Deformation and Damage in Structurally Graded Nano-Crystalline Aluminum Alloys Project

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Purpose

Design and develop a new class of aluminum microstructures that exhibit previously unachievable combinations of strength, ductility and toughness.

Background

Structurally graded nano-crystalline (SGNC) materials are a new class of metallic materials that offer the promise of obtaining previously unachievable combinations of strength, ductility and toughness. The structurally graded architecture is believed to mitigate the mechanisms that lead to poor ductility and low toughness in traditional nano- crystalline materials; those that have resulted in the inability to exploit the extremely high strength potential offered by nanocrystalline grains. SGNC materials consist of two or more alternating layers in which the grain size varies from relatively fine (nanometers (nm) or tens of nm) to relatively coarse (hundreds of nm to a few microns (µm). Here, the fine grains contribute much of the overall material strength while the coarser grains contribute much of the ductility and toughness.

SGNC materials have been shown to have exceptional mechanical properties[1], where the ability to produce a graded nano-crystalline structure in copper was demonstrated. Even without the benefits of computational design, the authors developed a material with a yield stress that was 10 times that of a coarse-grained material while exhibiting an extraordinary amount of plasticity. Inspired by the results in reference 1, the present work is believed to be the first attempt to design SGNC aluminum for aerospace applications.