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Leader in thin film meterology

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Application Note 5

Study of patterned wafer using spectroscopic picometer and imaging ellipsometer

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We have studied a sample which consited of lines of one medium separated by spaces of another. The lines can produce diffraction effects when the spacing is small compared to the wavelength of light, but when the spacing is wider, one measures the average ellipticity. The following pictures illustrate spatial signal averaging:

The two parameters we measure are x and y, which are related to the reflectivity ratio $r = r_p / r_s$ by $X = x + iy = 2\,r / (1+|r|^2)$. The parameters x and y depend upon the layer structure, the layer thicknesses, and their refractive indices. For a clean silicon surface at 650nm, y ~ 0 for all angles of incidence; x varies from 1 at small angles of incidence to -1 at large angles of incidence. Figure 1 shows the variation of x and y versus angle of incidence for squares with density between 0% and 100%. Both x and y vary smoothly with active site density. Density here is related to the relative amounts of medium 1 and medium2.

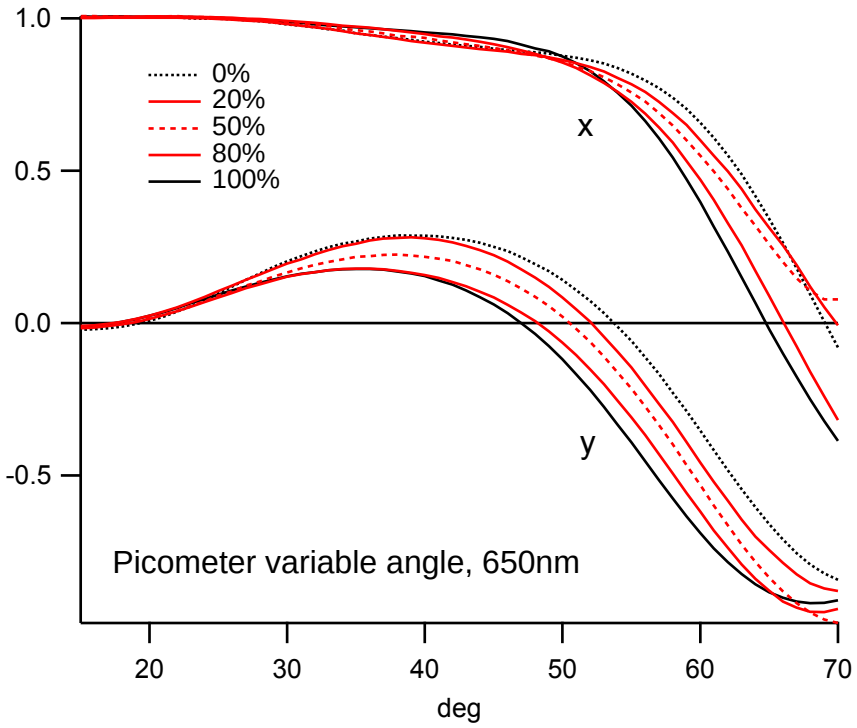

Figure 1 Picometer measurements on 5 squares with varying density as a function of the angle of incidence. The other density data interpolate smoothly in between.

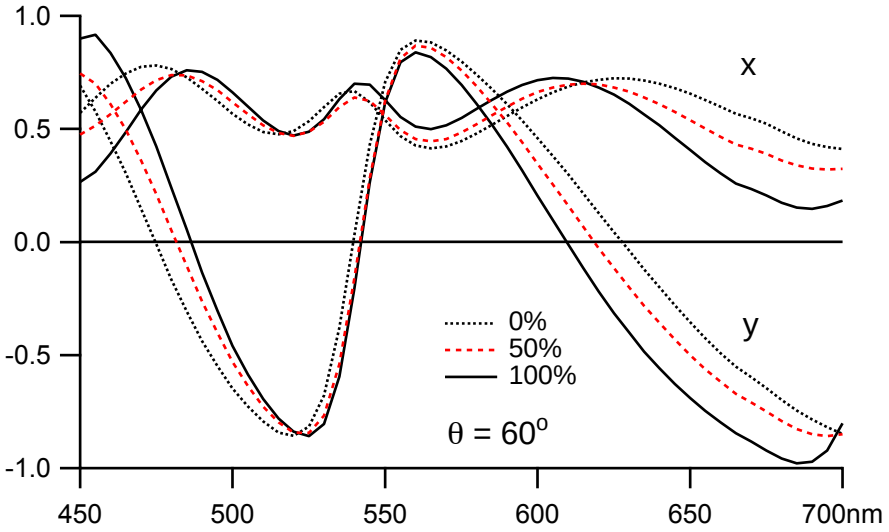

Figure 2 Spectroscopic Picometer study of the wavelength variation of the ellipticity of 3 squares. The data for other squares interpolate in between. The oscillations are characteristic of coloured interference fringes- fitting to these and the curves of Figure 1 determine the layer characteristics.

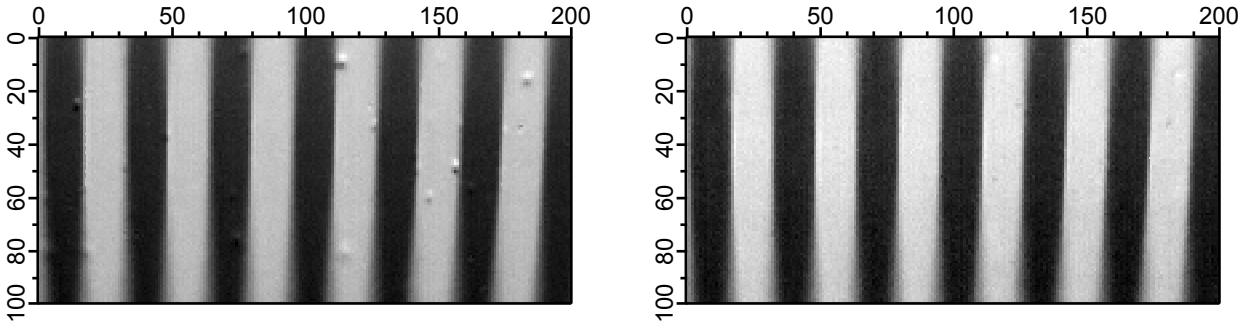

Figure 3: Ellipticity images for x (left) and y (right) for the 50% square (60^{o} angle of incidence, 650nm). The spots on the left picture are due to dirt on the sample, which affect the x signal more than the y signal. The focussing is excellent along a horizontal strip in the middle. For each pixel the grey scale colour represents the value of the ellipticity, white representing a larger (more positive) value than black. The horizontal scale for these images is approximately 5μ per pixel.

The easiest way to represent the variation of the imaging ellipticity is to run a horizontal line to determine the x and y profiles as a function of position. This is shown in Figure 4 for the 0%, 50% (above) and 100% samples.

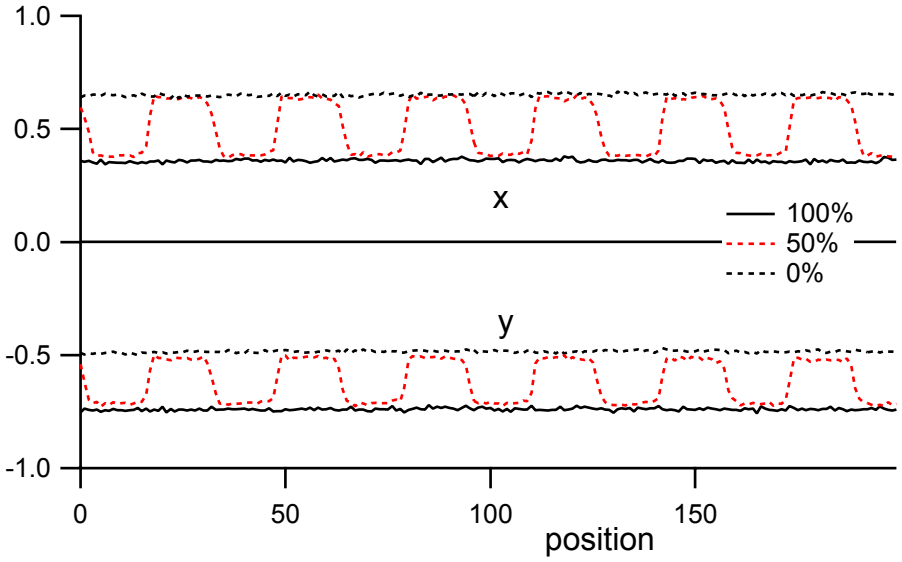

Figure 4: x and y profiles from the ellipticity images of Figure 3. Note the area average of 50% square is just half way between the 0% and the 100%, and the data follow the Picometer variation if the latter measures the area-averaged signal.