doi:10.1017/S143192761700544X
Microsc. Microanal. 23 (Suppl 1), 2017
© Microscopy Society of America 2017

In-situ TEM Study on Size-dependent Thermal Stability of Nickel Filled Silica Nano-Opals

Parivash Moradifar[1], Yunzhi Liu[2], Jennifer L. Russell[2], Thomas E. Mallouk[2], John Badding[3], Nasim Alem[1]

[1]Department of Materials Science and Engineering, Materials Research Institute, The Pennsylvania State University, University Park, USA
[2]Department of Chemistry, The Pennsylvania State University, University Park, USA
[3]Department of Physics, Department of Chemistry, Department of Materials Science and Engineering, The Pennsylvania State University, University Park, USA

Metalattices are three-dimensional interconnected ordered arrays of nanostructured solids with periodicity size range between 1 nm – 100 nm.[1, 2] Functional properties of 3D ordered frameworks such as nano-opals and zeolites can be tuned by infiltrating them with semiconductor materials (like Si, Ge etc) and/or metals (Pt, Ni, Ag etc). The geometry confinement in these metallic nanostructures, such as Ni infiltrated nano-opals, results in an equal length scale of the intrinsic electron mean free path and magnetic characteristic length which can lead to a strong interaction between the intrinsic physical and structural parameters resulting in novel magnetic, electric and thermal behavior.[2, 3,4]

Using in-situ heating high-resolution scanning/transmission electron microscopy (HR-S/TEM) techniques, we aim to understand structural changes, thermal stability, and thermophysical behavior of Ni filled silica opals before and after infiltration as a function of the size of the silica opals and temperature. This study will present the structural and chemical changes that occurs in Ni infiltrated silica opals under heating conditions. Morphology changes occurring at different temperatures are visualized by TEM.

Figure 1 shows TEM images taken after the first three 150 °C temperature increments, respectively. As can be seen from Figure 1a and Figure 1b, no observable change in morphology of nano-opals is seen at 150 °C and 300 °C, and Ni metalattices maintain long-range network connectivity. At 450 °C (Figure 1c), Ni migrates from metalattices to the top Ni coating while Ni in interstitial voids accumulate together forming smaller and thicker networks, resulting in partial deformation and disruption of long-range order in the Ni structure. While the closely-packed silica nano-opals, on the other hand, retain their 3-D order, no significant change in their morphology occurs through geometry or stacking.

Imaging the structural and chemical structural of Ni filled opals and understanding the thermal stability and thermophysical behavior under heating conditions can provide information on high temperature magnetic behavior of this material as a function of both temperature and size of the silica nano-opal templates as a 3D ordered template. This understanding is the key to develop novel metalattice materials for future high temperature magnetic and electronic applications.

This work was funded by the Penn State MRSEC, Center for Nanoscale Science, under the award NSF DMR-1420620.

https://doi.org/10.1017/S143192761700544X Published online by Cambridge University Press

References:

[1] C.B.Murray, C.R.Kagan and M.G.Dawendi, Annual Reviews of Material Science, 30 (2000), P.545.
[2] R.F. Wang, C.Nisoli, R.S. Freitas, J. Li, W. McConville, B.J.Cooley, M.S. Lund, N. Samarth, C. Leighton, V.H. Crespi and P. Schiffer, Nature , 439 (2006), P. 303.
[3] J.E.Han and V.H. Crespi, Phyiscal Review Letters, 86 (2001), P.696
[4] J.E.Han and V.H. Crespi, Phyiscal Review Letters, 89 (2002), P.197203

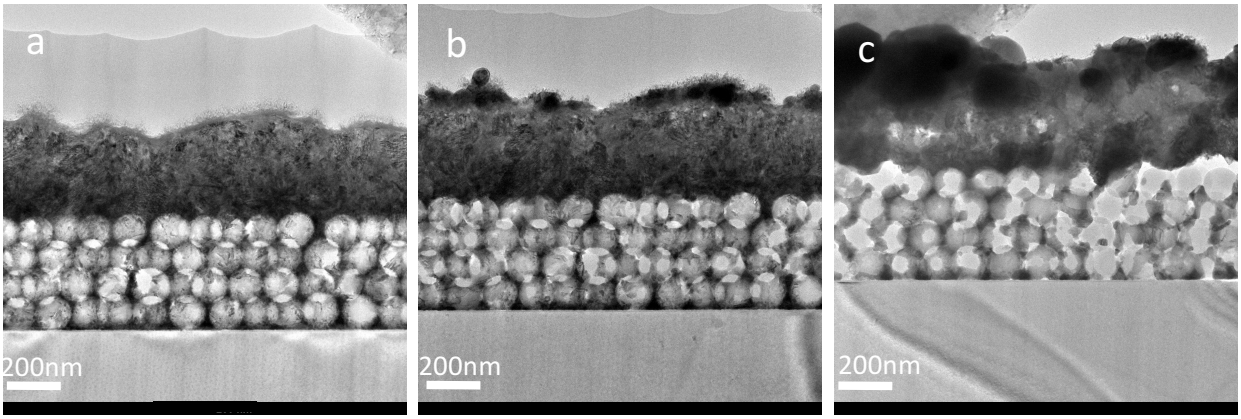

Figure 1. (a) TEM image of Ni infiltrated nano-opals at 150°C (b) TEM image of Ni infiltrated nano-opals at 300 °C (c) TEM image of Ni infiltrated nano-opals at 450 °C

https://doi.org/10.1017/S143192761700544X Published online by Cambridge University Press