3D Serial Sectioning of Metallic Materials Using fs-laser and Plasma Focused Ion Beam

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Certain microstructural phenomena can only be fully characterised when investigated in three dimensions. Examples include the tortuosity of interconnected features and the complete characterisation of grain boundaries. Serial sectioning within the scanning electron microscope (SEM) enables the analytical capabilities of the SEM to be extended into 3D, including nanometre-resolution imaging for feature segmentation, energy-dispersive X-ray spectroscopy (EDS) for chemical mapping, and electron backscatter diffraction (EBSD) for crystallographic analysis. Producing large cross-sections while maintaining the surface quality required for these analyses remains a significant challenge and has driven the development of new technologies. Figure 1 highlights the progression of these technologies over time and the volume of material that can be sectioned and analysed within a comparable timeframe. This talk focuses on a system that combines the final two technologies: an fs-laser PFIB 'TriBeam' platform that integrates the two ablative technologies and an electron beam within a single instrument (Figure 2). Several examples will be presented, including crack propagation in an aluminium aerospace alloys, electrode degradation and chemical leaching in a battery material, and grain-structure characterisation in additively manufactured metals.

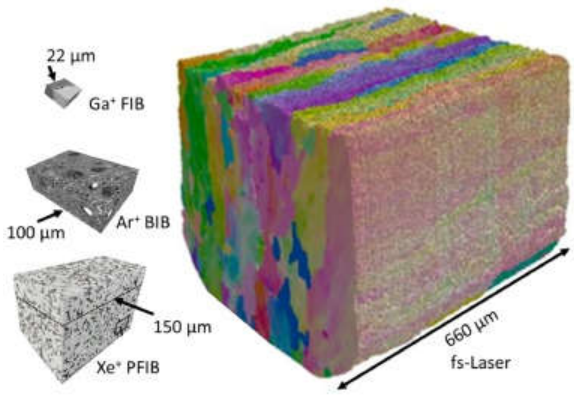

Figure 1. Representative volumes that can be milled in similar times with different ablative technologies. Adapted from [1].

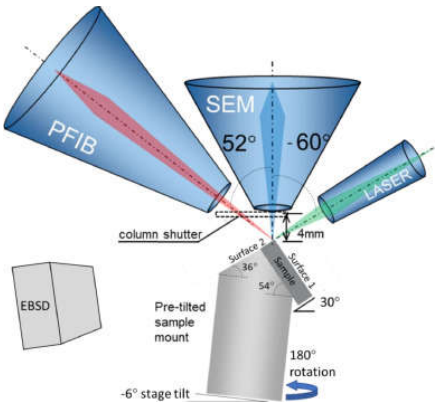

Figure 2. Schematic of the chamber of the Thermo Scientific Helios 5 Laser-PFIB TriBeam instrument [1].

1. Gholinia, Donoghue, Garner, Curd, Winiarski, Geurts, Withers, Burnett, *Ultramicroscopy*, **2024**, *Volume 257*