Integration of dissimilar nanoscale phases: Leveraging kinetics to densify functional nano-composites

A. Volodchenkov, K. Chan, Y. Kodera and J.E. Garay*

1 Materials Science and Engineering Program

Mechanical and Aerospace Engineering Department

University of California, San Diego

La Jolla, CA 92093

**Corresponding author: jegaray@ucsd.edu*

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Composites are often designed with two distinct materials with each component having a particularly desirable property—a highly conductive phase and an insulating phase, resulting in tunable conductivity or a ferromagnetic phase and antiferromagnetic phase resulting in magnetic exchange coupling for example. Highly successful cases of sintered composites with micrometer scale constituents are numerous whereas composites with nanoscale components are significantly rarer. The drive towards nanoscale phases is fueled by the unique and often superior properties that occur at nanoscale. The inherent difficulty is in densifying the powder while retaining grain size and without unwanted reaction at the interfaced between the constituent phases. We will present results on producing nanoscale composites composed of similar (oxide/oxide) and dissimilar material (metal/oxide) classes using current activated pressure assisted densification (CAPAD). The materials have a crystallite sizes below 100 nm and minimal unwanted reaction between phases. We discuss the results in light of differences in densification and reaction kinetics.

In addition to nano/micro-structural characterization using diffraction and electron microscopy, we will use property measurements—emphasizing magnetic properties—to probe phase content and phase interaction. We will also use these property measurements to highlight the success of pairing dissimilar materials at the nanoscale for augmenting material performance.