Development Of A High Brilliance X-ray Source For Advanced Thin Film Characterization

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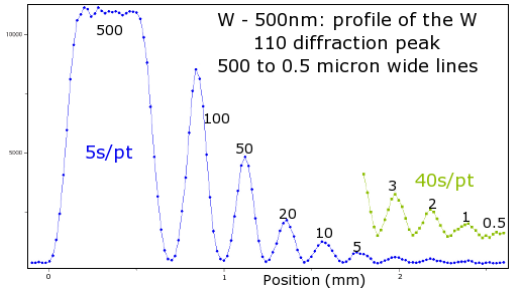
ABSTRACT

X-ray based metrology techniques have demonstrated their capabilities for the measurement of critical process parameters on complex microelectronic thin film structures such as layer crystallinity or texture analysis (X-ray Diffraction, XRD), multilayer thickness (X-ray Reflectivity, XRR), material composition (X-ray Fluorescence, XRF) [1]. Achieving the X-ray beam spatial resolution and photon density for fast, high precision data acquisition on small test structures is a real challenge. This requirement is being addressed by various equipment suppliers integrating microfocus sealed tubes X-ray sources with moderate brilliance coupled with advanced X-ray optics [2]. However the further increasing requirements of future technology nodes are increasing the challenge and higher brilliance solutions are required.

In the framework of a French collaborative project (HIBRIX), we have been investigating a new X-ray beam delivery concept. This solution is based on a relatively medium power micro-focus source (using rotating anode technology) coupled with a high efficiency multilayer optics to provide an intense high brilliance X-ray beam optimally shaped for the required application. A prototype has been installed at the CEA-LETI in France on a multi application diffractometer platform (XRD/XRR/XRF) consisting of a 4-circle goniometer and various detector configurations.

Performances of the setup (in terms of brilliance, spatial resolution, detection limits) have been demonstrated and compared with those of commercial diffractometers, highlighting the impact of increased photon density and high spatial resolution for process diagnostic on polycrystalline materials. Combined XRD and XRF measurements have been carried out on various samples with pattern sizes between 0.5 and 500 microns: W and TiN lines, back-end T-boxes, patterned SOI. Tilt and stress of patterned SOI layers have been measured.



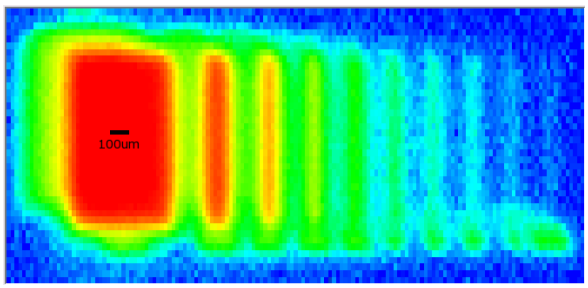


FIGURE 1 (left). Profile of a 500 nm thick W patterned layer on Si measured by X-ray diffraction.
FIGURE 2 (right). Mapping of a 60 nm thick TiN patterned layer on Si measured by X-ray fluorescence.

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Keywords : X-ray micro-focus source, mapping metrology, combined X-ray analysis

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