**Special Materials Seminar**

Department of Materials Science & Engineering

# Friday May 18, 2018

1:30– 2:30 ~ Ferris 405

"Temperature effect on Small-scale deformation on the phases of Al0.7CoCrFeNi High Entropy Alloy HEA"

**Speaker(s): Adenike M. Giwa &/or Prof. Julia R. Greer**

Abstract:

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High Entropy Alloys (HEAs) represent an important class of structural materials because of their high strength and ductility due to the solid solution nature of the multi-component metallic system. We investigate the compressive mechanical response of single crystalline nanopillars with diameters between 400 nm and 2 µm excised from individual grains within FCC and BCC phases of Al0.7CoCrFeNi HEA at 295 K, 143 K and 40 K. Micro-compression experiments were conducted in an in-situ SEM equipped with a custom-constructed cryogenic setup; FCC samples had <324> crystallographic orientation, and those extracted from the BCC phase - <0001>. We observed a “smaller is stronger” size effect in the Resolved Shear Stress (RSS) of both alloy phases for all temperatures, , with a power law exponent, *m,* decreasing from - 0.68 to - 0.47 to - 0.38 for FCC phase and remaining constant at ~ - 0.33 in the BCC phase, as the temperature was reduced from 295 K to 40 K. We also observed reduced work hardening rates and more extensive strain bursts during deformation at lower temperatures in all samples. Morphology of FCC deformed samples show multiple parallel slip in one direction for all the pillar sizes at the temperatures studied while the BCC deformed pillars show wavy slip traces and expanded volume in the top region of the pillar. The wavy slip lines are more prominent at pillars < 1 size and this behaviour occurred at all the temperatures studied. Transmission Electron Microscopy (TEM) microstructural analysis of the compressed <324> FCC samples reveals parallel slip lines and distorted slip planes showing stacking faults and lattice fringes in the High Resolution Transmission Electron Microscope (HRTEM) images at all temperatures. The <001> - oriented BCC samples deformed at 40 K also contained entangled dislocation networks indicated by interwoven dislocation loops, those deformed at 40 K also underwent twinning. We performed molecular dynamics (MD) simulations on representative nano-pillars constructed of model FCC and BCC HEAs and deformed at 300 K, 143 K and 50 K to gain physical insights into the observed experimental results. MD simulations revealed the deformation in FCC HEAs to be dominated by the emission and propagation of 1/6 <112> partial dislocations along (111) planes at all temperatures and partial dislocation emission and twinning in the BCC HEA. We also show a significant decrease in stacking fault energy with the high level of alloying in our HEA systems which promotes these observed deformation mechanisms. We place these findings in the framework of dislocation source nucleation-governed plasticity and propose temperature-dependent source strengthening as the underlying cause of temperature-dependent size effects in FCC phase and temperature-invariant ones in the BCC phase.