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Save your FIB from the hard work – Large-scale sample prep using a LaserFIB

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Focused ion beam (FIB) systems are widely used for high-accuracy sample preparation. Site-specific preparation of e.g. TEM lamellae or atom probe tomography (APT) tips is barely achievable by other techniques than FIB. However, FIB sample prep becomes really time-consuming once it comes to preparation of structures with lateral dimensions larger than several tens of microns. The same holds true for samples that need to be extracted from more than several tens of microns in depth below the sample surface. This prolongation of FIB milling time is caused by the limited ion probe currents in the order of 1 pA to 100 nA that are available from liquid metal ion sources (LMIS). Other source types, offering higher ion beam currents, are unfavorable because of their larger probe diameters and therefore lower resolution, which is required during the final fine polishing steps of these sample prep workflows. Turning to multi-instrument workflows is also not the best option, since every sample transfer between instruments bares the risk of contamination, sample damage or even sample loss. An ideal solution would feature rough milling capabilities for fast and yet precise removal of larger amounts of material in combination with a LMIS FIB for high-resolution final polishing in one single instrument.

In this contribution we present such a solution and illustrate different sample preparation workflows using the LaserFIB. The LaserFIB is an instrument that features a femtosecond (fs) laser integrated on a ZEISS Crossbeam [1]. This combination enables high-resolution SEM imaging and FIB patterning as well as site-specific sample structuring and preparation using the laser. Due to the ultra-short laser pulses in the fs-regime, the laser ablation can be regarded as athermal and introduces as good as no sample damage. The massive material removal capabilities of the laser allow to achieve milling rates up to millions of μm^3 per second. All laser processing is done in a separate chamber extending the airlock to avoid contamination of the FIB-SEM chamber components (Fig. 1).

Presented sample preparation workflows will cover surface structuring e.g. to prepare large-scale cross-sections as well as techniques to gain access to regions of interest (ROIs) buried deeper below the sample surface than feasible for FIB milling. For the latter we recently introduced the "Cut-to-ROI" workflow [2], which will be explained in detail. It features a two-step approach where a laser milled macro-lamella is further manipulated by FIB to expose a previously buried and inaccessible ROI. The process can be combined with lift-out techniques known from TEM lamella preparation or carried out in the bulk sample. Figure 2 shows an example of such an in-bulk preparation on a silicon wafer. The laser milled macro-lamella has been cut down by FIB milling from the side to a predefined depth in order to create a new sample surface at a lower level as base for automated standard lamella preparation of two TEM lamellae. Obviously, this workflow is not limited to TEM lamella preparation at the end, but provides a fast way to access buried ROIs for any kind of FIB experiment including also APT tip preparation or FIB-SEM 3D tomography.

Detailed application examples will be presented and illustrate the capabilities and benefits of the LaserFIB in the field of sample preparation which up to know could only be addressed by FIB.

Figure 1. Picture of ZEISS Crossbeam 350 laser with fs laser attached to the airlock.

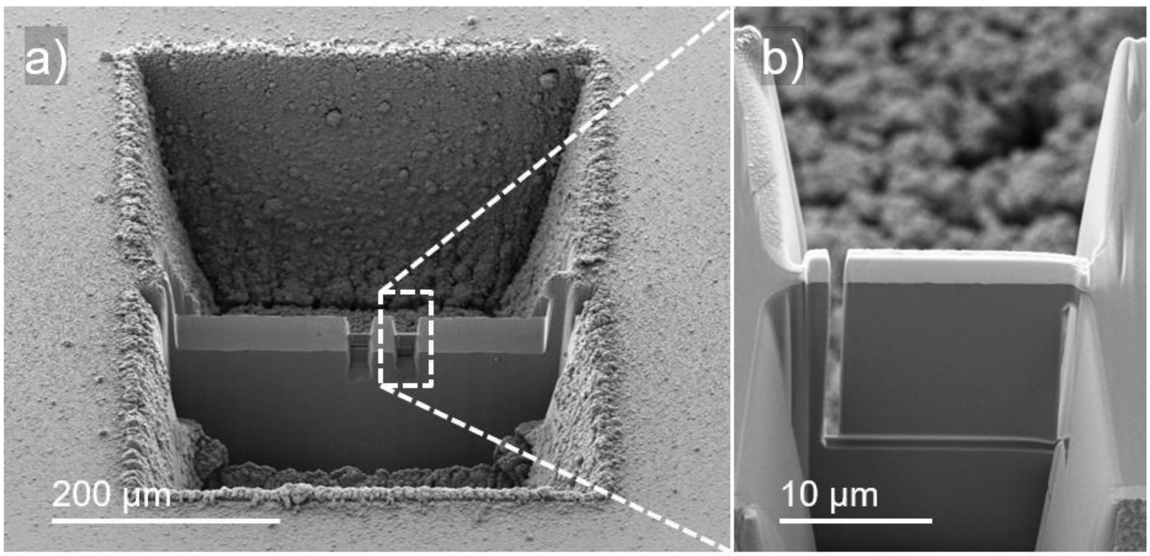

Figure 2. a) Laser milled macro-lamella in silicon cut down to a precise depth as base for standard TEM lamella prep. b) Magnified area in a) showing the automatically prepared TEM lamella.

References

[1] https://www.zeiss.com/laserfib
[2] https://www.zeiss.com/microscopy/int/cmp/mat/20/nanomaterials/temprep/temsample.html

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