Efficient and precise sample preparation by combination of pulsed laser ablation and FIB milling

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Today, focused ion beam (FIB) in combination with a scanning electron microscope is a widely used standard technique in research, analytics and for the modification and structuring of almost every material down to nanometer dimensions. Sample preparation for electron microscopy more often than ever requires the removal of large amounts of material e.g. to access deeply buried sample structures. Until now, such preparation has been achieved using demanding and slow techniques, such as metallographic cross sectioning and ion polishing, or FIB milling.

To overcome this challenge Carl Zeiss combined a pulsed ns-laser with an Auriga CrossBeam® FIB/SEM system. The Laser system is attached to the load-lock chamber in order to avoid contamination of high voltage parts in the main chamber by laser sputtered material (Figure 1). The ablation of material volumes in the order of several 10 mm³ can be performed within minutes, followed by FIB preparation and SEM analysis in the same instrument [1,4,5].

This new tool now allows a time efficient target preparation with high positioning accuracy of deeply buried structures and of extremely large cross sections.

One important dimension is the heat affected zone. It is necessary to know how much material have to be removed by subsequent FIB polishing until it is undisturbed. It has been shown, that the size of this zone is in the range of 5 μm [3,4]. Estimations about the whole preparation time taking into account the mentioned necessary subsequent FIB polishing will be shown in this presentation. That the laser FIB/SEM combination is capable to quickly expose deeply buried features in microelectronic devices in one workflow has been published [1,2,4]. Furthermore, to prepare large cross sections in brittle or soft materials can be very demanding and often conventional methods are not applicable. The feasibility of using laser cutting on these materials to get access to large cross sections for further FIB/SEM investigations has been presented also [5].

In addition, the ability to remove large arbitrary structures enables a wide field of novel sample preparation procedures. For example the preparation of structures for large volume FIB tomography. In order to avoid shadowing effects during the tomography run it is necessary to have as less as possible material surrounding the volume of interest.

A FIB tomography of a through silicon via (TSV) will be shown. The first step is the annular removal of the surrounding material by means of laser ablation. This is followed by the FIB tomography under 0° stage tilt (Figure 2). These procedure enables a quick start of the overnight tomography run in just ca. 20 min.

References

Figure 1. Scheme of the combined laser FIB/SEM tool. The laser process takes place in the load-lock to prevent contamination of the high voltage components in the main chamber.

Figure 2. Scheme of preparation workflow for a large volume FIB tomography on the example of a large via structure. Step I is the localization and the ablation of the laser pattern. The laser can easily remove the complete material around the structure so that a pillar remains including the whole structure. Additional large volume ablation to get access to the whole structure for e.g. EDX or EBSD tomography. In step II, the FIB tomography started.