Lightweight Metals

Lightweighting vehicles, infrastructure, and products, while maintaining or enhancing performance, promises to positively impact energy sustainability with numerous potential applications in both defense and civilian sectors. Consequently, the design and manufacture of lightweight metals (for example Al and Mg alloys, as well as advanced high strength steels) with superior combinations of properties in the finished product are of utmost importance. Georgia Tech faculty have employed an integrated approach that brings together expertise in materials science, manufacturing, product design, and data/information sciences to address this grand challenge. Capabilities include:

- A broad suite of experimental facilities and customized protocols that allow high throughput acquisition of multi-scale multi-modal measurements (e.g., microscopy, orientation image mapping, indentation, strain mapping, residual stress measurements, non-destructive imaging techniques).
- A broad suite of multi-physics multi-scale modeling approaches that span a broad range of length and time scales (e.g., atomistics, dislocation dynamics, phase-field, Monte-Carlo, crystal plasticity, finite element).
- Novel analytic tools for extracting property-structure-property linkages from large experimental and simulation datasets.

The image at right illustrates microstructure evolution in static recrystallization of AZ31 (a Mg alloy) using back-scattered electron diffraction (also called orientation image mapping). Colors in this image are associated with specific crystal lattice orientations. Observation the preferred nucleation of recrystallization in compression and double twins (produced in the prior deformation) and their subsequent slow growth.

An example of how indentation may be used to quantify the role of grain boundaries in the plastic deformation of polycrystalline metals is shown below. In this sample, spherical indentations were performed at varying distances from a selected grain boundary in a deformed metal, and the measured indentation yield strengths are plotted as a function of the distance from the grain boundary. Note the relatively low dislocation density region near the grain boundary in Grain 4. The length scale associated with this transition region is significantly larger than the indentation zone size (the width of the shaded region in the middle of the plot at zero distance from the grain boundary).

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