Physical Failure Analysis of a MEMS Motion Sensor

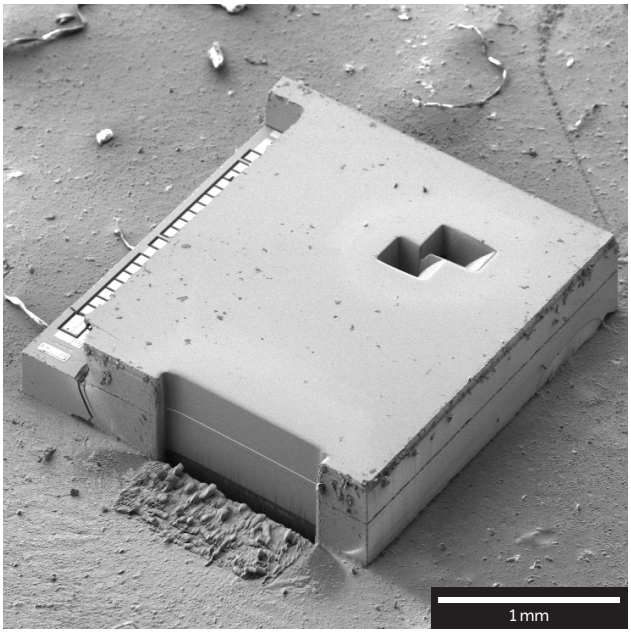
Creating 1 mm-wide cross sections with TESCAN SOLARIS X

Microelectromechanical systems (MEMS) are commonly used as actuators, sensors, radio frequency and microfluidic components throughout a variety of applications in health care, automotive and military industries. However, there are considerable challenges with both fabrication and packaging of such devices. In particular, issues related to yield and reliability need to be overcome.

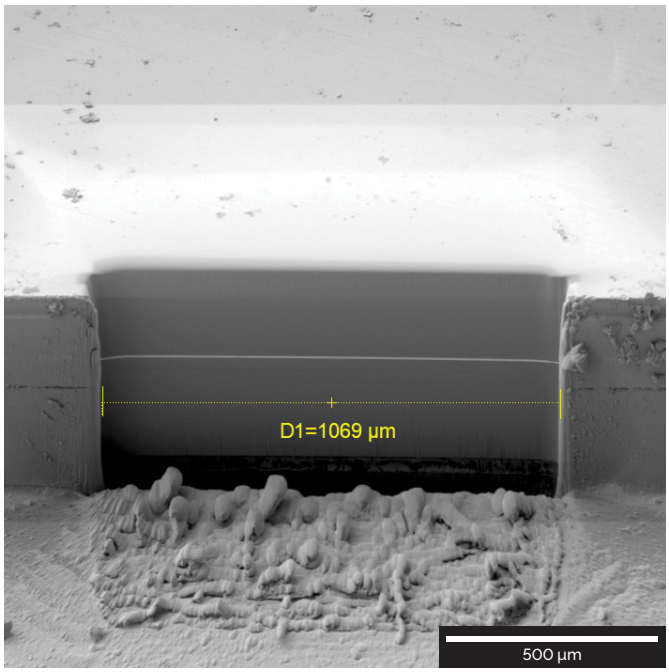
Structures for motion sensors are generally composed of wafer-to-wafer (W2W) cavity die. The lid is bonded to the sensor with a metallic material (Fig. 1). Routine failure analysis consists of examining the bonding layer for manufacturing defects that may lead to malfunction. For this purpose, preparation of large-area cross sections at specific locations on the MEMS device is required. These cross sections are typically prepared by mechanical polishing, a technique which indeed enables large-area cross-sectioning but, on the other hand, induces severe artifacts such as delamination, tearing, mechanical stress or even the total destruction of a part of the die. Additionally, it is difficult to maintain control for end-pointing.

TESCAN SOLARIS X is a Xe plasma Plasma FIB-SEM that provides an effective solution for preparing artifact-free, large-area cross sections of MEMS for the purpose of device failure analysis. The great advantage of the Xe ion plasma FIB is its ability to generate a very high current ion beam while maintaining reasonable beam spot quality. This results in high sputtering rates, making it possible to remove large volumes of material in short timeframes. In combination with effective milling strategies, an artifact-free cross-section surface can be obtained. TESCAN SOLARIS X has everything necessary for preparing and analyzing large-cross-sections. The iFIB+™ Xe plasma FIB column, with unmatched field of view of 1 mm, is one of the essential features that enables the preparation of such large-area cross sections. For imaging, the Triglav™ SEM column with immersion TriLens™ optics delivers excellent ultra-high-resolution performance, especially at low electron beam energies. Triglav™ also includes a unique in-beam detection system with BSE energy filtering and angular selective BSE detection. This improves materials contrast and enhances surface sensitivity, to enrich the information obtained during routine inspection of cross-sectioned MEMS.

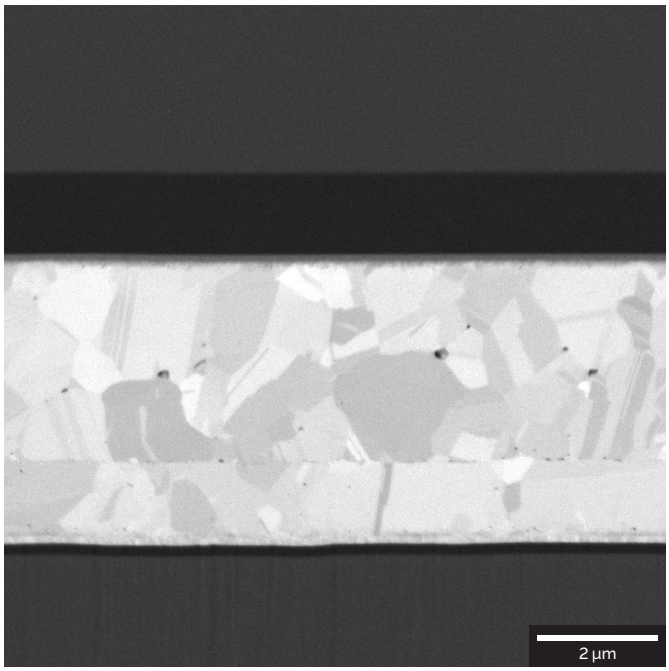
The example in Fig. 2 shows a cross section prepared in a MEMS motion sensor, width 1069 µm, depth 507 µm. In order to explore details in the metallic bonding layer, the surface is imaged with SEM at 2 keV with the Mid-Angle BSE detector (Fig. 3).



▲ **Fig. 1:** MEMS with multiple cross sections through the bonding layer of W2W cavity die.



▲ **Fig. 2:** The overview image using chamber SE detector at 2 kV shows the MEMS cross section with metallic bonding layer.



▲ **Fig. 3:** Detailed image of the metallic bonding layer acquired using the Mid-Angle BSE detector at 2 kV.

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