

## Thickness Analysis of natural oxide film on microscopic Si pattern

### Introduction

The MSV-5000 series microscopic spectrophotometer is for transmission/reflection measurement in a wide wavelength range from ultraviolet to near-infrared. It allows the measurement of the area of as small as 10  $\mu\text{m}$  diameter and the built-in high-resolution camera enables to observe the samples precisely to determine the area to be measured. This instrument is most suitable to measure the minute samples or samples having microstructure. This time, the sample on which Si patterns of 35  $\mu\text{m}$  widths are lined up on Ti substrate with 14  $\mu\text{m}$  intervals was measured as a microstructure sample. Actually, the thickness of  $\text{SiO}_2$  formed upon Si was analyzed from the obtained reflectance spectrum, because Si is easily oxidized in the air to form thin oxide film of  $\text{SiO}_2$ .

**Keywords:** microscope, silicon, absolute reflectance

### Measurement System

MSV-5200      Microscopic spectrophotometer  
 VWML-791    [Multi-Layer Analysis] program

**Sample:** Si and Si oxide film on the Ti substrate

### Measurement condition

UV/Vis spectral bandwidth:	5.0 nm	NIR spectral bandwidth:	20.0 nm
Scan speed:	100 nm/min	Response:	Slow
Data interval:	0.5 nm	Cassegrain objective mirror:	16x
Incidence angle:	23°		
IN aperture:	10 $\mu\text{m}\phi$	OUT aperture:	10 $\mu\text{m}\phi$

### Measurement

1. Baseline: Al vapor-deposited mirror as a reference 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 detected light.
3. Sample measurement: The reflectance spectrum is measured.
4. Transforming into absolute reflectance: The absolute reflectance spectrum of the sample is calculated by multiplying the obtained relative reflectance by the absolute reflectance of Al vapor-deposited mirror.

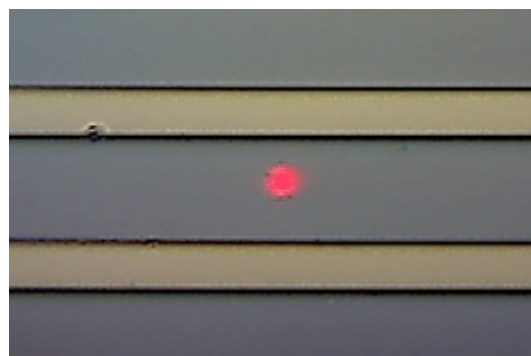


Fig. 1. Observation figure of measurement position

### Analysis

Reflectance(R) is expressed by the equation of refractive index of the film ( $n_f$ ), extinction coefficient ( $k_f$ ), the angle of incidence ( $\theta_i$ ), wavelength ( $\lambda$ ) and the film thickness ( $d_f$ ). This time, optical constants of Si and  $\text{SiO}_2$  are used from the literature value. and then the film thickness of  $\text{SiO}_2$  is estimated by using [Multi-Layer Analysis] program by fitting the calculated reflectance spectrum to the measured one to make the thickness value reasonable.

## Measurement Results

Measured absolute reflectance spectrum is shown in Fig. 2. MSV-5000 series adopts the confocal optical system, which enables the measurement eliminating the influence of back side reflection. In the range over 1100 nm where the light passes through Si, the spectrum would not be influenced by the back side reflection.

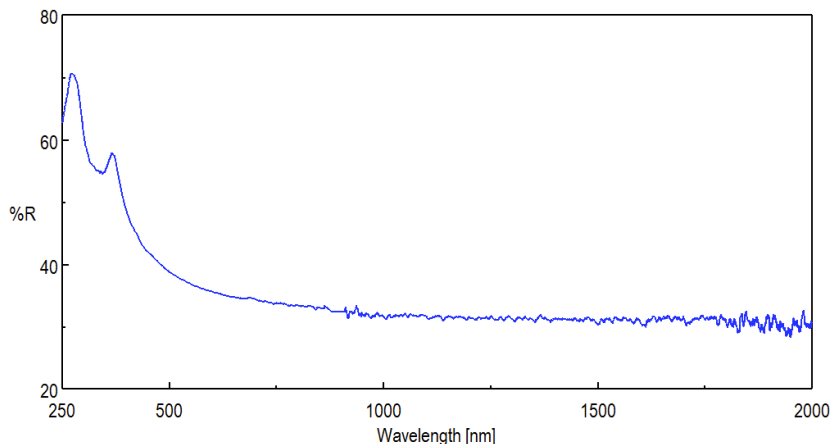


Fig. 2. Absolute reflectance spectrum of sample

## Analysis Results

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

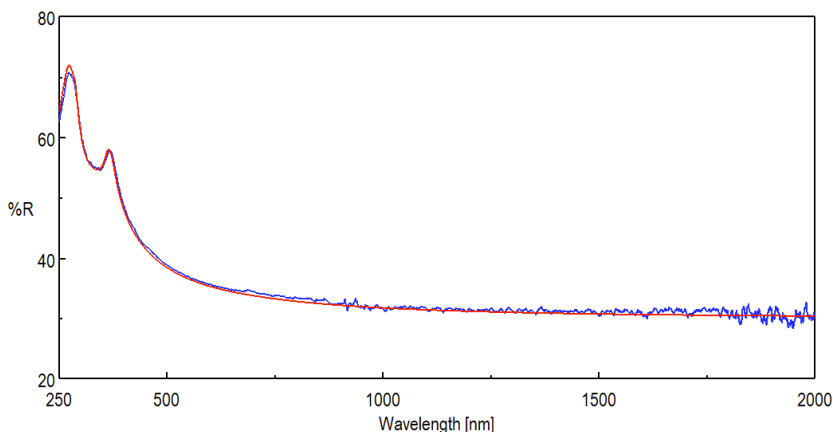


Fig. 3. Fitting result of reflectance spectra

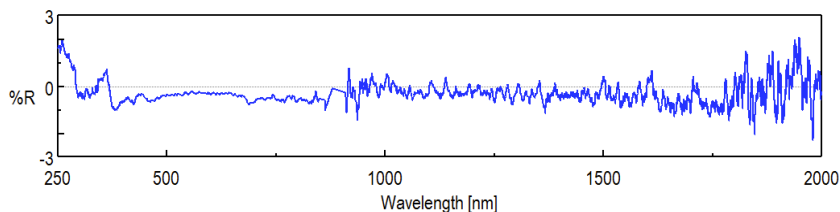


Fig. 4. The error between measured spectrum and calculated one