beaglehole instruments

Beaglehole Instruments Limited
32 Salamanca Road
Wellington, New Zealand
phone +64 4 473 7749
fax +64 4 473 2686
david.beaglehole@beaglehole.com

Leader in thin film meterology

December 2000

Application Note 6

Real-time study of etching of Photoresist on silicon samples

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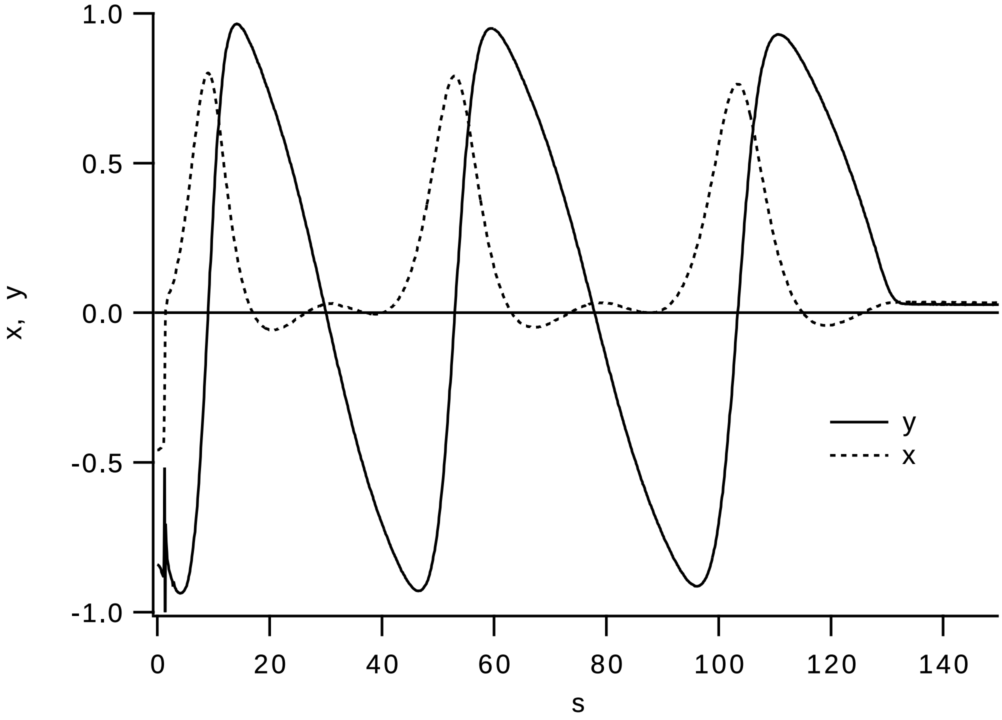
Real-time study of etching of Photoresist on silicon samples

Silicon wafers with thick (880nm) and thin (54nm) layers were prepared by Dr.Ted Fedynyshyn of MIT Lincoln Laboratory. Measurements on these samples were made by Allan Raudsepp.

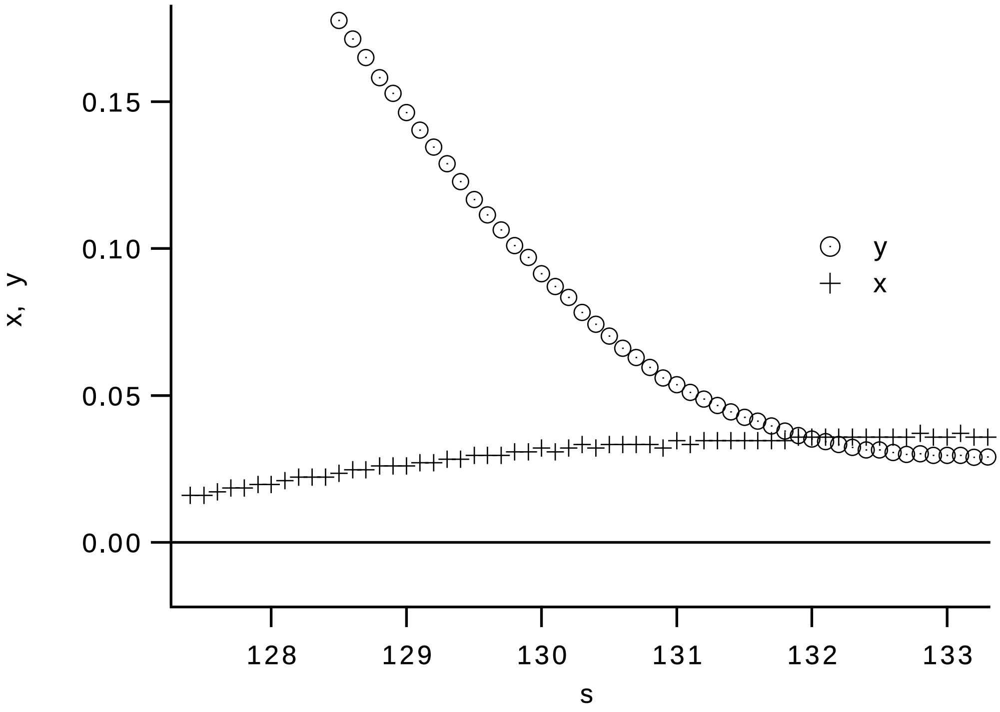
The samples were mounted in a 10cc cell and set with the sample vertical so that the dissolved resist would slide off. The measurement of x,y was commenced, and the cell then filled quickly but smoothly with solvent (tetramethyl ammonium hydroxide). The signal was erratic as the liquid level passed through the laser beam, but thereafter was steady, showing changes associated with thinning of the layer.

For thick layers 10 data points per second were recorded (total etch time between 80 and 200s). For thin layers 100 data points per second were recorded (total etch time about 2s).

1 Layer about 880nm thick. Passage through about 2.7 interference fringes observed as the layer thins. Raw data. Data erratic as beam liquid level passes through beam. (Angle of incidence 72^{o}.)



2 Detail of the above raw data on an expanded scale showing the individual data points.

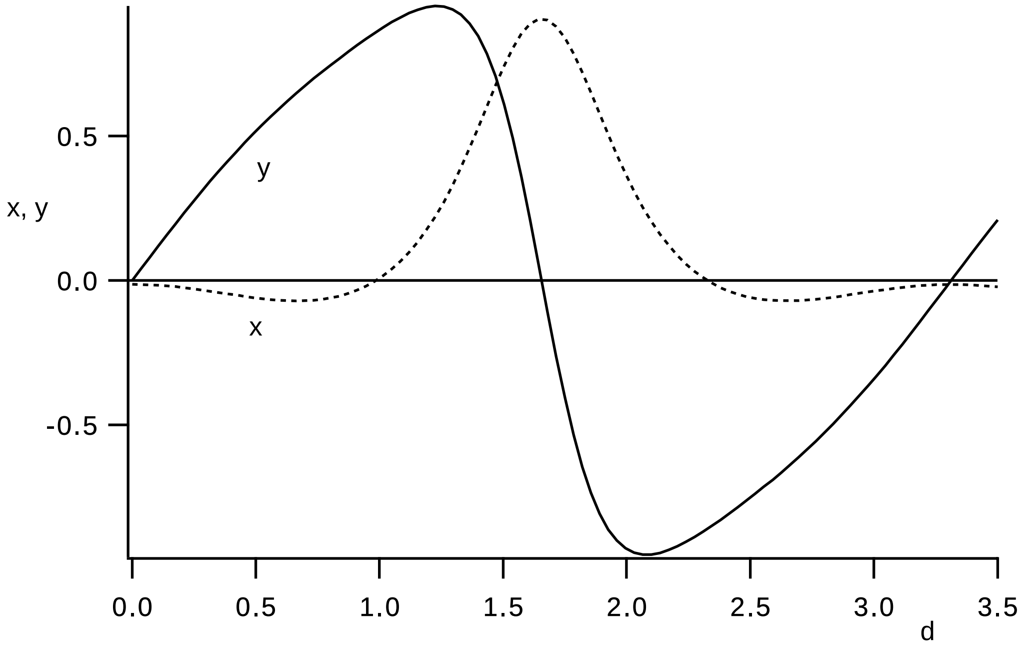


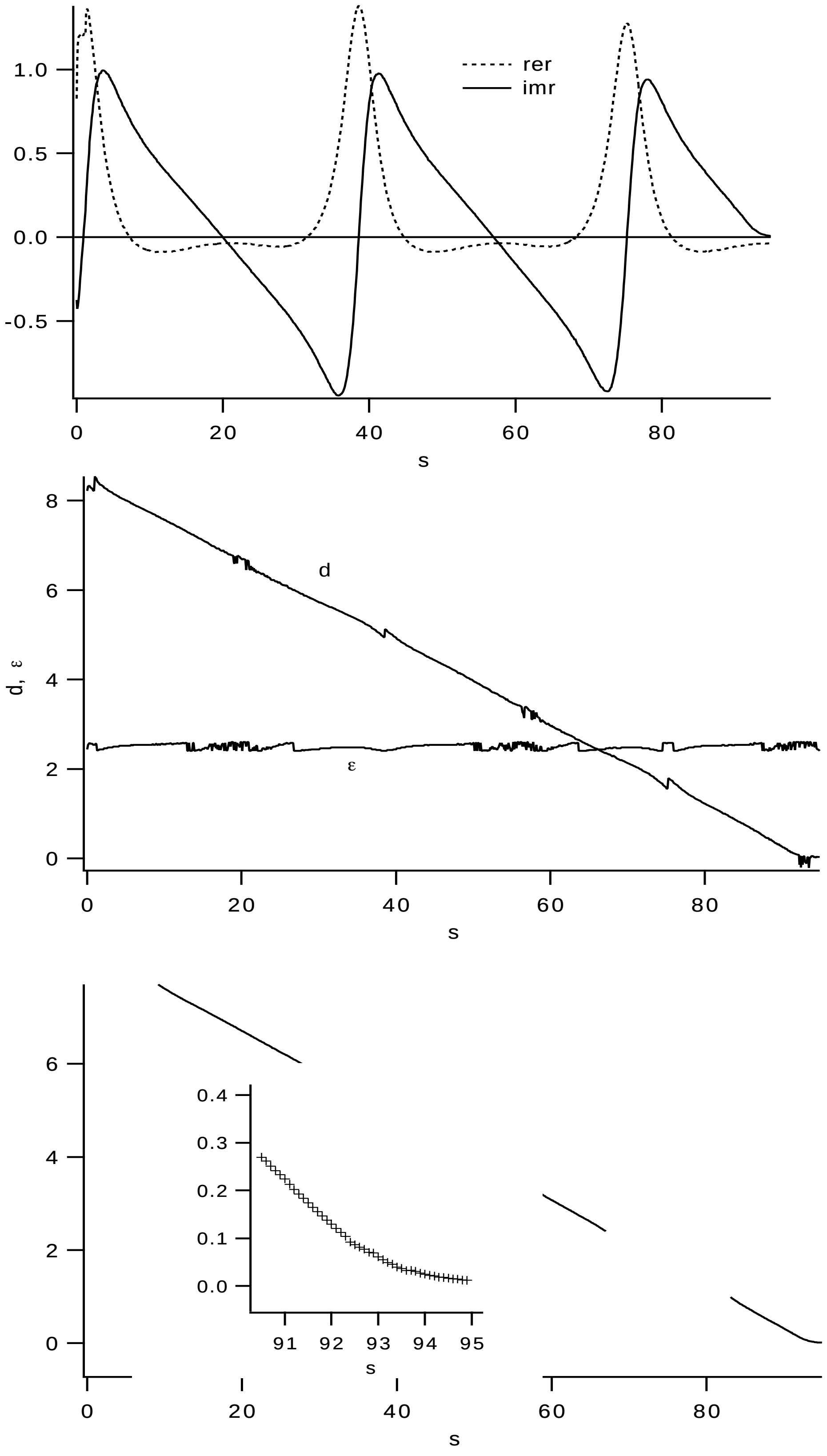
3 Expected variation of x and y as a function of reduced-thickness d for a layer of refractive index 1.58 on silicon in water. Here d = 2π t /λ,where t is the thickness and λ is the wavelength of light. For λ = 633nm, t (nm) ~ 100 d.

Note that y is essentially linear with d up to values of d ~ 0.5. If the measurements are made at the Brewster angle for the bare substrate

$$y \approx \frac{1}{2}\frac{\sqrt{\varepsilon_1 + \varepsilon_2}}{(\varepsilon_1 - \varepsilon_2)}\eta,\ \ \eta = \frac{(\varepsilon - \varepsilon_1)(\varepsilon - \varepsilon_2)}{\varepsilon}d$$

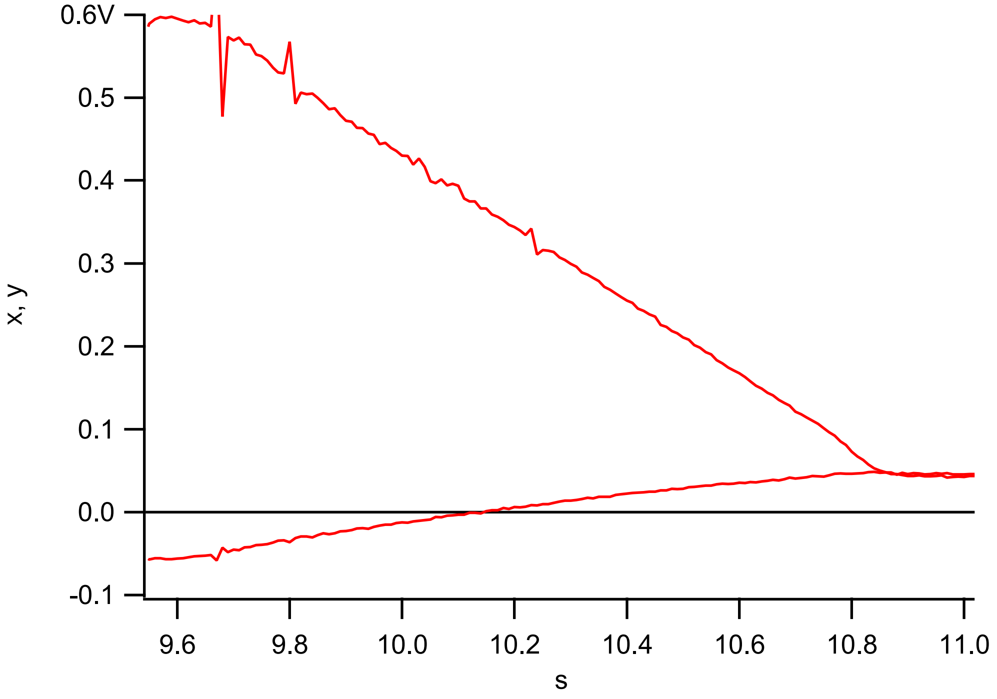
ε, ε_1 and ε_2 are respectively the dielectric constant of the layer, of the ambient medium (water) and of the substrate (silicon). x and y repeat periodically with period D ~ 3.3 (at this angle of incidence).





4 Top, raw data for another thick sample. Middle, ε and d derived by inversion of the data (both parameters allowed to vary). Note that the largest errors in ε and d occur around y ~ x ~ 0. Bottom, d derived from the linear relation between d and y assuming a constant ε set at the average value found from the middle graph. Inset shows the data points. The gaps arise when y and x are both large.

5 x and y for a thin layer, data points 100 per second. Fluctuations at the beginning occur while the solution is settling following filling.



6 Expanded scale at the end to show data variations.