

Measurements of thin films on a metal substrate using reflection infrared devices

The semiconductor industry has lost none of its research drive over recent years, and this research has resulted in the TVs, PCs and other familiar devices that surround us. A non-contact, non-destructive, and non-vacuum technology is required to evaluate these semiconductors. As Fourier transform infrared spectrophotometry (FTIR) uses light, it is one analysis

technique that can meet these conditions and it offers the additional benefit of extremely simple operation. This Application News describes the application of FTIR to the quantitative analysis of a fluoro-resin coating on a hard disk and to the film thickness measurement for the epitaxial layer on a silicon wafer.

■ Quantitative analysis of fluoro-resin on a hard disk

A fluoro-resin coating is applied to the surfaces of computer hard disks as a lubricant. Reflectance absorbance spectroscopy (RAS) is an effective means of measuring the thickness of fluoro-resin film coatings. A reflection infrared device with a large angle of incidence is normally used to measure thin films on a metal plate. A RAS device with an angle of incidence of at least 70° is able to measure film thicknesses of 1.0µm, or below.

Even thinner films, in the order of several nanometers thick, can be measured using a combination of the RAS device with a polarizer to measure the parallel-polarized component only.

Fig. 1 shows the spectra of the fluoro-resin hard-disk coatings measured with an RAS device (70° angle of incidence) and a polarizer. The film thicknesses of the various samples were 11.8, 25.4, 41.0, and 48.8Å. The measurement conditions are listed in Table 1.

Fig. 2 shows the calibration curve generated using the peak area near 1300cm⁻¹ in Fig. 1. This result permits quantitative analysis of the fluoro-resin film thickness on a hard disk.

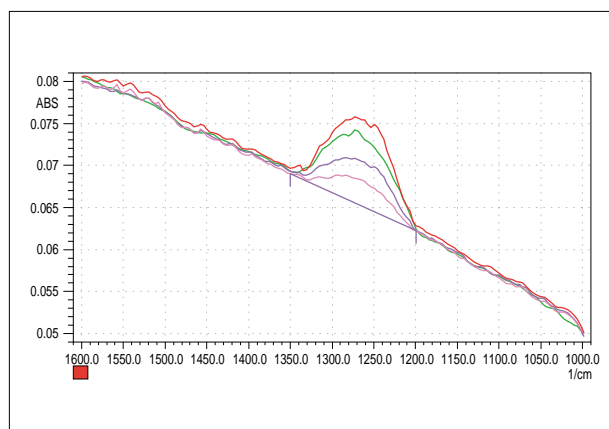


Fig.1 FTIR spectra of fluoro-resin coating on a hard disk

Table 1 Measurement conditions

Resolution	: 8.0cm ⁻¹
Accumulation	: 300times
Detector	: DLATGS
Mode	: Reflection

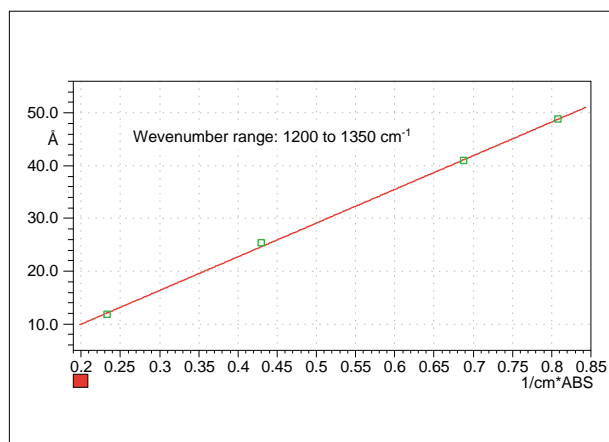


Fig.2 Calibration curve for fluoro-resin on a hard disk

■ Film thickness measurement of epitaxial layer on a silicon wafer

Various methods are available for measuring the thickness of thin films. As described above, FTIR methods are effective non-contact and non-destructive methods. Using the expression below, the film thickness can be calculated from the interference spectrum obtained by FTIR:

$$d = \frac{\Delta m}{2\sqrt{n^2 - \sin^2\theta}} \cdot \frac{1}{\left(\frac{1}{V_1} - \frac{1}{V_2}\right)}$$

Where, n is the refractive index, θ is the angle of incidence to the sample, Δm is the number of peaks or troughs in the calculated wavenumber region, and V_1 and V_2 are the maximum and minimum values of the wavenumber region.

Fig. 3 shows the spectrum measured with the specular reflectance microspectrophotometry (SRM) on an epitaxially grown layer of approximately $7.0\mu\text{m}$ thickness on a silicon wafer. The measurement conditions are shown in the Table 2.

When calculating the film thickness from this spectrum using the film-thickness calculation functions in the Hyper IR software quantitative analysis mode, the wavenumber range is designated with the cursor at first (vertical lines in Fig. 3).

Next, the dialog box shown in Fig. 4 prompts for the refractive index. In this example, the epitaxial layer is calculated at a refractive index of 3.41. The expression relating the interference fringes appearing in this spectrum to the film thickness yielded a film thickness value of $7.28\mu\text{m}$. (This value is displayed on the report screen, as shown in Fig. 5.) This indicates that the FTIR method produced satisfactory results.

FTIR is able to rapidly and simply evaluate semiconductor materials. Evaluation technologies based on FTIR will become increasingly indispensable as the semiconductor industry further develops in the future.

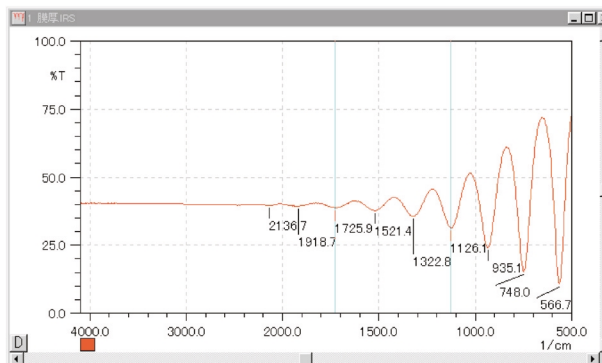


Fig.3 FTIR spectrum of epitaxial layer on a silicon wafer

Table 2 Measurement conditions

Resolution	: 4.0 cm^{-1}
Accumulation	: 60times
Detector	: DLATGS
Mode	: Reflection

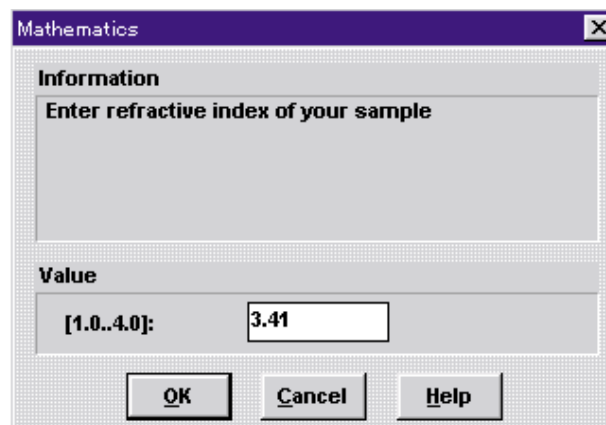


Fig.4 Dialog box to input the refractive index

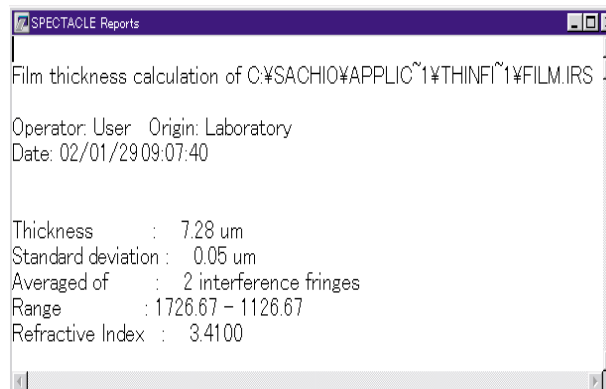


Fig.5 Results calculated by the film-thickness calculation software