Application Brief

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SMI no.8 Thickness Control Software

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1. Introduction

The demands for thinner TEM samples with minimal damage have increased in recent years. Target thickness is now 50 nm or less and specialized thickness control technology is required to meet these requirements. This brief provides an overview and an application of thickness control software (patent pending) that can minimize variation in the thickness of TEM samples.

2. Principles of the Film Thickness Control Software

The film thickness control of TEM samples is achieved by SEM observation of cross-sections during FIB processing.

When an electron beam irradiates a sample surface, mainly secondary electrons and backscattered electrons are produced from the surface as signal electrons. The signal intensity of these electrons is dependent on the thickness of the measurement sample. Figure 1 shows simulation results of the backscattered electron signal at different sample film thicknesses.

The backscattered electron intensity does not change until film thickness is reduced to approximately 200 nm. Below this value, the intensity rapidly decreases. This is due to the maximum depth of backscattered electrons. (When the acceleration voltage is 7 kV, the maximum depth of the electrons scattered from the sample is approximately 200 nm). When the measurement sample is thicker than this depth, the backscattered electron signal is constant. When the film is thinner than this depth, the production of backscattered electrons is reduced, which reduces the signal volume.

Monitoring the backscattered electron intensity produces stable thickness measurements because the signal volume of backscattered electrons is less influenced by surface conditions than that of secondary electrons.

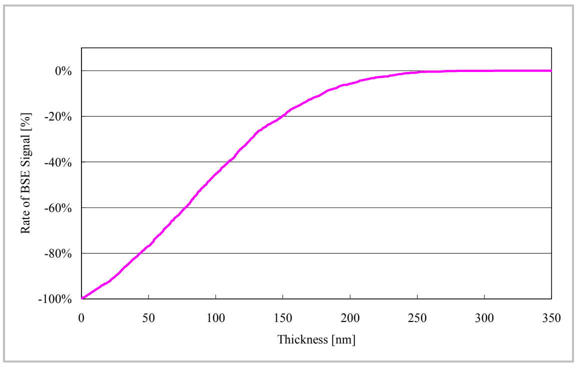

Figure 1 – Simulation of Changes in Backscattered Electron Intensity by Film Thickness

SEM Acceleration Voltage: 7 kV

3. Overview of the film thickness control software

Figure 2 shows the setting window of the thickness control software.

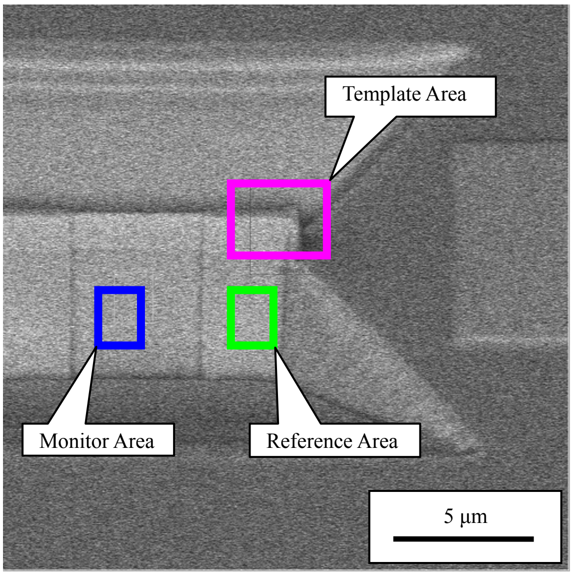

Figure 2 – Thickness control function

Thickness control is achieved through automatic SEM observation of cross-sections during the finishing of TEM samples. The SEM observation interval can be set by FIB feed amount or by time. For the film thickness measurement, an area to monitor film thickness (Monitor Area) and a sufficiently thick reference area (Reference Area) are set in the FIB processing area. Their ratio is acquired to measure the rate of change in backscattered electron intensity versus an infinite thickness. The end of processing can be detected by setting the rate of change of the backscattered electron intensity for the target film thickness. When the target film thickness is reached, processing stops automatically. Furthermore, pattern matching of the Template Area corrects shifts in observation positions caused by drift and other problems.

4. Repeatability of Film Thickness

The repeatability of the film thickness produced by the control software was measured. Target thicknesses of 175 nm (BSE -10%), 145 nm (BSE -20%) and 123 nm (BSE -30%) were used, based on the simulation results in Figure 1. Ten TEM samples were created for each condition and the thicknesses of the samples were measured for variations.

The film thicknesses were measured by FIB observation of the TEM sample cross-section. Figure 3 and Table 1 show the film thickness results.

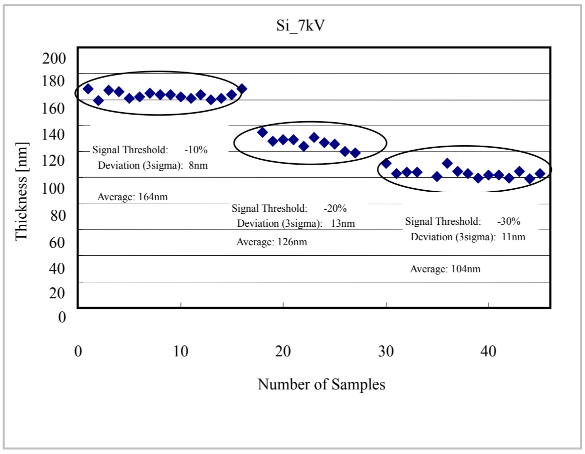

Figure 3 – Film Thickness Results

Table 1 – Film Thickness Results

Target	Film thickness	175 nm	145 nm	123 nm
	Change rate	-10%	-20%	-30%
Results	Avg.	164 nm	126 nm	104 nm
	3σ	8 nm	13 nm	11 nm

In all conditions, the variation of the 10 samples was about 10 nm. Adjusting the signal change rate for the end of processing can correct the difference between the average and target thickness values. These results confirm that the thickness control function can control TEM sample thickness within ±10 nm.

5. Conclusion

Film thickness can be controlled by monitoring the intensity of the backscattered electron signal during sample preparation and TEM sample thickness can be controlled within ±10 nm.