

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of: Mst. Sohanazaman Tanju

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Grain boundary (GB) studies in nano- and micro- crystalline materials

by

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Polycrystalline materials are composed of grains and grain boundaries. The total volume of occupied grain boundaries in polycrystalline material depends on the grain size. When grain size decreases the volume fraction of grain boundaries increases. For example, when grain size is 10 nm grain boundary volume fraction is ~ 25%. In polycrystalline materials, different properties (mechanical, electrical, optical, magnetic) are affected by the size of their grains and by the atomic structure of their grain boundaries. Nanocrystalline materials have unique properties compared to coarse grain counterpart because of the presence of more grain boundaries. Increased understanding of the role of grain boundaries play in nanocrystalline materials promotes the tuning of materials properties.

In order to study the grain boundaries in different materials, fully dense bulk materials are processed using Current Activated Pressure Assisted Densification (CAPAD) technique. CAPAD is a unique technique for materials processing. It offers faster processing of nanoscale materials compared to traditional sintering technique. Joule heating and pressure are used to densify the materials in CAPAD system. X-ray analysis, Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM) are used to characterize the materials.

There are three different parts in this dissertation: (1) Affect of grain size on grain boundary curvature on different materials; for example, nano and micro crystalline aluminum (metallic bond), silicon (covalent bond) and iron oxide (ionic bond); (2) Grain boundary geometry analysis of nanocrystalline materials and (3) Grain size dependent electrical and optical property investigation.

In the first part of the dissertation, the effect of grain size on the grain boundary curvature is investigated. Several different types of materials were chosen, such as, micro and nano crystalline aluminum (Al), silicon (Si) and iron oxide (Fe_2O_3). It is found that the slope of grain boundary curvature is grain size and material dependent. Nanocrystalline materials have higher grain boundary curvature compare to microcrystalline materials.

In the second part of the dissertation, grain boundary geometry of iron oxide is investigated by Electron Back Scattered Diffraction (EBSD) method. Coincident Site lattice (CSL) value of 5 and 19 was dominating in iron oxide system.

Finally, both nano and micro crystalline optically transparent strontium titanate are processed. Grain size dependent relative permittivity, dielectric loss and optical transparency are investigated. Relative permittivity of densified strontium titanate measured at room temperature at 1 MHz shows very high and it is in between 180 to 268. Relative permittivity increases by increasing grain size. By performing TEM-EDS point analysis, it is found that in addition to grain size space charge potential at grain boundaries gives higher relative permittivity.