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## Insights on OLED degradation mechanisms by correlative TOF-SIMS and XPS

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Since their invention in 1987 by Tang and Van Slyke, understanding the degradation mechanisms after environmental and/or electrical aging is essential to improve the performances of organic light emitting diodes (OLEDs). However, the study of thin aged organic multilayers (~100 nm thick) requires characterization techniques capable to probe small chemical changes with a high depth-resolution. Time-of-flight secondary ion mass spectrometry (ToF-SIMS) and X-ray photoelectron spectroscopy (XPS) are suitable surface-sensitive techniques providing complementary information: access to molecular information and the elemental chemical environment respectively. Nowadays, ToF-SIMS and XPS depth profiling are routinely used to investigate aged devices. However, the analysis and sputter beams used in these techniques may induce degradations on organic layers [1] and cause bond scission [2] that accumulate in buried layers. We developed a correlative depth-resolved protocol that aims to minimise damage related to analysis beams by analysing the surface of a bevel crater. This shallow angle bevel crater is formed using a continuous, linear variation of ion fluence across a rastered area of  $800 \times 800 \mu\text{m}^2$ . Typically, argon clusters of around 7500 atoms are used at an accelerating voltage of 5 kV. A comparison between an electrically-aged and fresh OLEDs (structure for green light emission) has been performed using this protocol. Electrical ageing consisted of maintaining a stable current of 4 mA for 430h in order to produce sufficient degradation that would be visible by TOF-SIMS and XPS techniques. The greater degree of fragmentation of the characteristic molecular ions originating from the emissive layers as well as the electron transport and hole blocking layers is observed in ToF-SIMS spectra. XPS measurements confirm that the chemical environment of the elements present in those layers appears to change after ageing, in particular in the hole blocking layer.

1. Morgan, D.J., *XPS insights: Sample degradation in X-ray photoelectron spectroscopy*. Surface and Interface Analysis, 2023: p. 1-5.
2. Postawa, Z., *Sputtering simulations of organic overlayers on metal substrates by monoatomic and clusters projectiles*. Applied Surface Science, 2004. **231-232**: p. 22-28.