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Observations of Damage, Defects, and Structuring in Femtosecond Laser Ablated Surfaces

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Femtosecond (fs) lasers have become essential for a range of applications including ultrafast microscopy [1], 3D data collection by serial sectioning [2], micromechanical sample preparation [3,4], and surface structuring [5]. In some of these applications, fs laser pulses are utilized at fluences that are below the ablation threshold producing minor changes in the material structure; however, for experiments requiring the ablation of material - the damage can be limited to surface topography and dislocation injection, or this damage can be much more profound - leading to phase changes or recrystallization [6,7,8]. Due to this wide range of potential damage outcomes, an understanding of the laser-material interactions that occur in these new microscopy applications that utilize fs lasers is becoming increasingly important.

In this work, we specifically focus on the implications of damage present during TriBeam serial sectioning experiments and ways of reducing damage for enhanced data collection speeds. For instance, the choice of scan optics, laser fluences, laser beam wavelength, and polarization will be discussed - as well as their impact on the laser surface modification and subsurface damage. One example of differences in surface profiles after fs-laser ablation is shown in Figure 1. In both cases, a bevel is created at the leading edge of the pedestals where the laser first interacts with the sample, whereas the rest of the ablated surface assumes the shape of a paraboloid. However, differences in scan optics can significantly alter the width and flatness of this cut surface. The incorporation of additional milling operations to reduce surface roughness using glancing-angle focused ion beam milling will also be discussed, as well as its role in improving electron backscatter diffraction (EBSD) yield.

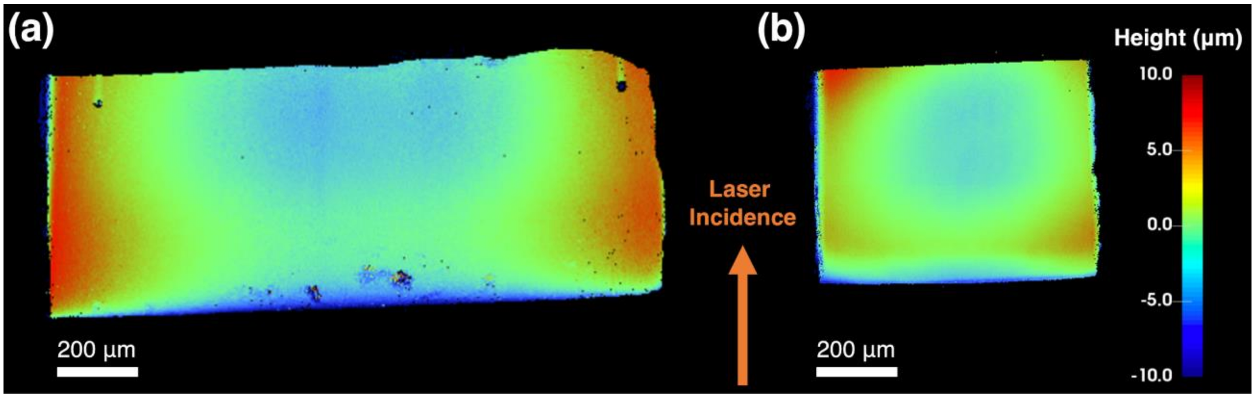

Figure 1 - Surface profile of two different metal sample surfaces after fs-ablation. (a) Sample of CoNi-superalloy machined using the ThermoFisher Scientific Helios 5 Laser-PFIB system. (b) Sample of high-purity Tantalum machined using the TriBeam system.

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