HARRICK SCIENTIFIC PRODUCTS

No. 40227

ANALYSIS OF THIN FILMS ON SI WAFERS BY FT-IR ATR

Figure 1. The GATR Ge-ATR Accessory.

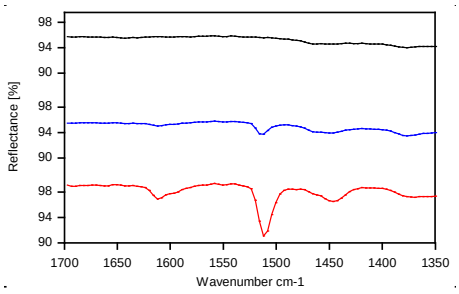

Figure 2. ATR Spectra of Uncoated Si (black), a 16Å Coating on Si (blue), and a 3µm coating on Si (red).

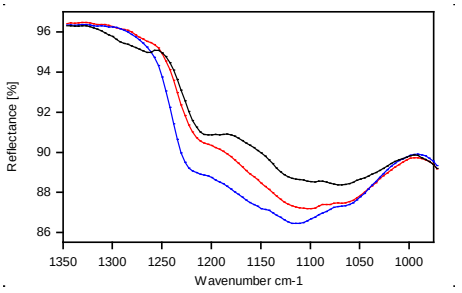

Figure 3. ATR Spectra of a 25Å Coating on Si with 40% (black), 50% (red) and 60% SiO_2 (blue).

INTRODUCTION

The semiconductor industry uses infrared spectroscopy to examine photoresist films, typically 20 microns thick or less, on semiconductor substrates. The most common methods of analysis are transmission spectroscopy and multiple reflection ATR. Transmission spectroscopy is limited by the thickness of the coating and the signal-to-noise ratio of the spectrometer. Hence transmission measurements generally require a large number of scans to extract good quality data from the coated wafers. Multiple reflection ATR is more sensitive but it is destructive, since the wafers are generally cut to fit into the apparatus, and is limited by the ability to obtain good contact between the sample and ATR crystal over the entire length of the crystal.

This application note examines extremely thin photoresist films on silicon substrates and changes in such coatings using the GATR, a single reflection Ge-ATR accessory. This method offers high sensitivity, due to thin-film effects, in addition to the potential to examine the wafers *in tact* with good ATR contact.

EXPERIMENTAL

Two sets of Si wafers were examined – an 18Å photoresist on an 8" diameter silicon wafer and several coated 8" diameter wafers with different concentrations of an additive, SiO_2, in the 25Å coating. Since contaminants readily adhere to these types of samples, each sample set included at least one standard. Both sets included a clean, uncoated silicon wafer that was exposed to the same environmental conditions as the coated wafers. An optically thick photoresist was also prepared as a standard.

The samples were examined using the GATR (Figure 1), a single reflection Ge-ATR accessory with a 65º incident angle, in an FT-IR spectrometer. The spectra were collected with 32 scans at 8 cm^{-1} resolution using a DTGS detector. The samples were placed on the ATR crystal and intimate contact obtained using 56 in-oz of pressure and referenced against the clean ATR crystal. The spectra of the uncoated reference wafers were measured prior to analysis of the coated samples to ensure that the ATR crystal was clean and that the samples were uncontaminated.

RESULTS AND DISCUSSION

In Figure 2, the ATR spectra of the photoresists and its reference are presented. Both coated wafers (middle and bottom spectra) have a peak at 1550 cm^{-1} that is due to the photoresist and does not appear in the spectrum of silicon (top). Note that the band intensity of the 16 Å film is one third that of the 3 µm film. This sensitivity to the thin film is due to interaction of the evanescent wave with the silicon substrate[1,2,3].

[1] M. Milosevic, S. L. Berets, and Y. Fadeev, *Appl. Spectros.*, 57 (6), 4724 (2003).

applications note

Figure 3 shows the ATR spectra of three 25Å coatings on silicon wafers. The coatings have different concentrations of SiO_2, which can be readily discerned from the band in the 1100 cm^{-1} to 1200 cm^{-1} region. The band intensities increase with greater SiO_2 concentration, as expected.

SUMMARY

Extremely thin photoresists and other coatings on silicon are readily detected by the GATR Ge single reflection ATR accessory. These measurements can be used to extract both quantitative and qualitative information about the coating.

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[2] J.E. Olsen and F. Shimura, *Appl. Phys. Lett.*, **53**, 1934 (1988).
[3] J.E. Olsen and F. Shimura, J. *Appl. Phys.*, **66**, 1353 (1989).

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