Analysis of Interface Condition between BARC and Resist Film by FT-IR/ATR

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Adhesion property of an ArF resist pattern formed on bottom anti-reflection coating (BARC) is considered to be sensitive to its interface condition. We examine the interface properties by Fourier transform infrared spectroscopy (FT-IR) attenuated total reflection (ATR) technique. As a result, a sample which was treated with a primer such as HMDS mixture indicates specific spectrums. This result gives an important suggestion that an intermediate layer between the BARC layer and the ArF resist would be formed by the primer treatment. This intermediate layer would act as a factor of the adhesion property.

Keyword: BARC, primer, resist, ArF, Intermediate layer, FT-IR, ATR, HMDS

1. Introduction

As shortening wavelength of exposure source for miniaturizing resist patterns, it is well known that a resist pattern shape is greatly distorted by a substrate reflection light. In this regard, bottom anti-reflection coating (BARC) is effective to prevent the pattern shape distortion.[1] Meanwhile, improvement of adhesion property of resist patterns formed on BARC materials has been recognized as one important problem that needs to be solved in nano-scale device fabrication. The adhesion property of resist patterns will be affected by the surface condition on the BARC layer. In this study, we try to analyze a boundary condition between a resist material and a BARC material by Fourier transform infrared spectroscopy (FT-IR) attenuated total reflection (ATR). The FT-IR/ATR technique provides some effective information on both a surface and near surface regions [2].

2. Experiment

2.1. Sample preparation

Three kinds of test structure were prepared as shown in Fig.1. In all samples, a BARC material was coated on a Si(100) wafer by spin-coating method. A hard-baking treatment was carried out at 215°C for 60 sec. In the case of the sample (1), there is no substance on the BARC layer. In the sample (2), an ArF resist was coated on the BARC layer. Then, a baking treatment was carried out at 130°C for 90 sec for the sample (2). For the sample (3),

Fig.1. Cross-sectional structures of samples for FT-IR/ATR analysis.

the BARC surface was primed by a HMDS mixture. Then, the ArF resist was coated on the sample and baked at 130°C for 90 sec.

2.2. FT-IR/ATR measurement with Ge prism

Infrared spectra were recorded by the Jasco FT/IR-410 spectrometer (wave number resolution: 4 cm⁻¹). Sample setup is illustrated in Fig.2. The ATR infrared spectroscopy was used for the experiment. The surfaces of samples were examined by placing the wafer face on a Ge (45°) ATR crystal (52 x 20 x 2 mm). An incident angle of infrared beam was controlled to be normal to the Ge ATR crystal bevel surface. The Ge ATR crystal was designed to satisfy the total internal reflection condition. The Ge ATR crystal geometry provided about 24 internal reflections at incident angle of 45°. And scanning number was set to 20000 times for the all samples. The scan speed of the interferometer was 4mm/sec. The penetration depth of the infrared beam can be calculated as the following equation:

$$d_p = \frac{\lambda}{2\pi(\sin^2 \theta - n_2^2/n_1^2)^{1/2}}, \quad (1)$$

where d_p is the penetration depth of the infrared beam, θ is the incident angle, λ is the wavelength of the infrared beam, and n_1 and n_2 are refraction index of the ATR crystal and the sample, respectively.[2] In this experiment, assuming the refractive index of the samples is about 1.0~2.0, the penetration depth is calculated to be 0.1~1.0μm which is enough depth to analyze the sample. All the experiments were conducted at room temperature in air.

3. Detection of intermediate layer by FT-IR/ATR method

Figure 3 shows the infrared spectra in the range of 2500-3000 cm⁻¹ obtained from the samples as shown in Fig.1. In the spectrum of the sample (3), two absorption bands related to CH₂ and CH₃ groups are observed at 2848 cm⁻¹ and 2915 cm⁻¹. [3] These absorption bands couldn't be observed in the spectra of the samples (1) and (2). Thus, these absorption bands probably relate to an intermediate layer which is formed between the BARC and the ArF resist layers. This

Fig.2. Setup of FT-IR/ATR measurement system. The samples were examined by placing the wafer on the Ge ATR crystal.

Fig.3. ATR spectra of the samples. The number at each chart corresponds to that in Fig.1.

layer would affect to the adhesion property of the resist pattern.

4. Conclusion

The interface condition between the BARC and the ArF resist film was analyzed by FT-IR/ATR technique on the point of HMDS primer treatment. It was found that the sample treated with the HMDS mixture shows the different spectrum from the reference samples. This result gives an important suggestion that the intermediate layer between the BARC and the ArF resist would be formed by the primer treatment. This intermediate layer would affect the adhesion property of the resist pattern formed on the BARC materials.

References

1. J. L. Lenhart, D. Fischer, S. Sambasivan, E. K. Lin, W. Wu, D. J. Guerrero, Y. Wang, R. Puligadda, *Applied Surface Science*, **253** (2007) 4166.
2. M. Tasumi and M. Ozawa, "FT-IR no kiso to jissai", Tokyo-kagaku-doujin, (1994) P.79 (in Japanese).
3. S. Manako, Y. Ochiai, J. Fujita, N. Samoto, S. Matsui, *Jpn. J. Appl. Phys.*, **33** (1994) 6993.