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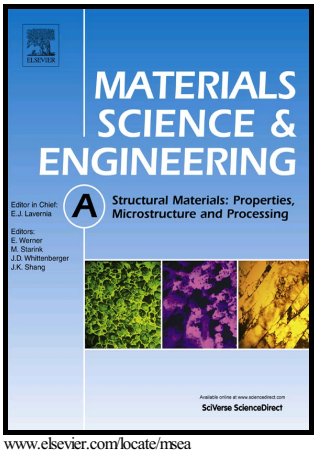

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Deformation Twin Identification in Magnesium through Clustering and Computer Vision

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Abstract

The application of clustering and computer vision to microscale deformation data for the segmentation and identification of deformation twins, the strains that they sustain, and their evolution under uniaxial compression across mm-scale fields of view is demonstrated on the magnesium alloy WE43. A 5.7 mm × 3.4 mm deformation map containing 100 million (7,678 × 13,004) data points was obtained using a combination of scanning electron microscopy and stitched digital image correlation. The experimental approach used a chemically-functionalized nanoparticle assembly for speckle patterning, external codes for improved microscope control and test automation, and post-test stitching of 209 individual strain fields. Deformation twins were segmented by k-means clustering, and clusters were then identified by two different metrics: the (i) use of the Schmid factor of the most probable twin system combined with the Euclidean distance of the cluster centroid strains to the theoretical twin strains; and (ii) cluster size evolution combined with cluster shape identification through use of a convolution neural net incorporating twin strains as a color map. The accuracy and precision of these approaches were examined through use of a ground truth data set, and possible improvements by combining metrics are discussed. The combined experimental and analytical approach was demonstrated on the analysis of the accommodation of effective strain by twinning in relation to the grain orientation relative to the compression axis.

Keywords: Magnesium; Twinning; Digital Image Correlation; Clustering; Computer Vision.

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1. Introduction

The emergence of experimental capabilities for material characterization that result in large, multi-dimensional datasets, combined with the increasing capabilities and flexibility of large data analytics, has opened the door for a powerful means of unbiased quantification of the complex interactions between microstructure and mechanical properties. The development of large data frameworks has the potential to significantly improve our ability to predict the effects of processing on material behavior, thereby accelerating the development and deployment of new materials, and increasing confidence in their reliability and performance.

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