Peeling Analysis of ArF Resist Pattern on BARC by using AFM

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1. Introduction

With further miniaturizing of a resist pattern, light wavelength for image exposure has become short. It is well known that standing wave effect is influence to sidewall flatness of a resist pattern. Therefore, bottom anti-reflective coating (BARC) has been employed to decrease the standing wave effect. Recently, adhesion of a resist pattern on a BARC layer is one of important factors for the fabrication of high quality resist pattern.[1] In this regard, direct peeling method with an AFM Tip (DPAT) is recognized as an useful technique for evaluate the adhesion of a resist pattern on a BARC layer.[2] When a resist pattern is collapsed with an AFM tip, destruction mode is classified into two modes: (1) interface separation between a resist pattern and a BARC layer, (2) cohesion destruction of a resist pattern. In this paper, we discuss the peeling processes of a resist pattern based on displacement signals of the AFM system.

2. Experiment

2.1 Sample preparation

The ArF excimer resist consisting of acrylic resin as a base polymer was used. The pattern width, length and height were 100, 700 and 200nm. Two kinds of BARC materials (A, B) consisting of acrylic resin were used. The thickness of the BARC layers after the hard baking at 205°C was 80-100nm. A commercially available AFM, integrated with a microcantilever tip, was used for the DPAT

investigation. The curvature radius of tip apex was approximately 8nm. The spring constant of the cantilever was 0.651N/m. The applied force F to the resist pattern is determined by multiplying the measured cantilever displacement by the calibrated spring constant of the cantilever.

2.2 DPAT method

The resist pattern adhesion was measured in dry air (relative humidity less than 5%). The experimental setup is shown in Fig.1. The applied force F can be estimated with the cantilever displacement. The cantilever deformation is divided into the factors, bending and distortion. The deformation of the cantilever was monitored by the four divided photo detector.

Fig.1 Schematic explanation of the DPAT method.

3. Results and Discussion

Figure 2 shows the AFM images of the resist pattern. The images, especially Figs.2a and 2b, show the pattern collapse clearly. In Fig.2a, the resist pattern was collapsed at the interface between the resist pattern and the BARC when the applied force was 50.1nN. In contrast, in Fig.2b, the residue of the resist pattern remains on the initial position when the applied force was 45.9nN. In Fig.2c, the resist pattern couldn't be collapsed. These destruction modes can be monitored simultaneously with the load signals. Figure 3a shows the displacement signals for the interface separation. (1):The resist pattern was deformed by the AFM tip, (2):The tip contacted on the BARC, (3):The tip run upon the collapsed resist pattern. Figure 3b shows the cohesion destruction. (1):The resist pattern was deformed by the AFM tip, (2):The tip moved along the residue surface, (3):The tip run upon the collapsed resist pattern. Figure 3c shows the failure to collapse. Thus, no signal was detected. The destruction difference among three cases can be explained by the cohesion of resist pattern. In Fig.3a, the resist pattern cohesion is higher than the resist pattern adhesion. In Fig.3b, the resist pattern cohesion is lower than the adhesion. The cohesion can be estimated with a slope of the displacement curve.

Fig.2 AFM images of resist pattern before (left) and after (right) of pattern peeling by using AFM tip. The white triangle in right image indicates the AFM tip position after the peeling.

(a) Interface separation at resist/BARC

(b) Cohesion destruction of resist pattern

(c) Peeling failure (No pattern peel)

Fig.3 Bending and distortion signals of the cantilever displacement.

4. Conclusion

We have analyzed the peeling process of the resist pattern formed on the BARC by using AFM. The difference between interface separation and cohesion destruction is determined by displacement signals during pattern peeling. The displacement monitoring will be useful to analyze the pattern peel.

References

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