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Xe Plasma FIB-SEM with Improved Resolution of Both Ion and Electron Columns

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Combined plasma Xe ion source FIB (Focused Ion Beam) with SEM (Scanning Electron Microscope) was introduced three years ago [1]. It proved to be an important tool for ultra-fast milling, especially for the semiconductor industry. Besides 50-times higher milling rate compared to traditional Ga ion FIB, it eliminates the conductive contamination of integrated circuits and it is useful for processing of compounds such as SiGe, (In)GaAs and (In, Al)GaN. We demonstrated its utilization also for other fields, for example preparation of large TEM lamella [2] or the first large-scale FIB tomography [3].

Here we present the latest advances of Xe plasma FIB leading to improvement of lateral resolution more than two times. This allows expanding Xe ion beam applications into the area of traditional Ga FIB applications. A special piezo manipulator called the rocking stage is designed to minimize curtaining effects.

The SEM column is improved as well by replacing conventional magnetic optics with recently developed immersion magnetic optics yielding ultra-high resolution imaging at low beam energies. The detection system comprises 8 electron detectors both in the chamber and in the column. Detectors of backscattered electrons have increased detection limits and efficiency, thus able to detect in the complete range of electron energies 0.2-30 keV. This is especially useful for imaging semiconductor samples and integrated circuits just after preparation of their large cross-sections by Xe plasma FIB, see Figures 1 and 2.

A wide range of integrated analytical instruments is kept including EDX, EBSD, TOF-SIMS, EBIC and even AFM reported previously [4]. Actually the TOF-SIMS analyser benefits from Xe primary ions by better detection limit compared to Ga primary ions.

Raman analysis in FIB-SEM [5] is also enabled here thus providing ultra-high resolution electron beam, ultra-fast milling Xe ion beam and finally photon beam in one instrument.

References:

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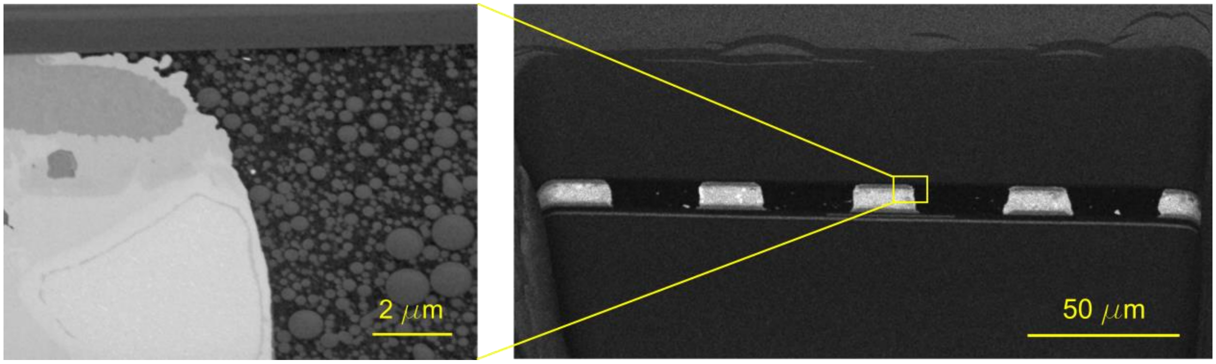

Figure 1. SEM image taken by low-energy In-Beam BE detector with acceleration voltage 2 kV.
Left: Detail on top edge of Al metal via, silicon layers and polysilicon filling.
Right: Large-area cross section through mold compound and Al bonding wires.

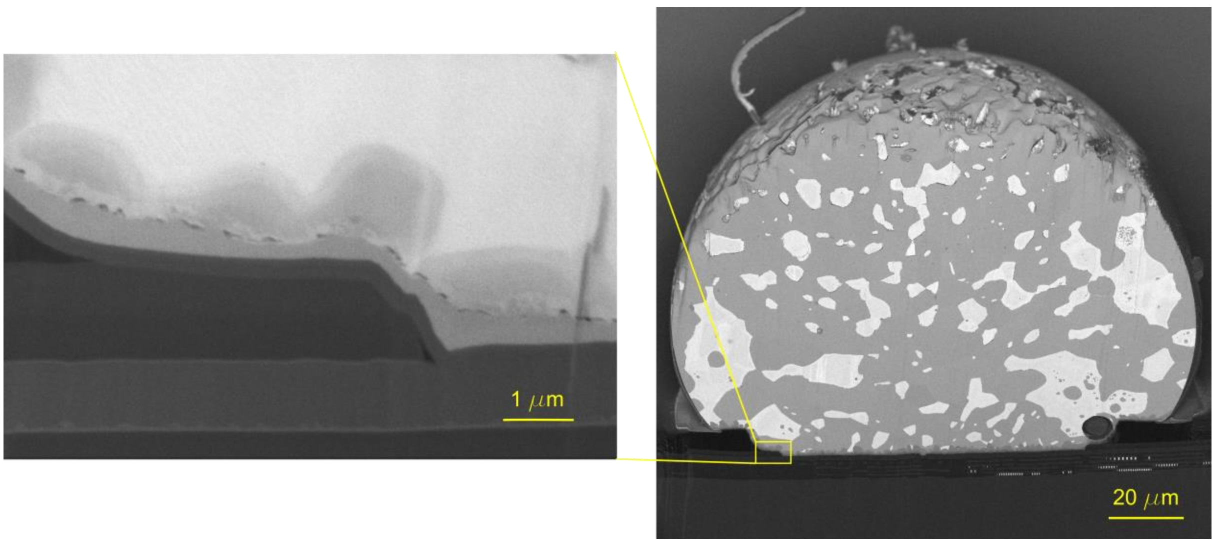

Figure 2. SEM image of the solder bump, cross-sectioned by plasma FIB, taken by low-energy In-Beam BE detector with acceleration voltage 1 kV (detail) and 5 kV (overview).
Left: Detail of the bump showing some cracks in intermetallic compound layer and delamination in repassivation layer. Sn - Pb island boundary is also clearly visible.
Right: Large-area cross section of the solder bump. The electrical and mechanical connection between the die and the substrate is critical for the flip chip package functionality. Inside Sn bump material there is visible formation of Pb dendritic structure points (white islands) caused by e.g. too rapid cooling. Intermetallic compound (IMC), repassivation layer (polyimide), under bump metallurgy (UBM) and integrated circuit layers are clearly visible due to the high material contrast of In-Beam BE imaging.