

Spectroscopic Ellipsometry for ALD Technology

The Woollam Company is pleased to be working with Oxford Instruments on their latest generation of Atomic Layer Deposition (ALD) systems. ALD deposition of thin films has become very important in recent years, particularly for growing the latest transistor gate oxides in modern integrated circuit chips.

In ALD, growth is controlled at the atomic level by self-limiting surface reactions from the alternate exposure of the substrate surface to different gas-phase reactants, known as precursors. The first gas phase precursor flows into the deposition chamber and reacts to form a layer on the surface. The first precursor is then pumped from the chamber and the second precursor admitted. It reacts with the new surface and completes an ALD “cycle” with the formation of no more than a single monolayer. Choosing suitable precursors enables ALD of high-quality oxide, nitride, and metallic films.

Since ellipsometry is monolayer sensitive, it is capable of monitoring the growth of each atomic layer. Ellipsometry data are automatically acquired between the ALD cycles using a Woollam M-2000® ellipsometer integrated in situ on an Oxford Instruments FlexAL® or OpAL™ ALD reactor. It is possible to plot a real time graph of any measured parameters such as thickness or refractive index versus the number of ALD cycles.

The photo above shows the FlexAL tool with M-2000 integrated onto the chamber. The M-2000 is controlled by the Woollam CompleteEASE® software integrated with the Oxford Instruments PC2000® software (see figure below).



The application of in situ ellipsometry to ALD has several distinct advantages. The thickness determined by ellipsometry can confirm the film growth is linear with number of ALD cycles. In the early growth stages the nucleation behavior of the films on various substrates can be investigated. In situ ellipsometry saves a great deal of time when plotting precursor saturation curves without the need to remove the wafer.

Ellipsometry can also measure the optical properties, crystalline phase, and material composition of films. For ultra thin metallic films, electrical resistivity SE provides insight into the Drude absorption profile. The Oxford Instruments-Woollam package provides both in situ and ex situ mounting which is particularly useful when comparing measured properties in relation to post oxidation effects.

Applications of in situ ellipsometry to study ALD film growth have been published extensively by Woollam customers at the Eindhoven University of Technology in the Netherlands. We would like to acknowledge Professor Erwin Kessels and his colleagues in Eindhoven for their pioneering work in ALD process monitoring using Woollam ellipsometers.

For more information on the ALD process and on the FlexAL and OpAL chambers, please visit the Oxford Instruments web site at www.oxford-instruments.com.

