Application note:

Spectro-ellipsometry innovation using Avantes Spectrometers by Chonbuk National University, Korea

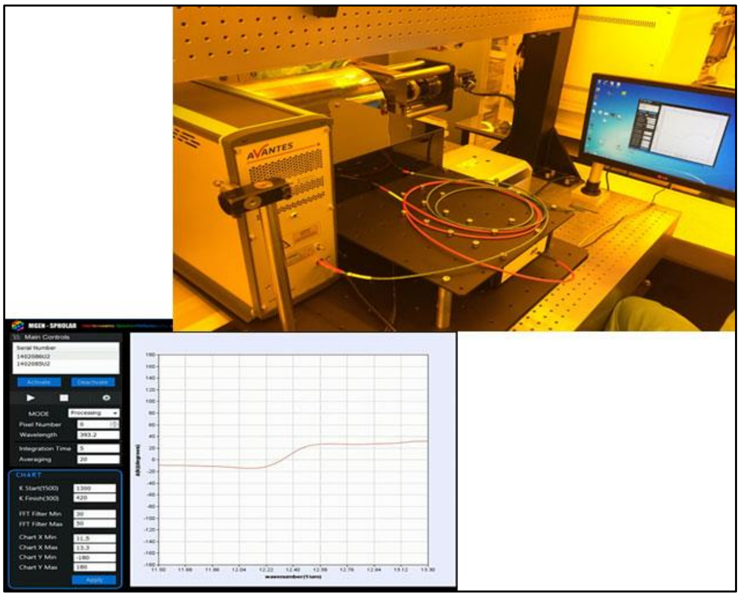
Polarization-sensitive spectral measurement technology is among the most precise and promising nano-metrology solutions in semiconductor manufacturing process. However, typical spectroscopic ellipsometry employing a mechanical or electrical polarization modulation scheme has a limitation in applying for real time in-line nano-pattern monitoring due to slow measurement speed.

Our approach is a kind of point measuring technique. So, to get 2D information, scans must be made. The proposed technology can provide a thin film layer thickness measurement capability and also it can be used to extract the 3D nano pattern profile information. The substrate of the thin film and periodic nano patern can be any substrate like polyimide film or other.

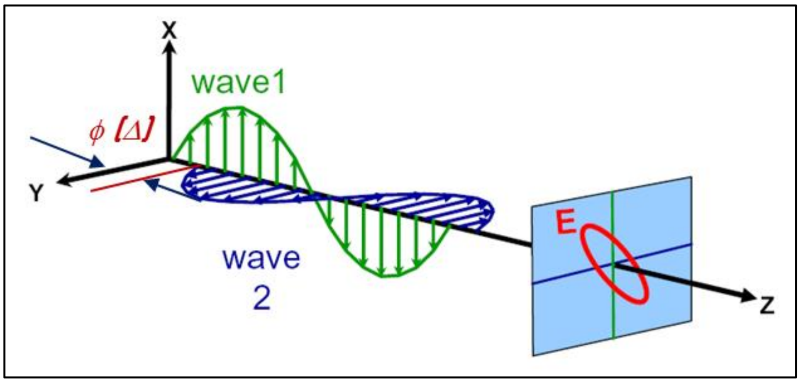
Recently, a new dynamic spectro-ellipsometer has been invented by the Optical Metrology Lab. (OML) at Chonbuk National University (CBNU) in collaboration with MGEN Corp. in Korea. A Korean patent and a PCT international patent have been filed for this innovation and some key journal publications are planned early of this year. (Korean patent application number: 10-2016-0013928, PCT patent application number: PCT/KR2017/000934)

This new technology can provide a unprecedented real time spectroscopic ellipsometric phase in-line monitoring capability of more than 20Hz. Most commericalized spectroscopic ellipsometer can provide the speed of less than 1Hz. For that reason, dynamic measurement and display capability is not provided in the current market. Such uniqueness has enabled the Korea Institute of Machinery and Materials (KIMM) to employ this technology for in-line monitoring of the next-generation large-scale Roll-to-Roll (R2R) nano-pattern manufacturing system which is targeting uniform 150nm width patterning on the entire 1m size roll substrate.

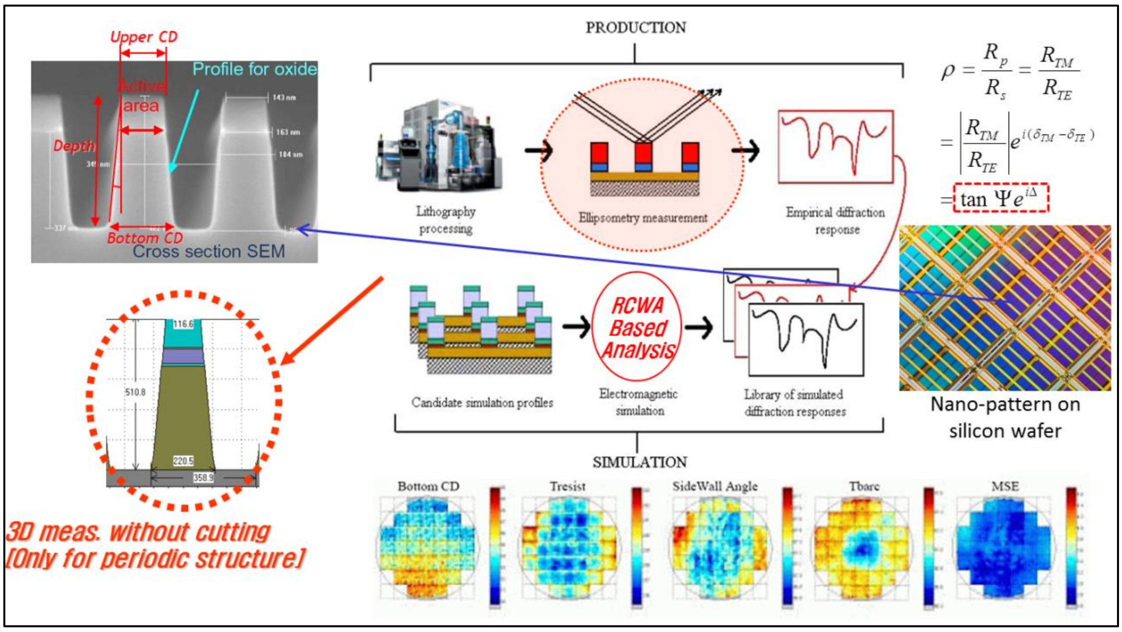
Explanation of the new technology



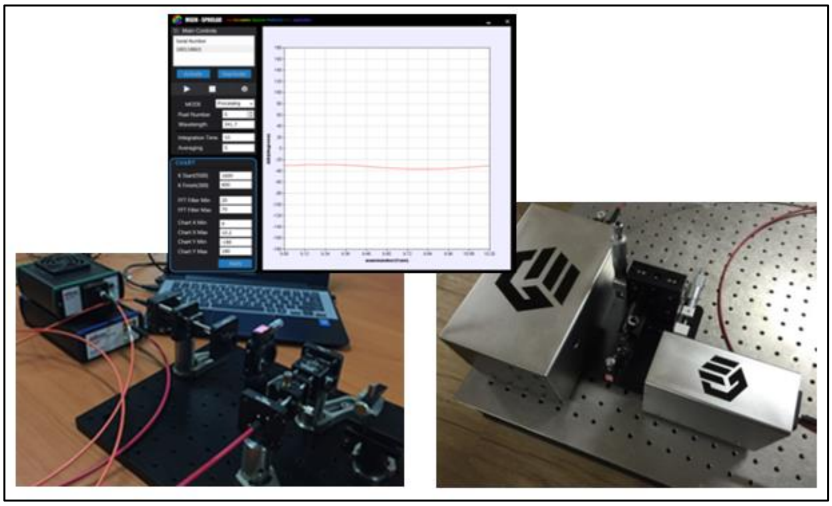
The above graph shows the phase difference between p- and s-polarization Δ(k) measured in the visible spectral range. X-axis represents the wavenumber(k) which is a reciprocal of wavelength and y-axis denotes Δ(k). The below figure illustrates what Δ means for a specific wavelength. All anisotropic transmissive or reflective objects generate their own distinctive Δ(k) by which we can get useful information such as thin film material property and geometrical shape.



Speaking of the anisotropy measurement of nano-pattern in more detail, we can extract the 3D profile information of a periodic nano-pattern by using the measured Δ(k) as we can make a simulated nano pattern model which means a modeled Δ(k) based on an algorithm called RCWA(Rigorous Coupled Wave Analysis). By varying the models and comparing with the measured Δ(k), we finally get the best-fit(the most similar to the measured Δ(k)) simulated nano-pattern model. The best fit result can give the real 3D information we can get from the cross-section SEM image. Without cutting the sample, we can extract the nano patern 3D information. As explained, the spectral shape of the dynamically measured Δ(k) correponds to one certain nano-pattern 3D profile, and we can extract the nano-pattern 3D information by using modeled DB(data base) made by the RCWA. We are displaying the Δ(k) only. It is needed to apply RCWA to extract the nano-pattern 3D profile. This procedure has not been conducted for our project. But, we can measure the non-uniformity of the 1 meter R2R nano-pattern object quantitatively by using the real time Δ(k) measurement results.



This new dynamic polarization-sensitive phase measurement technology can also be applied for in-line monitoring of transmissive anisotropic objects such as Quarter Wave Plate (QWP) or flexible nano-pattern films for Wire Grid Polarizer(WGP) etc. as illustrated below.



AvaSpec and AvaLight have been used to get highly accurate and stable spectra in real time speed. Thanks to the stability of these components we were able to achieve the $\Delta(k)$ measurement repeatability of around $0.1°$ with the measurement speed of 20Hz. To our knowledege, this is the first dynamic $\Delta(k)$ measurement demonstration in the spectro-polarimetry and ellipsometry.