Internal Stress of Dry Film Resist in Multilayer Structure

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Multilayer resist process has been recognized as one candidate to realize high aspect ratio resist pattern. As one important control factor, strain and stress matching in multilayer structure should be taken into consideration. By using a strain gauge, the strain of dry film resist (DFR) in single, double and triple layer structure are measured as a function exposing time. The strain of DFR increases in proportion with the exposure dose but slightly decrease as number of multilayer. The stability of DFR multilayer structure is discussed.

Keywords: multilayer structure, DFR, strain, internal stress, strain gauge

1. Introduction

It is well known that the internal stress of resist film causes pattern peel or wet etching failure. [1-3] The precise control of internal stress in resist system is required. In this regard, recently, multilayer resist process has been recognized as one important control factor as one candidate to realize high aspect ratio resist pattern. In this case, strain and stress matching in multilayer structure should be taken into consideration. In this study, by using a strain gauge, the strain of dry film resist (DFR) in single, double and triple layer structure is measured as a function exposing time.

2. Experiment

2.1 Sample preparation

The negative type of DFR (NCP325 Nippon Synthetic Chemical Industry Co., Ltd.) was laminated onto 6-inch Si wafer by a rubber roller system. The laminating rate of the roller system was 0.4m/min and laminating temperature was 110°C. The single, double and triple layered samples were formed on the Si wafer as shown in Fig.1. The thickness of each structure was 45, 98 and 141 micro meters. After the lamination, the strain of the samples was measured as a function of UV exposure dose to all area.

![Fig.1. Schematic diagrams of multilayer structure of DFR.](image)

2.2 Strain measurement system

The internal strain and stress of the multilayer DFR was measured with the strain measurement system as shown in Fig.2. The deflection of the wafer back size can be detected using the optical system. Half of the fiber in the probe transmits light from halogen lamp and half receives light which is sent to the photodiode detector.

The internal stress $\sigma$ of the resist layer was calculated by Eq.1

$$\sigma = \frac{d}{\left(\frac{d}{2}\right)^2} \cdot \frac{E_S}{3(1-\nu)} \cdot \frac{T_s^2}{T_f} \quad [\text{Pa}], \quad (1)$$
where \( d \) is strain of wafer, \( D \) is diameter of stand edge, \( E_S \) is Young’s modulus and \( \nu \) is Poisson’s ratio of the Si[100] direction, \( T_S \) is wafer thickness and \( T_F \) is total thickness of the multilayer. The measurement method is described in detail in the previous report.[1]

3. Results and Discussion

Figure 3 shows the strain increase as the exposure dose increase. As increasing the exposure dose, it is found that the tensile strain of all samples increases in proportion. (The minus values of deflection indicates tensile strain) For the single-layer DFR, the increasing rate of strain is relatively large among the multilayer samples, and the tensile strain reaches saturation about 4.5 \( \mu \)m. For the double-layer DFR, the strain reaches saturation about 7.5 \( \mu \)m for the double DFR and about 11 \( \mu \)m for the triple DFR. The exposure dose for strain saturation is almost proportional to number of laminating layer.

Figure 4 shows the internal stress of the multilayer DFR structure calculated by Eq.1 with the strain data in Fig.3. It is clearly observed that the internal stress in multilayer DFR structure becomes lower as increasing of number of laminating.

In general, it is recognized the larger internal stress becomes the factor of adhesion failure because resist-substrate interface has a larger strain. In this study, the tensile strain becomes large as increasing number of lamination as shown in Fig.3. Therefore, the exposure dose and laminating structure of DFR are important.

4. Conclusion

We discussed the internal strain and stress in DFR multilayer structure as a function of exposure dose. The Si wafer laminated with the multilayer DFR was deformed due to the internal stress. The strain of DFR sample becomes larger as a number of lamination increases. It can be considered that the internal stress should concentrate at a weak area of interface bonding. Therefore, in order to prevent adhesion failure of resist pattern, strain and internal stress should be controlled at lower level by strain monitoring system as demonstrated in this study.

Acknowledgement

The present work was partially supported by Grant-In-Aid Scientific Research from Japan Society for the Promotion of Science. (Scientific Research (B) 19360157).

References