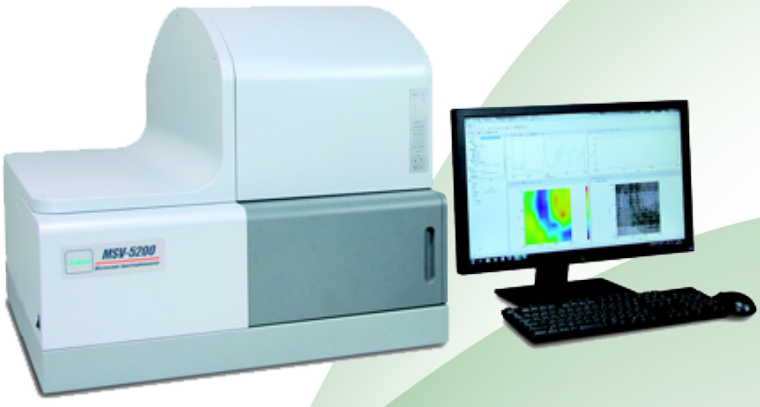
Application Note

Thickness Analysis of a Natural Oxide Film on a Microscopic Si Pattern

Introduction

The MSV-5000 series micro-spectrophotometer is designed to obtain transmission/reflection measurements over a wide wavelength range from the ultraviolet to the near-infrared wavelengths. It allows the measurement of an area as small as 10 µm diameter and the integrated high-resolution CCD video camera enables visual observation of the samples to determine the precise area to be measured. This instrument is suitable for measurement of micro samples or samples with microstructural features. In this example, a sample with Si patterns of 35 µm widths aligned upon a Ti substrate with 14 µm intervals was examined. The thickness of the SiO_2 layer on the Si features was analyzed from the obtained reflectance spectrum, as Si is easily oxidized in the air to form a thin oxide film of SiO_2.



MSV-5000

Keyword: microscope, silicon, absolute reflectance

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Measurement System

MSV-5200	Microscopic spectrophotometer (micro-spectrophotometer)
VWML-791	[Multi-Layer Analysis] program
Mixer:	X-LC 3180MX

Measurement Conditions:

UV/Vis spectral bandwidth:	5.0 nm
Scan speed:	100 nm/min
Data interval:	0.5 nm
Incidence angle:	23°
IN aperture:	10 µmf
NIR spectral bandwidth:	20.0 nm
Cassegrain objective mirror:	16X
Injection volume:	1 µL
OUT aperture	10 µmf

Measurements

1. FiBaseline: an Al vapor-deposited mirror is used for baseline measurement.

2. Measurement area: the sample is observed by the high-resolution camera to determine the measurement area (Fig. 1). The red spot in Fig. 1 shows the size and position of the source illumination.

3. Sample measurement: the reflectance spectrum was measured.

4. Transforming into absolute reflectance: the absolute reflectance spectrum of the sample is calculated by multiplying the obtained relative reflectance spectrum of the sample by the absolute reflectance spectrum of an Al vapor-deposited mirror.

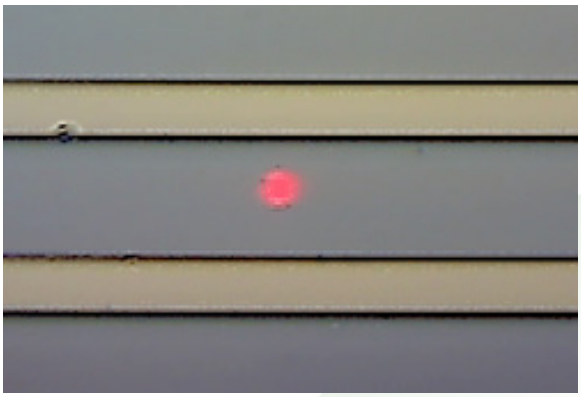

Fig. 1. Observation figure of measurement position

Analysis

The reflectance (R) is expressed by the equation of the refractive index of the film (ni), the extinction coefficient (ki), the angle of incidence (qi), wavelength (l) and the film thickness (di). The optical constants of the Si and SiO2 are used from the literature values and then the film thickness of the SiO2 layer is estimated by using the [Multi-Layer Analysis] program by fitting the calculated reflectance spectrum obtained by the program to the measured sample spectrum.

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Measurement Results

The measured absolute reflectance spectrum is shown in Fig. 2. the MSV-5000 series utilizes a confocal optical system, which obtains the sample measurement while eliminating the influence of any back or side reflections. In the range over 1100 nm, where the light passes through the Si, the spectrum is not influenced by the back or side reflections.

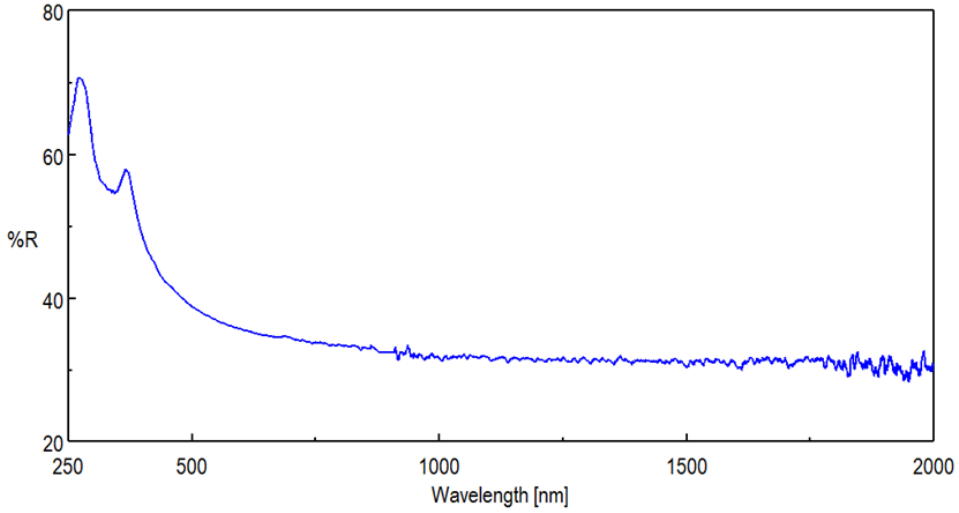

Fig. 2. Absolute reflectance spectrum of sample

Analysis Results

The result of fitting the reflectance spectrum using the [Multi-Layer Analysis] program is shown in Fig. 3. The error between the measured spectrum and the calculated spectrum was within 2% (Fig. 3) and the film thickness of the SiO2 was calculated to be 7.6 nm.

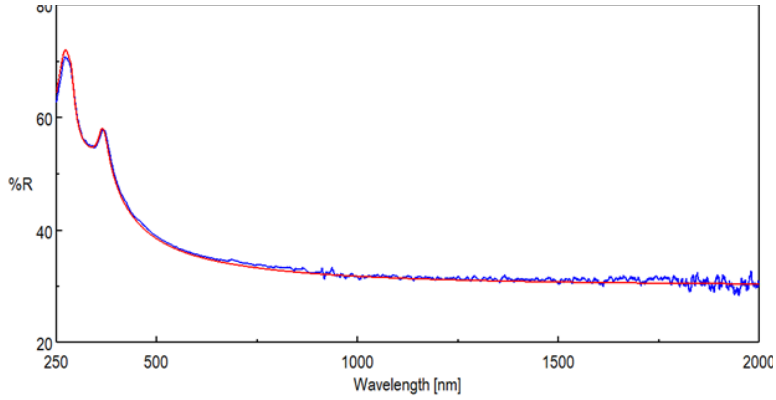

Fig. 3. Fitting result of the reflectance spectra

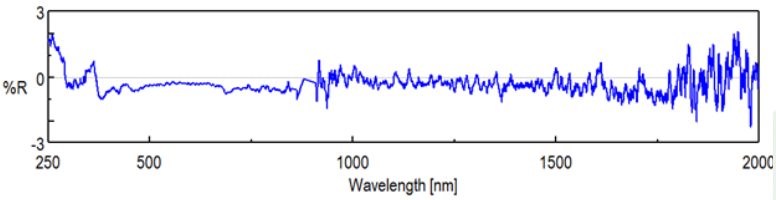

Fig. 4. Error between measured and calculated spectra

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