8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

An Automated Framework for the Incorporation of realistic Microstructures in Computational Models

Michael Groeber[1], Somnath Ghosh[2], Michael Uchic[3] and Dennis Dimiduk[3]

[1] Universal Technology Corp.
Air Force Research Laboratory
2210 10th St. WPAFB, OH 45433
Michael.Groeber.ctr@wpafb.af.mil

[2] The Ohio State University
201 W. 19th Ave.
Columbus, OH 43210
ghosh.5@osu.edu

[3] Air Force Research Laboratory
2210 10th St. WPAFB, OH 45433
Michael.Uchic@wpafb.af.mil
Dennis.Dimiduk@wpafb.af.mil

Key Words: *Microstructure Modeling, Synthetic Structures, 2D to 3D Extrapolation.*

ABSTRACT

Over the past few years there have been significant advances in developing microstructure characterization methods that provide quantitative data describing the structure and crystallography of grain-level microstructures in three dimensions (3D). This work utilizes one such method, serial sectioning, with a focus on the automation of the process. The subsequent analysis and representation of the collected information can provide modeling and simulation efforts with a highly-refined and unbiased characterization of specific microstructural features. The grain structure of an engineering alloy, similar to that seen in Fig. 1, could be translated directly into a 3D volume mesh for subsequent Finite Element (FE) analysis. However, this approach requires a multitude of data sets in order to appropriately sample the intrinsic heterogeneity observed in typical microstructures. In order to circumvent this issue, computational tools can be used to create synthetic microstructures, like that shown in Fig. 2, that are statistically-equivalent to the measured structure.

This presentation will discuss the automation of the data collection process, the subsequent processing of the data and the robust quantitative characterization of the 3D structure. The presentation will also focus on the development of software programs that generate a host of synthetic structures which are analogous to the real material. Additionally, this presentation will introduce new methods for inferring the 3D structure of a microstructure from only 2D sections. The mathematical assumptions and derivations used will be presented in detail. Importantly, the objective of this study is to provide a framework towards complete microstructure representation that is consistent with quantifiable experimental data.

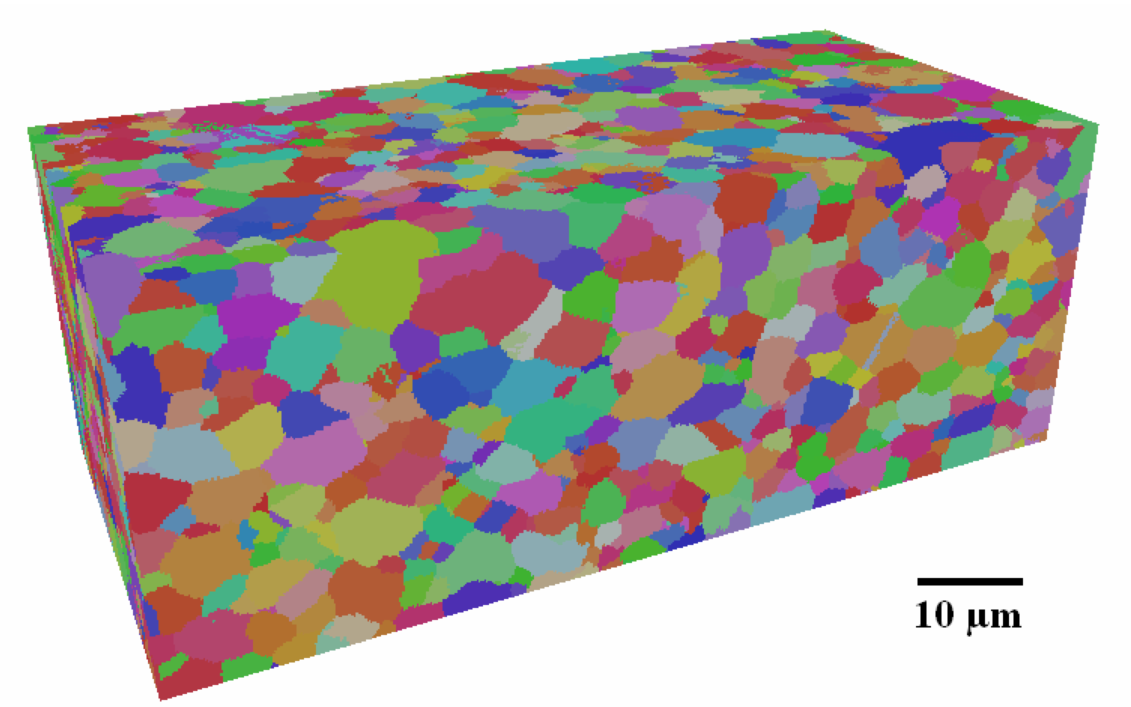

Figure 1: Experimentally collected 3D volume of an IN100 nickel-based superalloy. The volume is reconstructed from Focused Ion Beam serial sections.

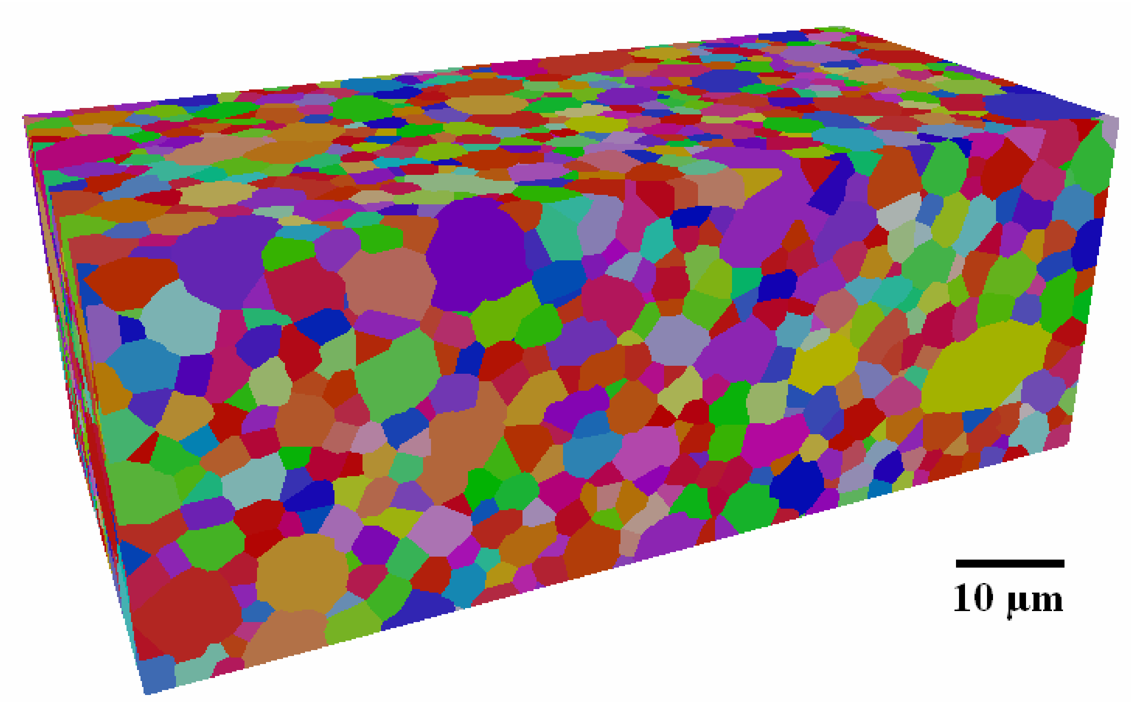

Figure 2: Synthetically generated 3D volume of an IN100 nickel-based superalloy. The volume is generated from statistics measured from the reconstructed volume shown in Fig. 1.