GRADUATE RESEARCH POSITION ANNOUNCEMENT
IN
NANOSCALE PROPERTIES OF STRUCTURAL MATERIALS

Study of the Nano-Scale Fracture Mechanism of a High-Strength, Light-Weight Alloy Using Electron Backscattered Diffraction (EBSD) and Nanoindentation

This announcement is for a one year funded graduate research position, on-site at NASA Langley Research Center in Hampton, VA. The position is suited for a M.S. candidate and is restricted to U.S. citizens.

Background

Commercial Al-Li alloys have strength and weight advantages over non-Li aluminium alloys, and these advantages are especially important for aerospace applications. The recently (1998) adopted Space Shuttle Super Lightweight External Tank, for instance, is constructed of the Al-Li alloy 2195 and offers a weight savings of 7500 lbs. over the prior design. The failure mode of these alloys, however, is unusual and has limited their use. The grains of these alloys are extremely thin (20 – 100 m) with aspect ratios of up to 1000. The fracture behavior resembles that of layered, composite materials, and is termed delamination. The delamination fractures are intergranular, along high angle grain boundaries parallel to the rolling plane of the plate. Relatively few of the high angle boundaries delaminate, and this suggests that characterization of those grains and grain boundaries may indicate a solution to this problem. We suspect the key selection factors for delamination may be simply effects of rolling and heat treatment parameters of the alloy plate. These effects are evident in the distribution of recrystallized and unrecrystallized grains, the statistical distribution of which is termed crystallographic texture.

Two recently developed experimental methods are being used in this study: electron backscattered diffraction (EBSD) and nanoindentation. EBSD utilizes a scanning electron microscope to collect a grid of diffraction patterns from a polished surface. The patterns are then solved for the three-dimensional orientation of the crystals and relationships are plotted as color maps revealing grain boundaries, grain orientations and local deviations from grain orientations. Nanoindentation testing technique is utilized to accurately measure the mechanical response of the material to a diamond indenter tip under a very low load (e.g. 100 g). From the plastic zone beneath the indenter, we can measure properties such flow stress, hardness, elastic properties, creep properties, and strain hardening.
Our studies of an Al-Li alloy by an EBSD system show that a small volume fraction of grains from the retained deformation texture show high levels of crystalline orientation variation, which we attribute to stored strain energy. Recent nanoindentation measurements have indicated a higher hardness for these grains, and EBSD shows that delaminations tend to occur between these and adjacent, recrystallized grains.

This research program will pursue characterization of the Al-Li alloy plate by EBSD and nanoindentation, using facilities at NASA Langley Research Center. Familiarity with fracture mechanics, polycrystalline deformation mechanisms, and processing effects on metal alloys will be needed for this work. Comparisons will be made between fractured, undeformed and Li-free aluminium alloys. Results from this study will provide the experimental basis for a finite element and crystal plasticity modelling study at the University of Illinois.

If interested please contact:

Dr. Abdelmageed Elmustafa, Assistant Professor
Department of Mechanical Engineering
Old Dominion University
Norfolk, VA 23529
aelmusta@odu.edu
phone: 757.683.5576 or 757-269-6067