NMT: A Novel Technology for In-Line Ultra-Thin Film Measurements

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Abstract: XwinSys has developed a novel technology capable of measuring ultra-thin films down to 1Å accurately and precisely, based on an enhanced XRF technique.

Introduction

Semiconductor nano-device manufacturing is at an inflection point; 2D shrinkage, while still the preferred method of miniaturization, is giving way to 3D stacking and interposers in the race to miniaturize at a competitive cost. This has caused a profusion of changes to system architecture that expresses itself in a wealth of new and complex geometries and materials. Thin films are becoming ultra-thin and more localized, and features comprise more material variations and interactions at smaller scales and with less tolerant to aberrations.

This demands smarter metrology tools to identify and analyze these paradigm shifts, and a need for a multipurpose approach in methodology.

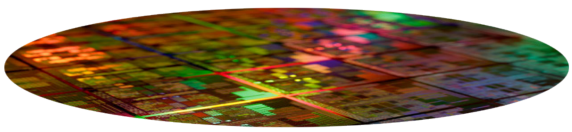

FIGURE 1: Semiconductor Pattern Wafer

NMT: a new generation of XRF technology

XwinSys has identified the semiconductors recent market trends and after investigating the disparities between existing solutions and evolving needs, has developed a novel XRF technology named **NMT**: **N**oise-reduced **M**ultilayer **T**hin-film measurement. This innovative approach can be used for in-line multipurpose inspection, metrology and analysis of localized ultra-thin layers - down to 1Å!

FIGURE 2: XwinSys Onyx System

Overcoming EDXRF weaknesses

Unlike other XRF systems that are limited due to high levels of background noise, the NMT concept improves the S/N ratio, resulting in low background noise and high quality net signal, by implementing the following approach:

- Using a unique silicon drifted detector (SDD) with a novel design, focusing on light elements, to analyze the elements with more resolution.
- Replacing the air atmosphere between the x-ray sensors and the wafer with helium which dramatically reduces signal noise.
- Implementing a vertical incident X-ray beam enabling both high flux and small spot size, without the tradeoff of a reduced S/N ratio.
- Applying a unique algorithm designed to remove background noise from the elemental signal.

The NMT volumetric technology allows accurate and precise results of single layer and multilayer analysis within a single acquisition, aimed to meet R&D and In-line applications.

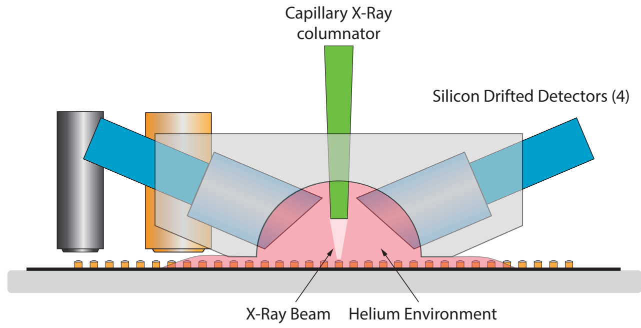

FIGURE 3: XwinSys XRF Module

Free from optical constants

When using common optical techniques to analyze layers below 50Å, density [D], refraction index [N] and extinction coefficient [K] are very unpredictable. It is imperative to accurately calculate these constants in order to determine the absolute film thickness. In a multi-layer stack the value of these constants are challenging to analyze.

The benefit of X-ray physics is not having sensitivity to density, refractive index or extinction coefficient. Therefore, film thickness values are independent of the fluctuation of the above "constants", hence can be valued absolutely by the NMT.

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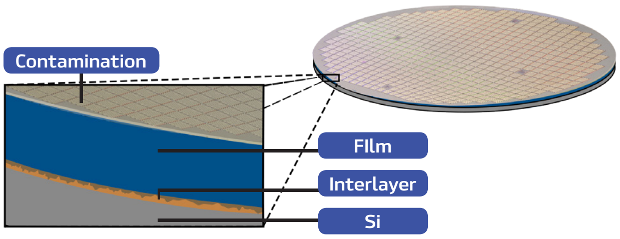


FIGURE 4: Layers Structure of Ultra-Thin Film

Genuine analysis of opaque thin films

Most materials (e.g. metals, organic, alloy and glass) are transparent or semi-transparent when in thin layers. At a certain thickness, some of the materials become opaque and therefore invisible to optical thickness monitoring. NMT technology enables the accurate measurement of both transparent and opaque materials.

Spotting down to microns

Today thin film measurements are being performed mainly by large spot inspection techniques; it seems like measuring on a blanket wafer instead of a patterned wafer has become "status-quo".
With the novel NMT invention, analysis of thin films and ultra-thin films in small features is now achievable. For the first time an X-ray based metrology tool is a reliable technique for in-line process control of ultra-thin films.

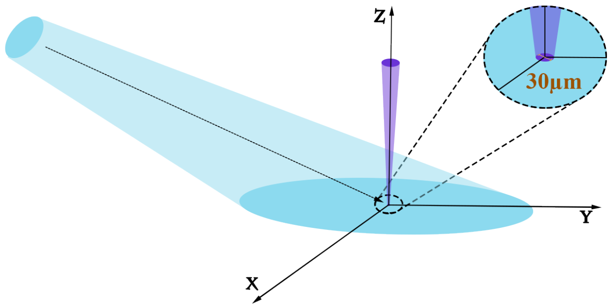
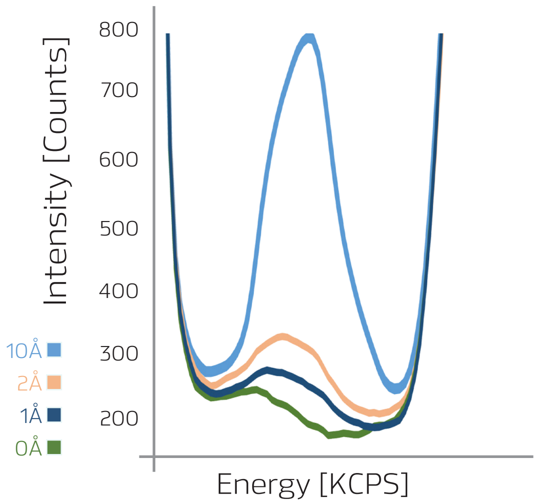
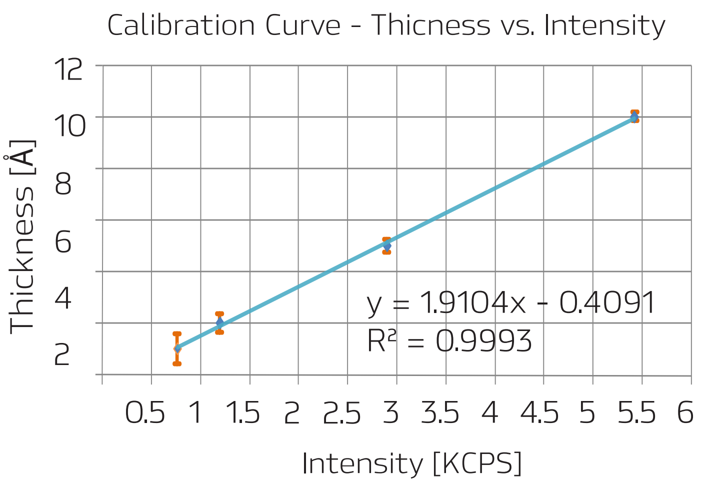


FIGURE 5: Vertical Micro-Spot Incident Beam vs. Grazing Beam

Case Study: Exceptional Accuracy, Down to 1Å





The XwinSys system has successfully measured thin films down to a single Angstrom while maintaining the specified precision (see Case Study above).
The above graphs refer to results of XwinSys system using the NMT technology for ultra-thin films of a metal sample. The measured thicknesses were: 1, 2, 5 and 10Å. These graphs present the accuracy and precision of the results.

In summary, the XwinSys system incorporating the novel NMT technology, can be utilized for in-line applications ranging from localized ultra-thin film stacks to the inspection of 3D localized features to the analysis of defects involving geometries, voids and material elements.