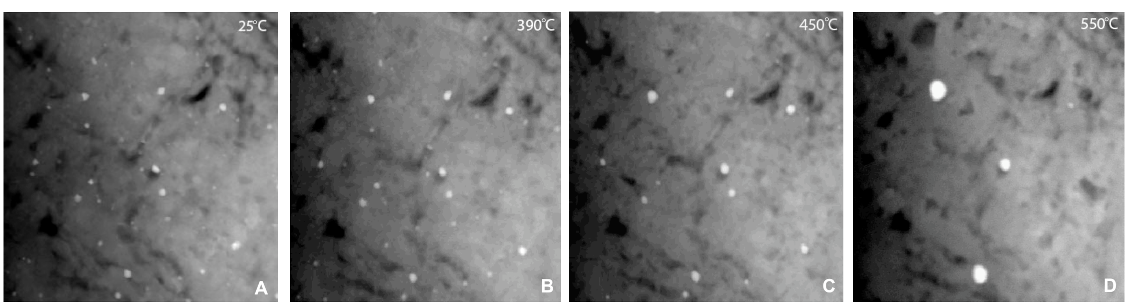

Fig.1. HAADF-STEM images taken for selected temperatures during heating experiment of AuNPs embedded in $Fe(S,As)_2$. No visible changes occur during heating from room temperature **(A)** until ~390°C **(B)**, where smaller clusters disappear into the matrix and larger ones coarsen. Above 450°C **(C)**, larger clusters have grown at expenses of the smaller ones. At 550°C **(D)**, only three clusters of >20 nm diameter survive. Scale bar is 100 nm.

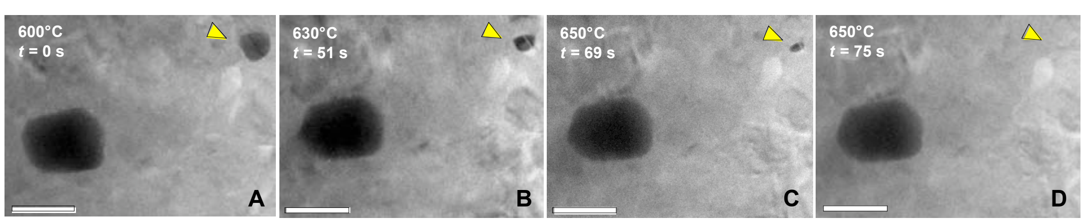

Fig.2. Sequence of selected HRTEM images during heating of two AuNPs of different sizes (~ 50 and 25 nm). Starting at 600°C **(A)**, the smaller AuNP progressively decreases in size **(B-C)** until it dissolves at 650°C, 75 seconds after the initiation of the experiment. Scale bar is 50 nm.

[1] Ercolessi, F., Andreoni, W. & Tosatti, E. Melting of small gold particles: Mechanism and size effects. *Phys. Rev. Lett.* **66**, 911-914 (1991).