Prepare extra-large-area cross sections in an OLED display using the new TESCAN SOLARIS X

Organic Light Emitting Diodes (OLEDs) are flat light emitting technology, consisting of a series of organic thin films placed between two conductors. When an electrical current is applied, a bright light is emitted. OLEDs are emissive displays that do not require a backlight and as a result, are thinner and more efficient than LCD displays (which do require a white backlight). Another advantage of OLED displays is that they are flexible. For this reason, OLED technology has recently gained significant presence in today's display market. Today, OLED displays are mass-produced for mobile phones, tablets, TVs and wearables.

One type of OLED display is the Active Matrix OLED or AMOLED display, which has a back panel of thin-film transistors, a feature that makes pixel control easier and more accurate. It is this feature which makes AMOLED technology suitable for large size displays. Compared to conventional glass-based displays, plastic AMOLED panels are much thinner and lighter, enabling either thinner devices or larger batteries. Future flexible displays will also make foldable mobile devices a reality. The two main segments are currently smart phones and wearable devices such as smart watches. However, as the technology matures it will be possible to use those displays in other applications, such as automotive displays.

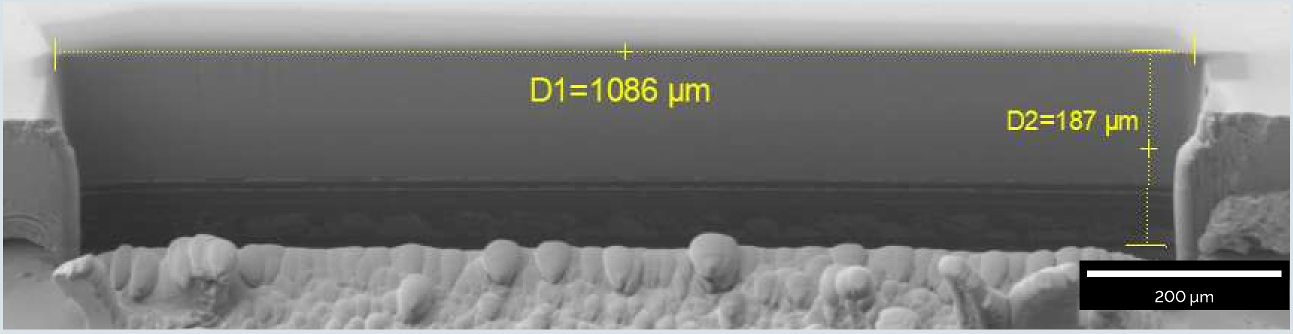
Physical failure analysis of OLED/AMOLED displays can be quite tricky due to the presence of a large variety of materials such as polyimide, ITO, glass, organic layers, Al electrodes and other metals whose physical properties differ significantly from each other. These materials are placed in the form of very thin films with thicknesses that can range within the nanometer scale.

A standard technique to inspect failures in displays is to prepare cross sections at specific locations on the display, thus enabling detailed examination of these multi-layered structures. The cross sections are then examined by means of high resolution scanning electron microscopy imaging which makes it possible to resolve such thin layers and find possible manufacturing defects or artifacts that lead to display malfunction.

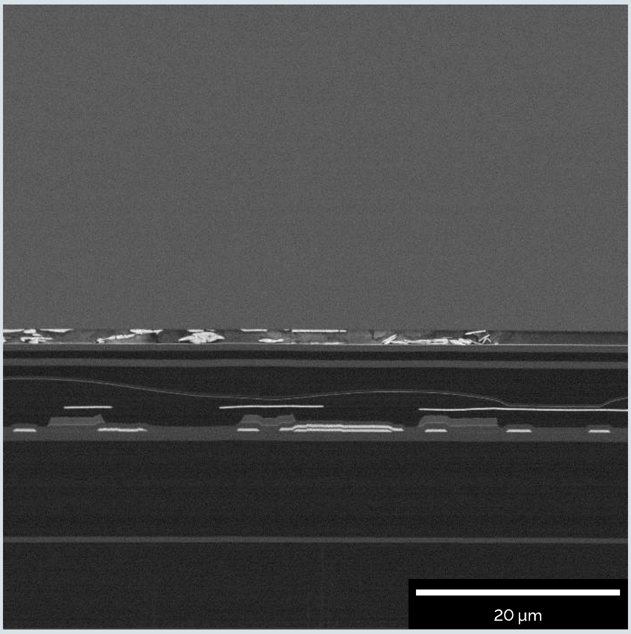
Mechanical polishing is the standard technique to prepare cross-sections in displays. While this enables rapid preparation of large-area cross-sections, it has drawbacks, like inducing severe artifacts such as delamination, tearing, mechanical stress or even the total destruction of a part of the display.

TESCAN SOLARIS X is a Xe plasma focused ion beam scanning electron microscope that has it all for preparing large-area cross sections — as large as 1 mm wide — while at the same time providing the high resolution and excellent contrast at low beam energies required to image and resolve the delicate and small structures in the displays. For sample modification, TESCAN SOLARIS X is equipped with the new iFIB+™ Xe plasma FIB column capable of achieving an extremely large field of view, 1 mm at 30 keV, that is unmatched in the market. This is a key feature that, together with the high milling rates that are possible with high current Xe plasma FIB, enables the preparation of extra-large cross-sections in displays (and in other large structures such as TSVs, MEMS, BGAs, etc..). Thus, with TESCAN SOLARIS X, 1 mm-wide high-quality and artifact-free cross sections can be prepared effortlessly in matter of hours, something which simply isn't possible with conventional Ga FIBs. For imaging, the next generation Triglav™ ultra-high-resolution SEM column is equipped with an improved in-beam detection system with extended detection capabilities, like energy-filtering axial BSE signal detection, that provide excellent contrast and enhanced sensitivity, especially at low beam energies that are essential to resolve nanoscale features and thin-layers in displays.

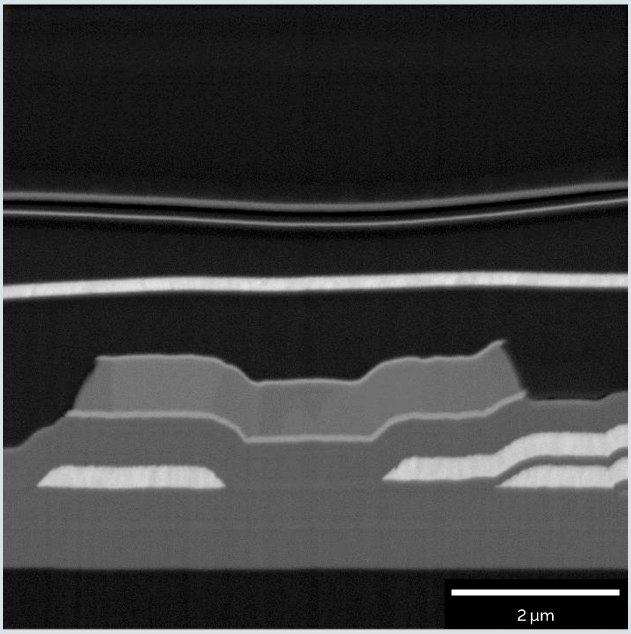
Figure 1 shows a 1086 µm wide, 187 µm deep cross-section prepared at 2 µA ion beam current, and a beam energy of 30 kV. The in-column Mid-Angle BSE detector provides high contrast images of the metallic layers inside display (Figure 2 and Figure 3).



▲ **Fig. 1:** 1086 µm wide cross section through part of an OLED display, SE detector at 2 kV.



▲ **Fig. 2:** Detailed image of the vertical structure of the OLED display: top passivation/Al electrodes/polyimide/ITO/polyimide. Mid-Angle BSE detector at 2 kV.



▲ **Fig. 3:** Detailed image of the Al contacts and SiO_2/SiN_x layer structure. Mid-Angle BSE detector at 2 kV.

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