Novel template releasing process by multi-axis controlled systems in nanoimprint lithography

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Introduction

Template releasing process is one of the most important processes in nanoimprint lithography, because resists ware fractured or peeled off due to mechanical stress induced at the template releasing. To eliminate the defects, chemical or mechanical approaches had been reported such as anti-sticking layer coating by fluorine layers oe ultra sonic releasing[1)]. However, few reports have been published to investigate how to release the template in mechanical ways[2)]. We had been reported on evaluation of surface energy between resist and template in various releasing modes[3)]. In this paper, we newly propose 3-axis controlled dynamic releasing mode and investigate the releasing energy and defect yields.

Experiment

Figure 1 shows schematics of the template releasing modes. In the peeling mode, the template is lifted up by one side as shown in Fig.1 a). The line orientation is also modulated against a peeling direction. In the lift off mode, the template is lifted perpendicularly using three rods and the template is removed in normal direction to the resist surface as shown in Fig.1 b). In the screw mode, the rods are alternately push up the template as illustrated in Fig.1 c). The resist is NITC 702 (Daisel Co.) and the pattern is 2.0 um line & space. The aspect ratio of the patterns is modified.

Results and discussions

Figure 2 shows the energy consumption in template releasing process. The energy is extracted based on classical fracture theory[4)] by observing crack propagation between template and resist observed by high speed camera. The line orientation to template peeling direction such as normal and parallel are examined. The releasing energy of the screw mode is middle of the normal and parallel peeling.

Defect ratio after template releasing is evaluated for each mode. The defect ratio is defined as a ratio of number of defected lines versus imprinted lines in randomly extracted area. Figure 3 shows the relation between defect ratio and aspect ratio of the pattern in various releasing modes. At lower aspect ratio of the pattern, defect ratio of the parallel peeling and the screw releasing are almost the same, nevertheless the normal peeling is hevely defected because the normal stress to the pattern side wall induces pattern. The defect ratio in lift off mode is larger than others due to strong stretching stress. The defect ratio increases as the aspect ratio of the pattern increases because both stretching stress and lateral stress increases. The screw mode is effective to eliminate releasing defects for voluntary layout patterns with low aspect ratio like VLSI, even if the pattern is scaled down to nano scale because mechanical situation is almost the same in micro scale releasing.

References

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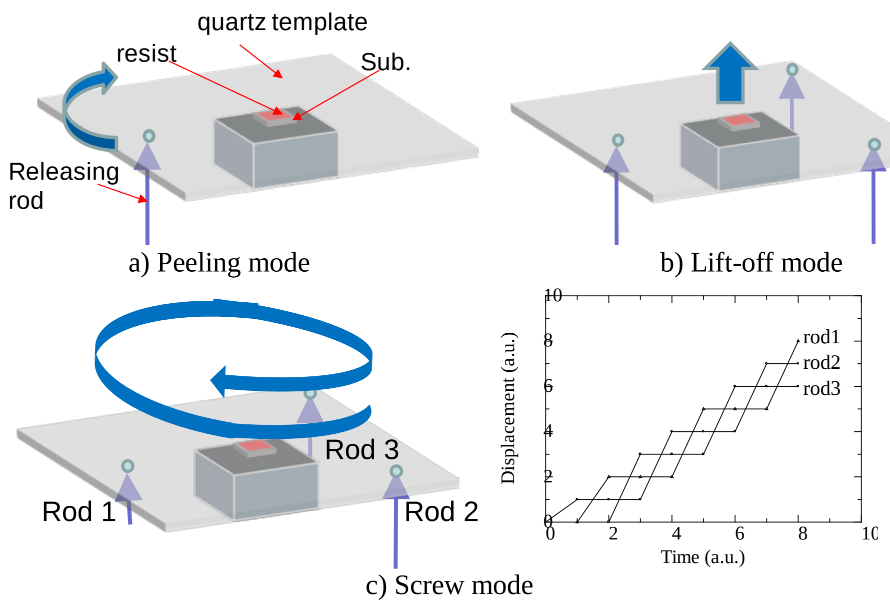

Fig.1. Schematics of releasing modes using multi axis controlled template releasing system.

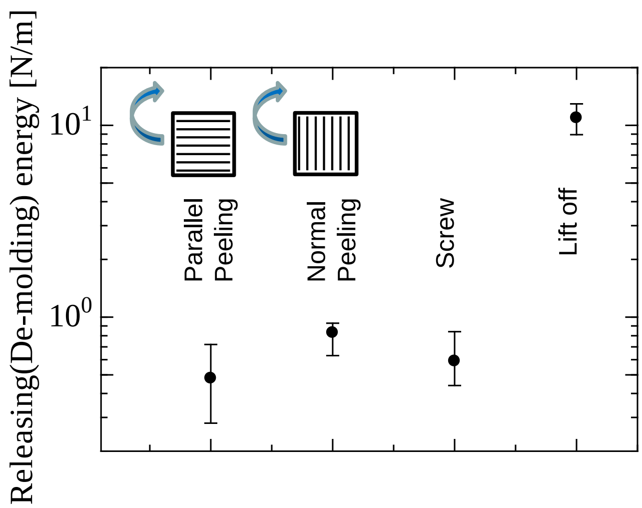

Fig.2 Template relesing energy in various releasing modes. (Aspect ratio=1.0, 2.0um Line & Space)

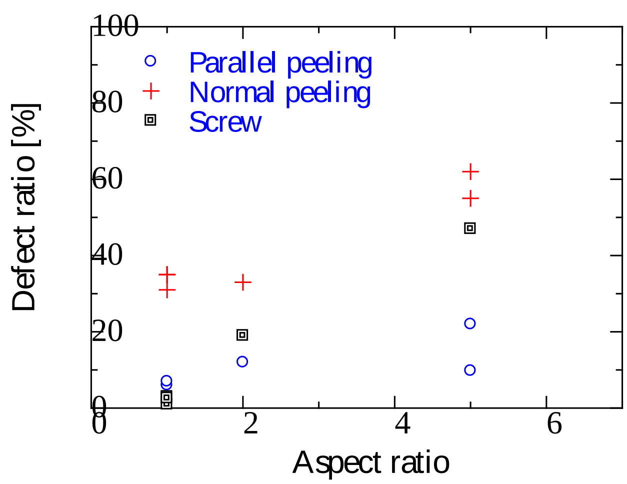

Fig.3 Defect ratios in various releasing modes.(2.0 um Line & Space)