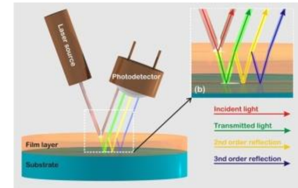
ThetaMetrisis APPLICATION NOTE #045

In-situ monitoring of dry etching process



Introduction:

Dry etching (ICP and RIE) is widely used during the last decades for the precise definition of the features (both in terms of lateral dimensions and depth as well) in the fabrication process of microelectronic and MEMS structures and devices. As the semiconductor industry continues its long-lasting progress toward higher performance circuitry, designers are shrinking the minimum device feature sizes continuously. Because of its widespread use for feature definition, control of dry etching is of particular importance to this effort. The present report demonstrates the capabilities of FR-tools in the real time monitoring of microelectronic processes. In particular, in this report the in-situ characterization of thin film thickness evolution during a plasma etching process is demonstrated.

Means & Methods:

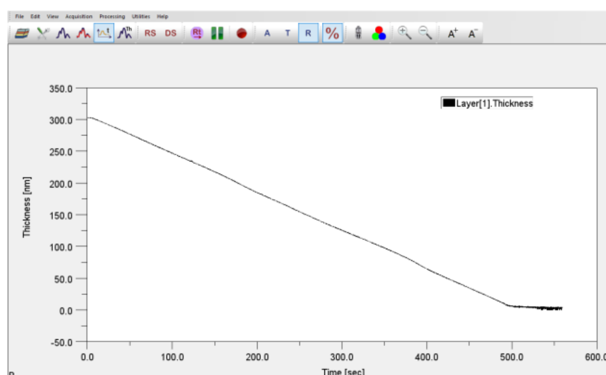
For the characterization of the etching process an **FR-pRo VIS/NIR tool operating in the 380-1000nm** was employed capable for **thickness** measurements in the **12nm-90µm range**. The tool was equipped with a FR-insiTu module that allows for the position of the reflection probe in front of the optical port of processing chambers. The FR-insiTu is equipped with a) a reflection probe of appropriate length b) the focusing optics c) the optomechanical part for mounting on the processing chamber and fine adjustment in front of the optical port. The **distance between the FR-insiTu module and the sample was ~60cm**. The sample under characterization was a Si wafer with a polymer layer coated on top via spin coating. The initial thickness of the polymeric layer was 303nm.

Results:

The sample (Si wafer with 303nm polymeric coating on top) was processed in an Alcatel ICP etcher with O_2 for the etching of the polymeric layer. The fitting of the reflectance spectrum was restricted in the 400-770nm spectral range to exclude the spectral regimes with the characteristic peaks of O_2 (processing gas).

In figure 1a, the time evolution of the polymeric film is illustrated, (FR-Monitor screenshot). The O_2 flows into the processing chamber at time-8sec and then the etching of the polymeric layer proceeds linearly. At the time-495sec the polymeric material is fully etched.

In Figures 1b-d, typical experimental reflectance spectra and the fitted ones are illustrated for film thicknesses of ~300nm, ~100nm, etc. Clearly in all cases the fitting is excellent despite the long distance between the FR-insiTu module and the wafer under processing.



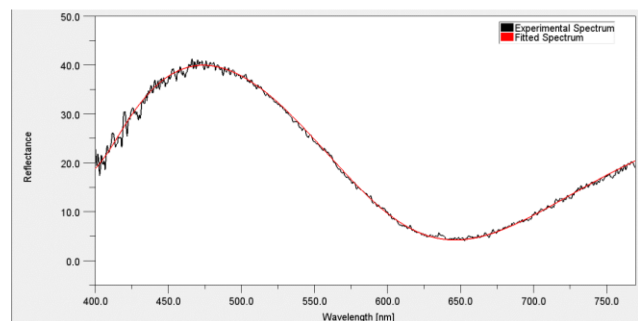


Figure 1: (Left) Real-time thickness evolution of the polymeric film during the processing with O_2. (Right) Experimental and fitted reflectance spectra at a certain time-stamp. The measured polymeric film thickness is 302.6nm

ThetaMetrisis © 2020, www.thetametrisis.com

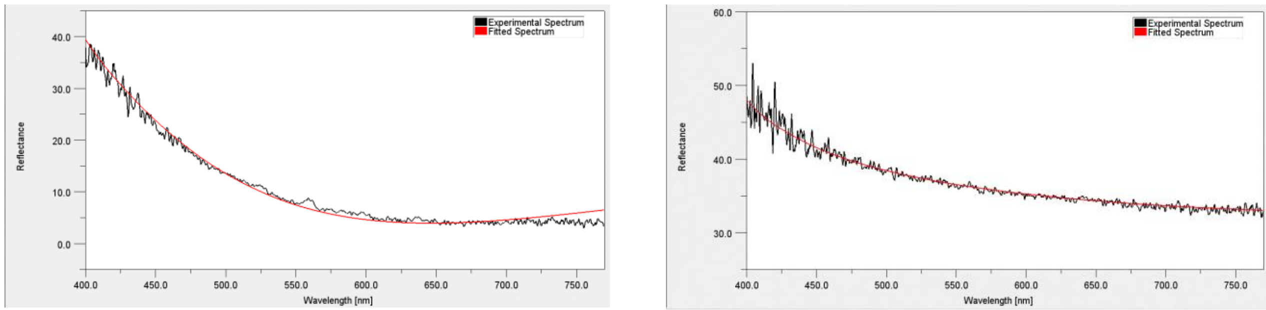


Figure 1: (Left) Experimental and fitted reflectance spectra at a certain time-stamp. The measured polymeric film thickness is 97.8nm. (Right) Experimental and fitted reflectance spectra at a certain time-stamp few seconds before the total removal of the polymeric layer. The measured polymeric film thickness is 5.6nm.

In figure 2, the optical emission evolution due to the processing with O_2 at two characteristic wavelengths (777.4nm and 884.6nm) are illustrated.

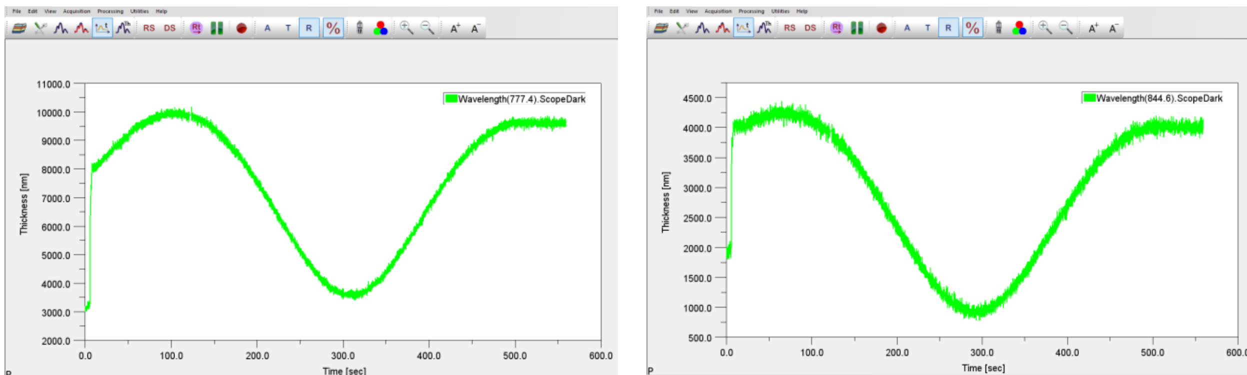


Figure 2: The reflectance signal (a.u.) at the two characteristic for O_2 wavelengths

Conclusions:

The real time monitoring of the thickness evolution of a polymeric film during etching with O_2 in an ICP etcher is successfully demonstrated.

ThetaMetrisis © 2020, www.thetametrisis.com