Ocean Optics

Application Note

Thickness Measurement of ARC and Silicon Thin Films

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Anti-reflection coatings (ARC), silicon and silicon nitride films are often used in semiconductor processing. Because silicon film is relatively thick, the film thickness measurement method must be capable of producing results free of order ambiguity. The Ocean Optics NanoCalc XR reflectometry system has the capability for a proper measurement across the extended spectral range from 200-1100 nm.

Introduction

NanoCalc uses the well-known measurement principle of interference of light in thin layers. Light is reflected (and eventually transmitted), resulting in phase shifts and superposition of amplitudes and adding up to different intensities for different wavelengths. This optical phenomenon is called thin film interference, and is the same effect that causes soap bubbles to shimmer with a rainbow of colors when illuminated. Indeed, you observe thin film interference effects every day in the colors of thin film oils on water and the colored anti-reflective coatings on camera lenses and binoculars.
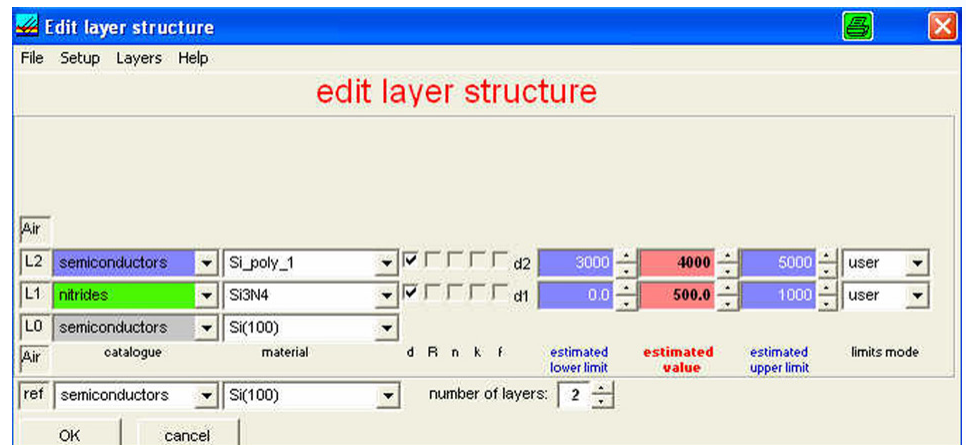

Figure 1: The setup for the thickness measurement includes information on sample layer structure and other parameters.

NanoCalc uses a broadband light source to generate wavelength dependent reflectance data. A fit to this data requires reasonable knowledge of the wavelength dependence of the refractive index n and the extinction coefficient k. Values for these parameters are often based on lookup tables compiled from material models describing n and k with a few adjustable parameters. Knowledge of n and k means that a highly accurate value for the absolute film thickness can be calculated.

Experimental Conditions

We evaluated ARC, silicon and silicon nitride films using a NanoCalc-XR reflectometer equipped with a 6-inch (150 mm) mapping stage and a
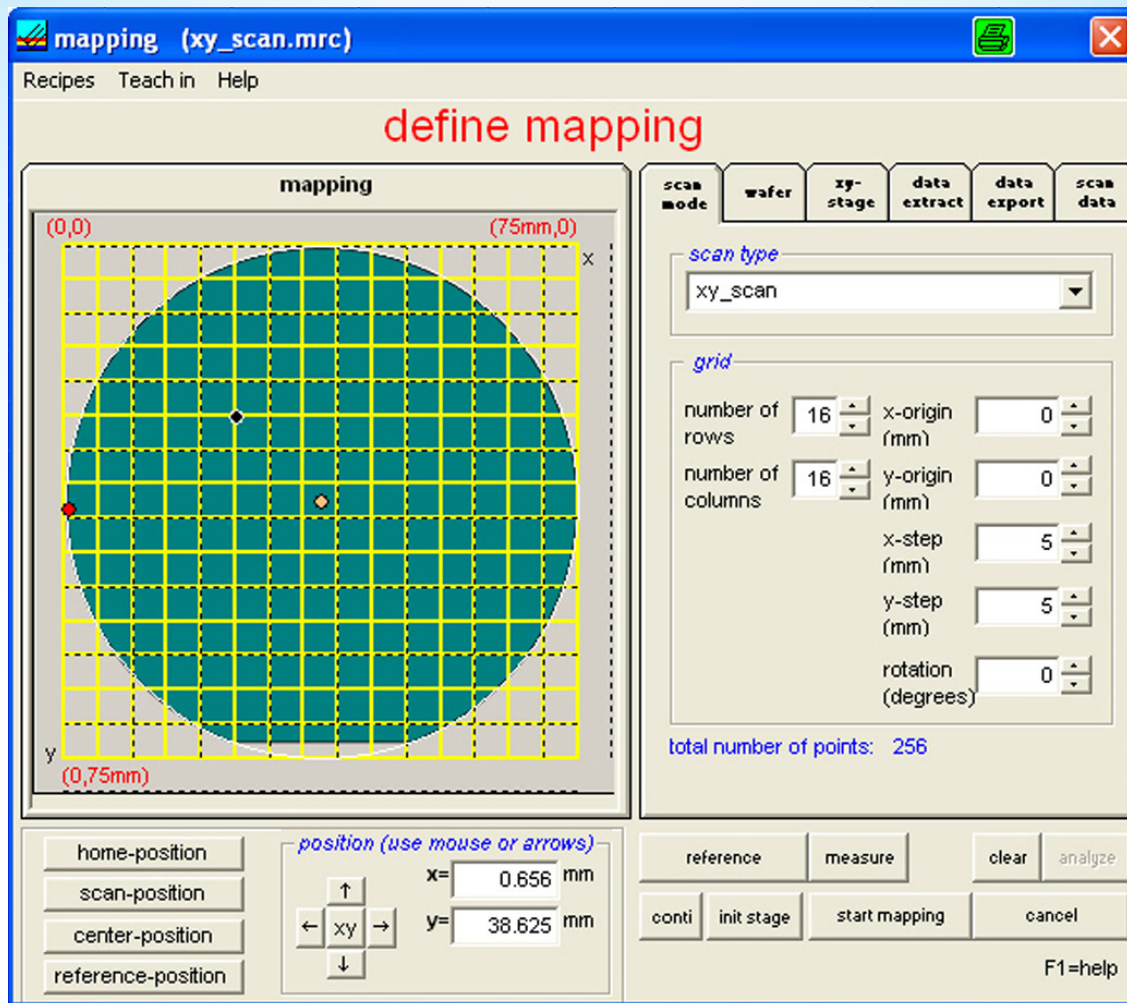
Figure 2: Mapping recipes can be stored in software for later retrieval by QC operators.

200 μm UV-VIS reflection probe with 6 illumination fibers, flexible metal jacketing and a common end with 0.25" (6.35 mm) stainless steel ferrule. The film samples (wafers) can be measured with a mapping stage in a single layer or multiple layers. NanoCalc operating software completed the system.

By accounting for expected and actual contrast in the interference pattern, the NanoCalc's fit algorithms have been designed to be tolerant of film interface roughness. For our ARC, silicon and silicon nitride measurements, we created a recipe in the software by defining the number of layers, their assumed properties and the thickness range. The measurement mode as multiple points with a mapping stage can be stored as a recipe to the recipe directory of NanoCalc, ready to be retrieved by the operator in user mode. Figure 1 shows the setup for the layer structure and Figure 2 shows the setup for the mapping recipe.
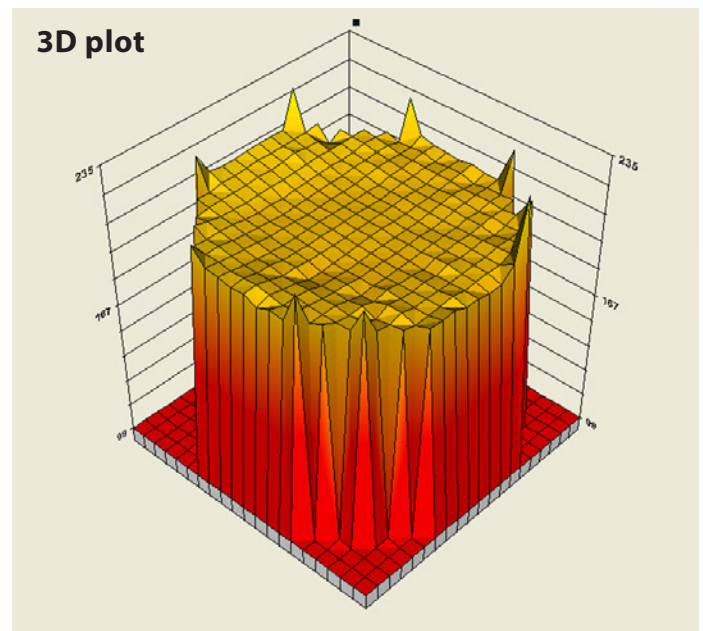

Figure 3: Thickness topography of thin film layers can be mapped in software.
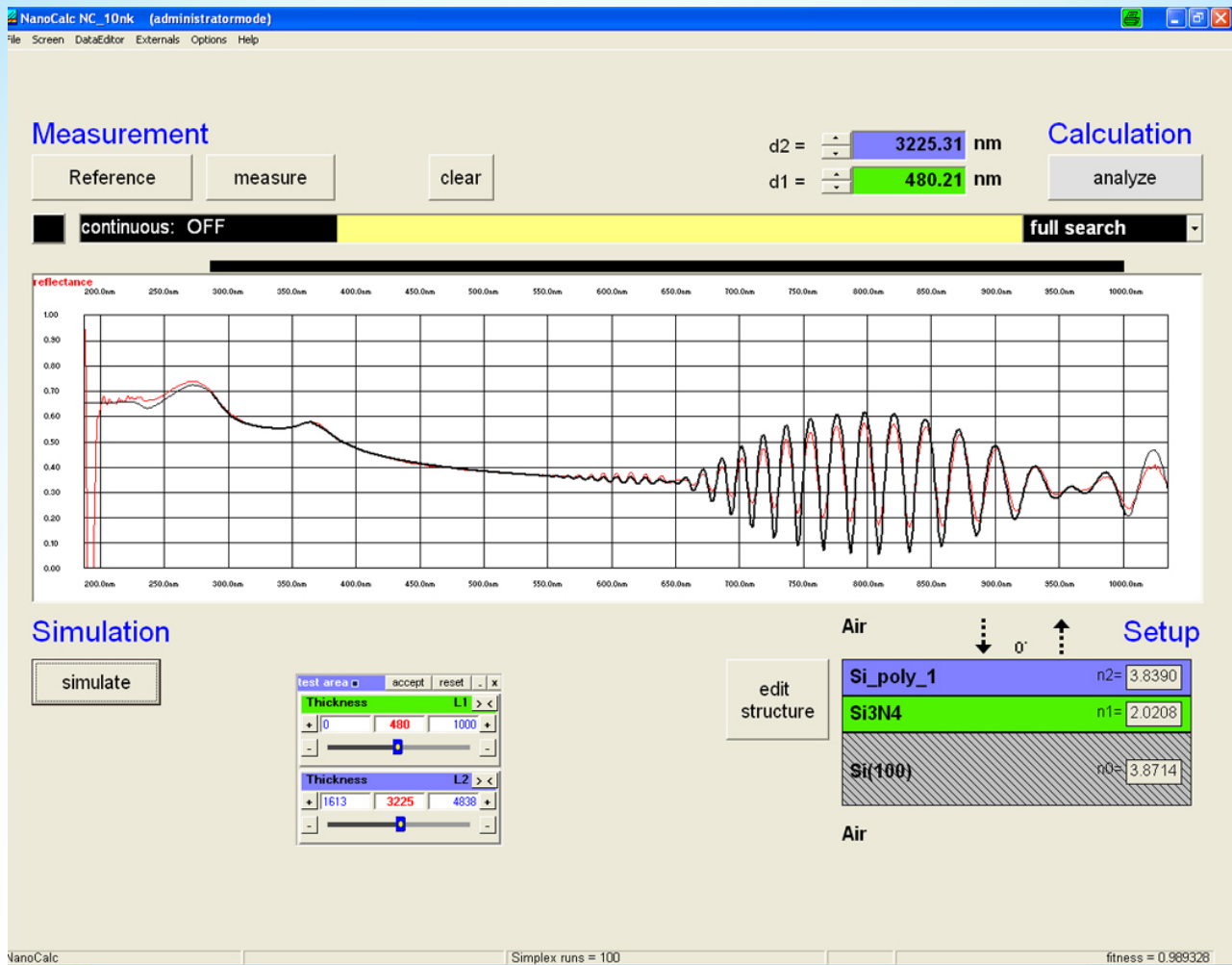
Figure 4: NanoCalc uses reflectometry techniques to provide the full analyzed spectrum for double-layer silicon on silicon nitride samples.

Results

A mapping scan in 3D plot of the film thickness topography is shown in Figure 3 for the sample with the ARC layer. ARC layers are often applied to silicon substrates because silicon has such a highly reflective surface and the interference effects between ARC and silicon layers will reduce reflection.

In addition, we measured the thickness for the double layer of silicon on silicon nitride, with good results (Figure 4). Additional analysis could be performed for center position on the thin film and other parameters.

Conclusion

Reflectometry is a good option for thin film analysis. The NanoCalc system is able to measure stacks of up to 10 layers, provides resolution to 0.1 nm, and is available in various wavelength configurations and with software and accessories for a range of application needs.

Contact us today for more information on setting up your spectroscopy system from Ocean Optics.