Department of Materials Science and Engineering,
PhD Dissertation Proposal

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LeBow 348

"Incipient Kink Bands (IKBs) in Hexagonal Metal Single Crystals and the MAX Phases"

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Abstract

Hexagonal metals have been the subject of study in various experiments as well as used in alloys. The MAX phases are ternary layered carbides and nitrides having the general chemical formula $M_{n+1}AX_n$, where M is a transition metal, A is an A-group element, X is either carbon or nitrogen and n = 1, 2 or 3. Certain hexagonal metals and the MAX phases respond similarly to mechanical loading, which may indicate the same mechanism is present in both materials under mechanical loading. Typically, as solid materials are subject to mechanical loading, the mechanical response is typically elastic followed by brittle fracture or plastic deformation.

More recently a third response has been documented, viz. kinking non-linear elasticity characterized by fully and spontaneously reversible stress-strain loops whose size is a strong function of grain size. At this time it is established that plastically anisotropic solids such as mica, graphite, other layered solids, the MAX phases, and certain hexagonal metals can be classified as kinking nonlinear elastic (KNE) solids. Furthermore, the mechanism by which kinking occurs has been postulated to be the incipient kink band (IKB). An IKB consists of multiple coaxial dislocation pairs on multiple parallel planes, which remain open under an applied load but shrink and annihilate when a load is removed. While IKBs have been proposed to explain kinking, direct evidence for their existence is still lacking and some have made the

case that microcracking can explain the observations made. However, results from numerous experiments suggest their existence based on how well the results fit the KNE model. The goal of this work is to further our understanding of KNE solids and to attempt to obtain direct evidence for their existence.

To accomplish this goal, in situ SEM along with Digital Imaging Correlation (DIC) and OIM will be used in an attempt to see an IKB within a hexagonal single crystal under compression. The objective is to load the single crystal until a kink is forms, which will be evidence of IKB formation. Nanoindentation and TEM will also be used to examine the domain on IKBs, as it is believed that IKBs scale with grain size.