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EBSD Imaging of Femtosecond Laser Ablated Surfaces Using the TriBeam System

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A TriBeam system has been developed to enable the femtosecond laser ablation of materials *in situ* in a dualbeam microscope. Material can be removed at rates that are 5-6 orders of magnitude faster than a conventional gallium source FIB, enabling the gathering of tomographic sectioned datasets with volumes approaching mm^3. Femtosecond lasers have been well characterized in the literature as having low collateral (dislocation) damage [1] and a negligible heat affected zone [2], making them well suited to material removal for tomographic sectioning. In a tomography experiment using the TriBeam, millions of tightly focused pulses are used to ablate the surface of a material. In order to characterize surface modification produced by the laser ablation events, a series of TEM foils have been cross-sectioned from the imaged surfaces from the last slice from tomography experiments.

A single crystal nickel-base alloy, strontium titanate, and titanium have been investigated to illustrate the differences in dislocation structure and the degree of crystallinity near the surface as probed by electron diffraction and EBSD [3]. Studies of damage using FIB milling were made by Saowadee [4] in strontium titanate, but to our knowledge femtosecond laser damage has not been studied for this material. Femtosecond laser damage has been studied in single crystals of nickel [1], but only in thin sections. FIB liftouts have been made for all three materials to determine the differences in laser-material interactions for these metals and ceramics. The strontium titanate and nickel-base alloy samples were exclusively laser machined in order to prepare surfaces ready for EBSD analysis, whereas the titanium alloy required an additional FIB milling step. The titanium alloy was laser machined and then gallium ion milled at 30kV with near glancing angle in order to produce a surface that generated EBSD patterns which could be indexed.

The laser damage depths for the three materials have been compared to Monte-Carlo simulations of the X-ray escape depths (EDS) and backscatter diffraction signal depth (EBSD) and we propose a model for the ability to extract chemical and structural information as a function of laser fluence. Surface roughness will be discussed, particularly with regard to its influence on EDS and EBSD mapping quality. The FIB liftouts from the combined laser and ion beam milling areas in titanium will also be discussed, including the reasons diffraction patterns could be imaged in the strontium titanate and nickel but not directly in titanium. In Figure 1, a reconstruction of the titanium 3D dataset is shown in order to illustrate the 3D EBSD datasets able to be captured.

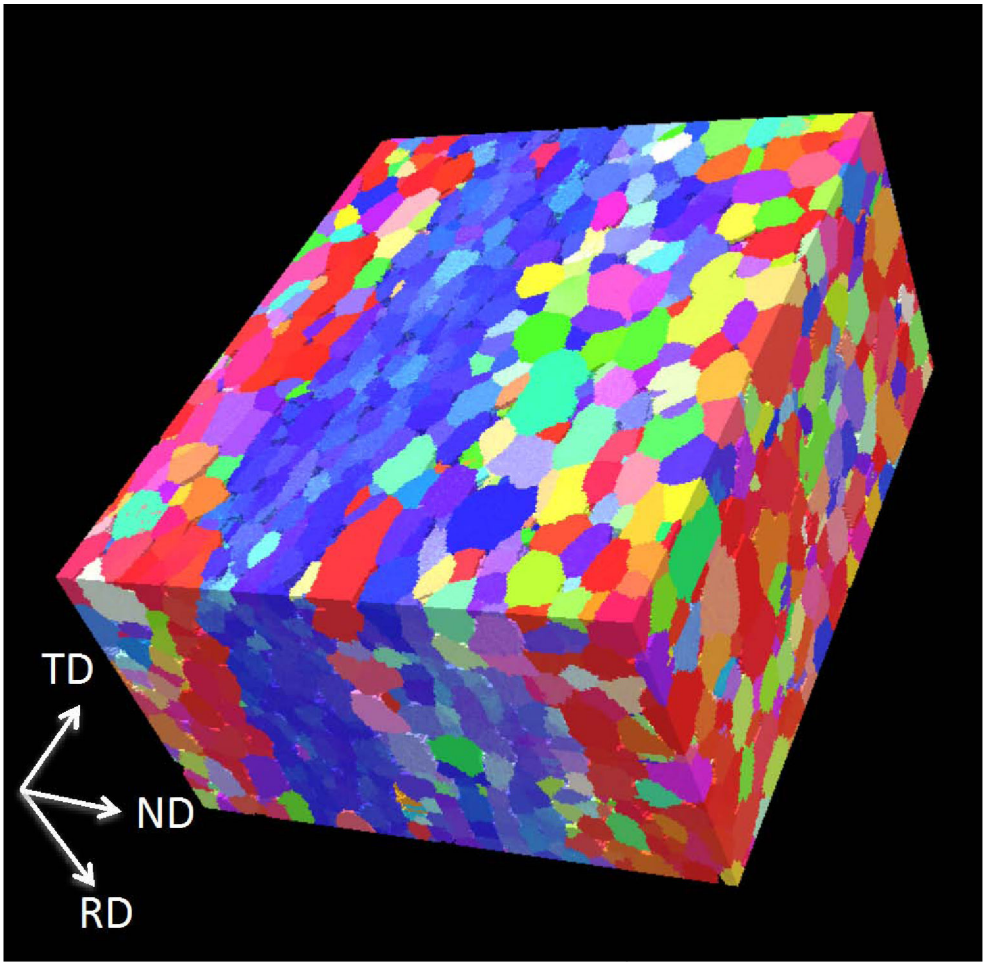

Figure 1: Ti6-4 alloy that has been serial sectioned using the Tribeam system to gather 3D EBSD data. The inset indicates the material processing directions. The dataset is sized 190x250x108μm.

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