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**IT-13-P-2724 Novel strategies towards faster and smoother FIB cross-sectioning**

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The Focused Ion Beam (FIB) and the Scanning Electron Microscopy (SEM) are essential techniques for many applications. FIB modifies the sample by the milling or, when accompanied by the Gas Injection System (GIS), by the deposition; SEM is used for imaging of resulting shapes at the high resolution, for charge compensation, or as a source of electrons for other analytical techniques. Common FIB-SEM instruments allow creation and imaging of a broad range of shapes. The most important shape is the cross section, which is used both for sectioning the sample and TEM sample preparation, by milling two cross sections at both sides of TEM sample [1]. Two parameters of the cross section are crucial – the fast milling rate and the high quality of the surface, with no damage or artifacts.

The milling rate depends on the sample material and on the beam incidence angle (Fig. 1). An optimized scanning strategy for the cross section is introduced, to keep the slope of the sample surface under the ion beam closer to the maximum rate. Apart from increasing the milling rate, this method also reduces the redeposition artifacts to avoid obstacles limiting the effective depth. The resulting cross section shape is greatly improved and around 2.5 times deeper when compared to classical stair shape (Fig. 2). This shortens the cross-sectioning and TEM sample preparation time significantly.

The common width and depth of the cross section, milled by Ga FIB, are ~10 μm. For larger cross sections with dimensions up to ~100 μm, Xe plasma FIB is much more efficient [2]. As the surface milled by Xe plasma FIB is often not as smooth as the surface milled by Ga FIB, the quality has to be improved by tilting the sample and milling from several directions [3]. This makes cross-sectioning more difficult and less accurate. To overcome these drawbacks, a novel method was developed to greatly improve the surface quality, while keeping the milling process easy and accurate. Commonly used eucentric sample stages allow the tilting only around the axis perpendicular to both FIB and SEM columns. The novel multi-tilt sample stage allows an additional tilting also in the plane of the cross section. Unlike the solution described in [3], where the eucentric stage was used, the proposed method allows to control the whole milling/tilting process by SEM imaging, which is essential for the precise end-point detection (Fig. 3). Greatly improved results were obtained on polycrystalline material samples and on semiconductor samples, like solder bumps (Fig. 3), packaged ball-bond Au wires (Fig. 4) and TSV.

References

[1] MHF Overwijk et al, J. Vac. Sci. Technol. B 11 (1993), 2021.
[2] T Hrnčíř et al., ISTFA Conf. Proc. (2012), 26.
[3] F Altmann, et al., ISTFA Conf. Proc. (2012), 39.
[4] http://www.srim.org

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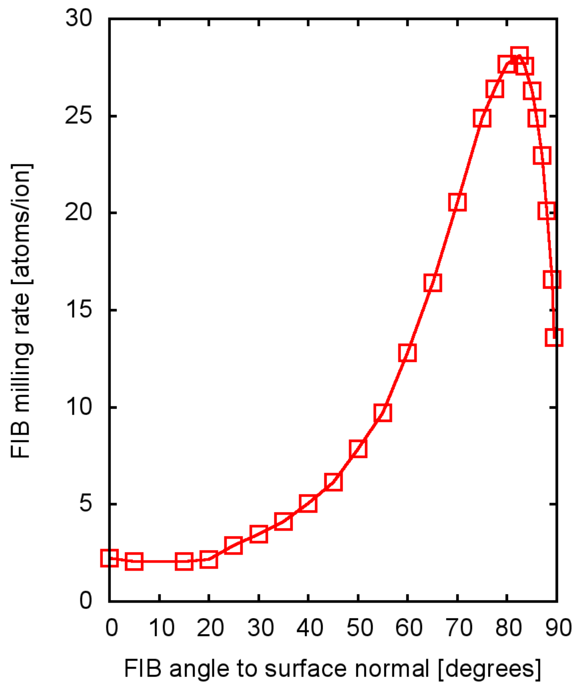


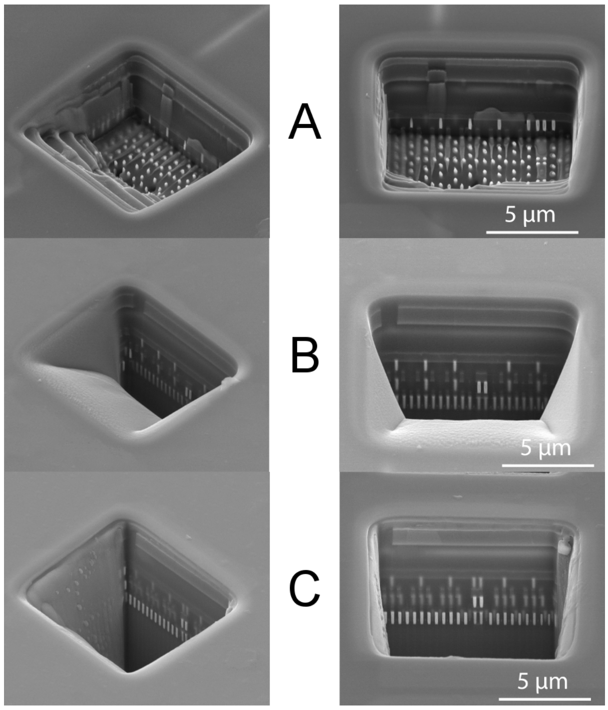
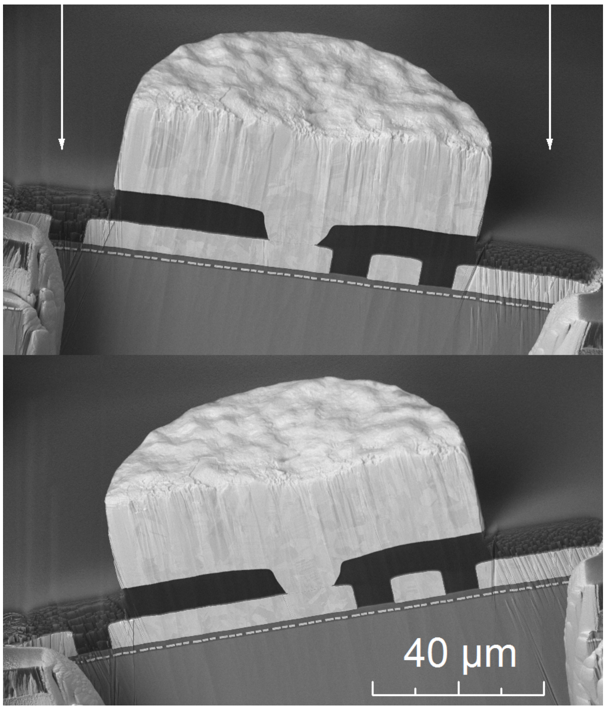




Fig. 1: Ga FIB milling rate on Si when changing the incident angle, modeled by SRIM [4]. Beam energy is 30 keV.

Fig. 2: Increasing cross-sectioning rate by optimizing the scanning strategy. A) Classical stair strategy, which gives a nice shape but it is slow; B) One-pass polishing, where the shape is corrupted by redeposition artifacts; C) Novel optimized strategy, with the nicest shape and the highest depth of the cross section.



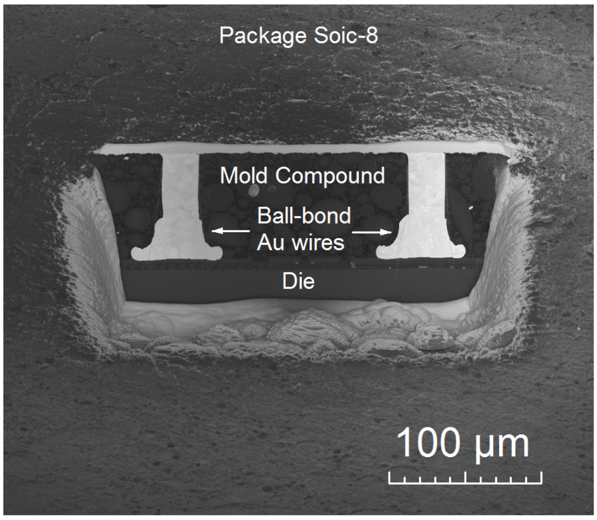




Fig. 3: Xe plasma FIB polishing of the solder bump by alternating the stage tilt in the cross section plane. Arrows point in FIB direction and the polishing process is controlled by SEM imaging, allowing to stop the process in the center of the bump accurately.

Fig. 4: Cross section through the packaged semiconductor sample (PWM controller from ON Semiconductor) by Xe plasma FIB, which was practically impossible to perform by Ga FIB previously.