SiON ARC LAYERS

The microelectronics industry reduces its critical dimension by a factor 2 every 4 years and is now using the KrF excimer laser at 248 nm as the source of photolithography steppers in production in DUV. Furthermore, the development of the ArF excimer laser (λ=193 nm) lithography has been undertaken for sub 0.25 µm design rule device fabrication.

In order to keep an accurate line width control, the reflectivity of the photoresist must be minimised. One way to achieve this is to use a photoresist / antireflective coating / substrate structure. The ARC cancels reflective lights in optical amplitude and phase as shown in Fig. 1.

SiO_xN_y:H films are an appropriate ARC. SiO_xN_y:H films are obtained by PECVD using SiH_4 and N_2O gases, whose flow ratio can be adjusted during the deposition process.

These coatings have been shown to reduce thin film interference effects in photoresist and notching effects by halation.

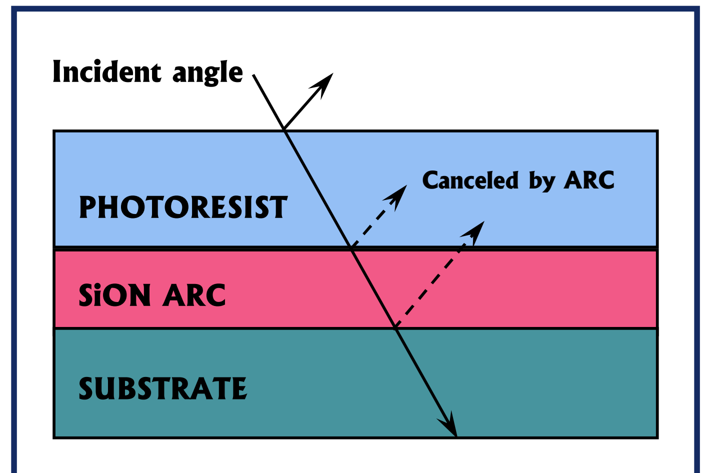

Figure 1

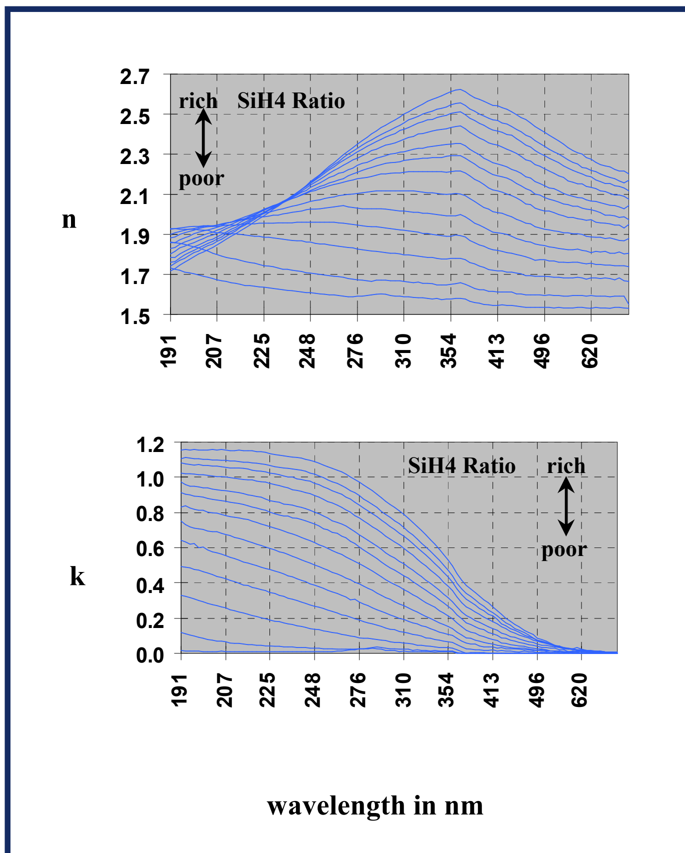

Figure 2

It is important to characterise not only the thickness but also the optical parameters of these films. Such a characterisation must be made in a simple and straightforward manner. **Spectroscopic Ellipsometry**, which is rapid, contactless, non-destructive and allows on-line control, is an excellent technique to perform precise and accurate characterisation of ARC materials and layers.

From the measurement of two parameters tan Ψ and cos Δ, thickness, refractive index n and extinction coefficient k can be extracted. These parameters are determined accurately and independently one from another.

Figure 2 shows the refractive indices, determined with one of **SOPRA's Ellipsometers**, of the SiO_xN_y:H films dependence on CVD process conditions. At 248 nm, n values are approximately constant but k values are strongly affected by the flow ratio of the SiH_4 gas.

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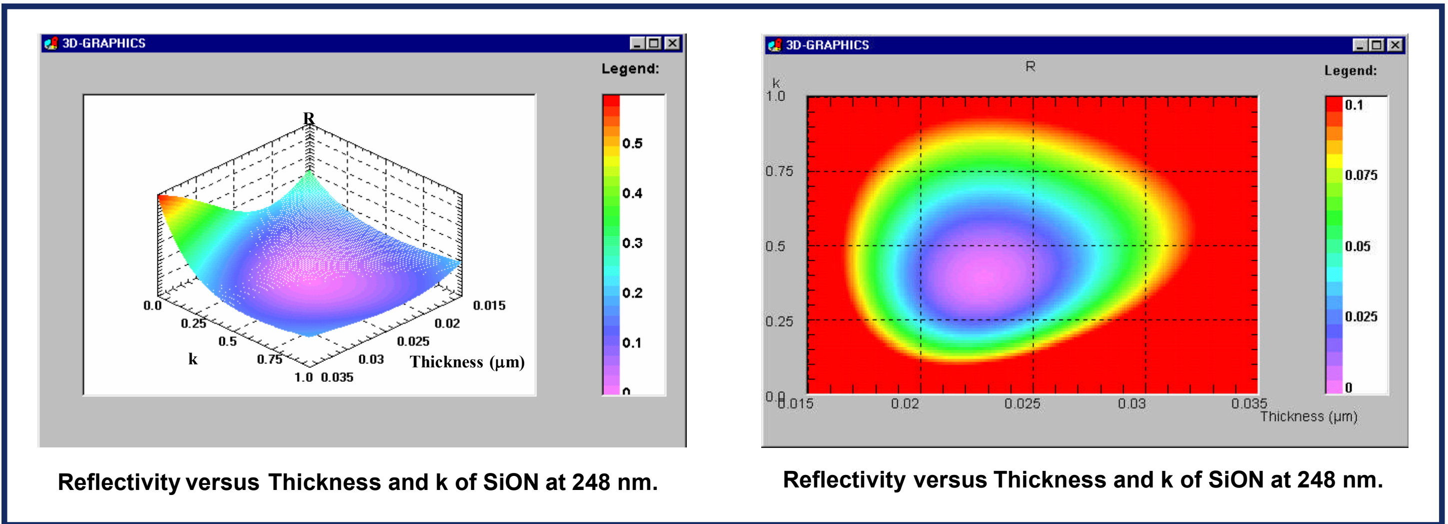
Using these optical indices and the **WINELLI software** developed by SOPRA, we simulate the reflectivity of the material for any floating parameters.



Reflectivity versus Thickness and k of SiON at 248 nm.

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Figure 3

Figure 3 shows the simulation of the reflectivity versus the thickness and the extinction coefficient k of AR coating of an ARC / Si structure at 248 nm. This simulation allows to determine the optimal optical characteristics of the layer in order to process high performances antireflective coating.

Figure 4 shows reflectivity at 248 nm versus thickness of photoresist on the final stack photoresist / ARC / Si. Using SiO_xN_y:H films, reflectivity variations in swing ratio are reduced to less than 0.2 %.

Moreover, SiO_xN_y:H films can be applied for the various high reflective substrates by controlling the deposition conditions and the chemically amplified photoresist without pattern degradation caused by film compositions, these films can be left in the device structure.

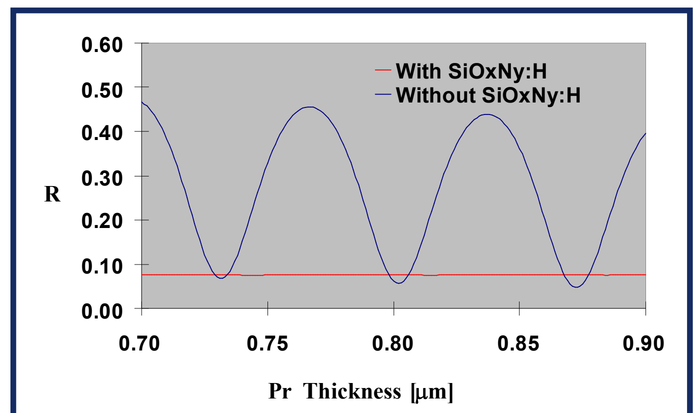

Figure 4

Using SOPRA's Spectroscopic Ellipsometer down to 190 nm in the deep UV range allows to determine accurately the optical properties of antireflective coatings which will be used for the new and future optical lithography at both 248 and 193 nm wavelengths.

Accurate characterisation of antireflective coatings with SOPRA ellipsometers helps make KrF excimer laser lithography a robust mass production tool for 64MDRAM and 256MDRAM devices, and ArF excimer laser a promising candidate for 1GDRAM class lithography tool.

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