High aspect ratio fine pattern transfer using novel mold by nanoimprint lithography

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Introduction

Nano size patterns around 10 nm will be required in near future. Nano-imprint lithography (NIL) is one of the most powerful candidates to fabricate such tiny patterns. In this report, Si mold with very fine trench pattern is fabricated by use of new edge lithography process [1] and its pattern is transferred to PMMA film on Si wafer by thermal NIL.

Experiment

Mold fabrication process is shown in Fig.1. (a) Initial Si patterns are fabricated by the advanced Bosch process [2]. (b) The patterned Si wafer is oxidized in wet oxygen ambient at 900 ºC. The SiO_2 film except the side wall is removed by CHF_3 plasma. (c) The initial pattern bottom is covered by photo-resist. (d) The initial pattern top is etched by SF_6 plasma at 13 Pa. Fine SiO_2 pattern can be obtained by the edge lithography. (e) Cr is evaporated on the wafer and the Cr/SiO_2 is removed. (f) Si is etched by the advanced Bosch process and Cr is removed. The fine patterns are transferred to PMMA film by the thermal NIL. The imprint pressure and temperature are 32 MPa and 170 ºC, respectively. Since the very fine pattern with high aspect ratio is fabricated, the following modified NIL process is used. The pressure is decreased to 24 MPa just before the cooling step in order to decrease a stress concentration at the corner of the polymer pattern and the demolding is carried out at the lower temperature than 5 ºC to avoid the polymer stretching [3,4].

Results

Figure 2 and 3 show the examples of the SiO_2 pattern by the edge lithography and the trench pattern in the Si wafer, respectively. Figure 4 shows the transferred PMMA patterns when the modified NIL process is used. The PMMA pattern width and height are 25nm and 230nm in Fig 4. The PMMA pattern with the high aspect ratio can be successfully fabricated by use of the mold obtained by the edge lithography. However, the PMMA pattern top is not flat. The imprint process will be further improved in order to obtain the PMMA pattern with good pattern shape. Since it is not difficult to obtain finer SiO_2 patterns by the edge lithography, the proposed process can be expected as the powerful process to fabricate nano patterns around 10 nm.

References

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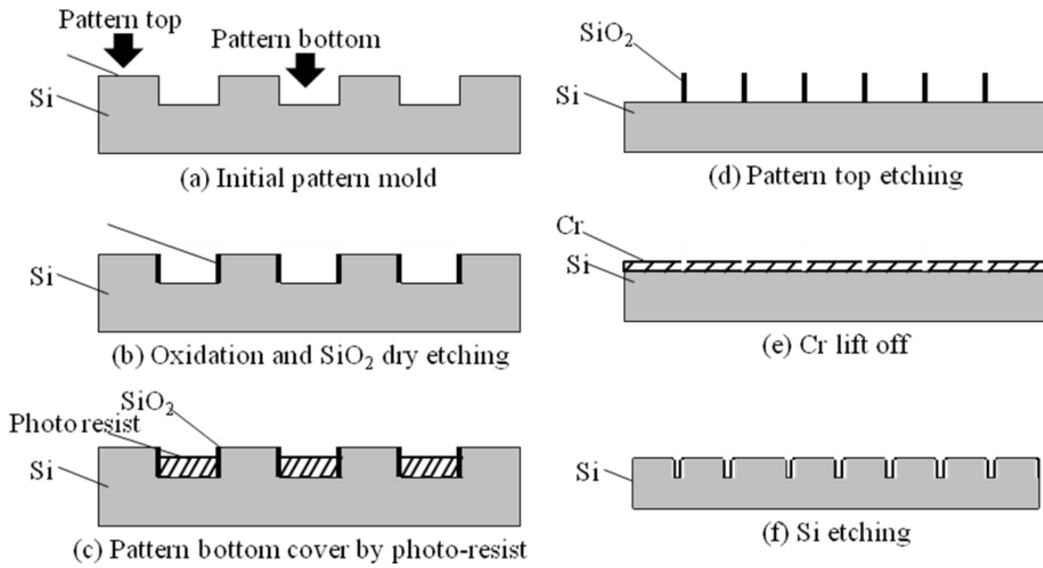

Fig.1 Mold fabrication process

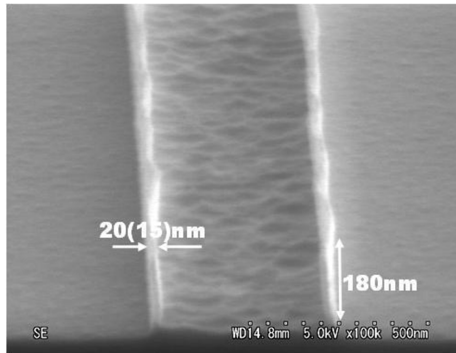

Fig.2 SiO_2 pattern by edge lithography

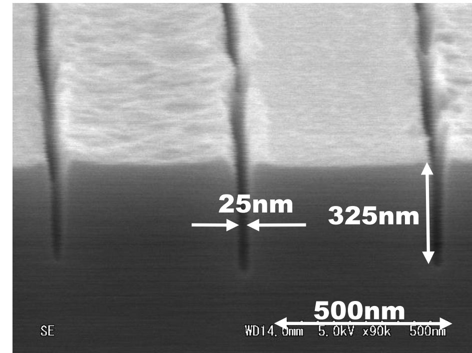

Fig.3 Trench pattern in Si wafer

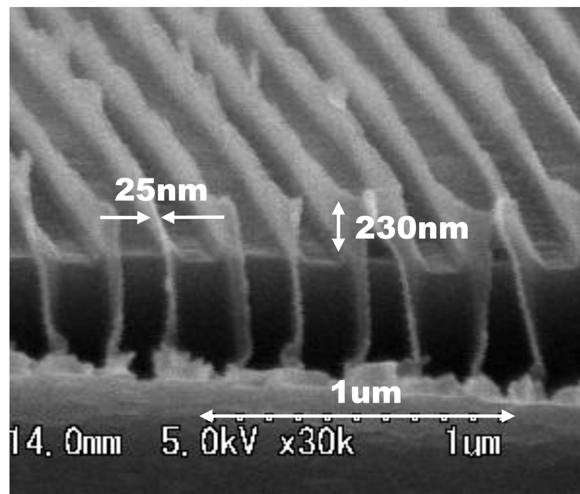

Fig.4 Fabricated PMMA pattern by use of modified NIL process.