Novel nanoimprint lithography using dispersed molecular weights resist

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Introduction

Thermal nanoimprint lithography is promising technology for fine pattern transfer using various functional materials. Several approaches are expected to apply for optical elements, bio sensors, and solar devices to enhance the functions by novel micro-nano structures. however high pressured imprinting is demanded for large modulus materials to obtain fine patterns, which is not good for mold durability[1)].

To solve this problem, we proposed multi-layered resist process consist of low and high molecular weight layers and demonstrated high aspect ratio pattern transfer in low imprinting pressuer[2)].

Based on the process, we newly propose dispersed molecular weights resist system, which consists of mixture of multiple molecular weight polymers to realize low pressured imprinting process for high aspect ratio patterns.

Experiments and discussions

Two kinds of PMMA polymers having M_w=996k and 100k are mixed as a dispersed molecular weight resist. The modulus of the polymers in various temperatures is shown in Fig.1. From the rheological characteristics as shown in Fig.1, the dispersed molecular weight resist only shows merged properties of these two components, however, smaller M_w polymer (100k) is expected to work as a filling component and larger M_w polymer (996k) as a base component to keep mechanical strength.

Figure2 illustrates the concept of dispersed molecular weights resist system. After imprinting, the smaller M_w chains are well filled into the fine pattern and larger one remains in the residual layer, which will assist high aspect ratio pattern transfer under low pressured condition and defect elimination[1)].

To evaluate the effects in experimentally, pattern heights of the resists after imprinting are evaluated under unity imprinting pressure condition where the mixture ratio of the 100k and 996k PMMA polymers are varied from 0% to 100%..

Figure 3 shows experimental results for 200nm line pattern under 10MPa in imprinting pressures. By mixing small amount of lower molecular weigh polymer, the pattern high increases, which means printability is improved.

The dispersed molecular weights resist is expected to fabricate high aspect ratio pattern with lower pressure and lower temperature.

High aspect ratio fine pattering will be approached by the uses of the dispersed molecular weights resist systems.

Reference

1) Y. Hirai, S. Yoshida, N. Takagi ; J. Vac. Sci. Technol. B 21(2003) 2765.
2) T. Konishi, H. Kikuta, H. Kawata, Y. Hirai; Microelectronic Engineering 83 (2006) 869.

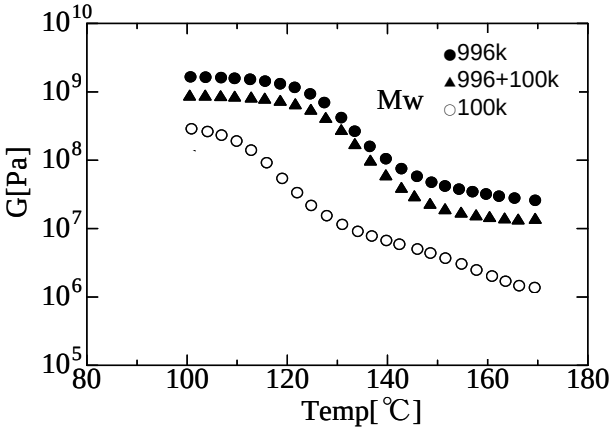

Figure 1. Modulus of various M_w polymers for PMMA

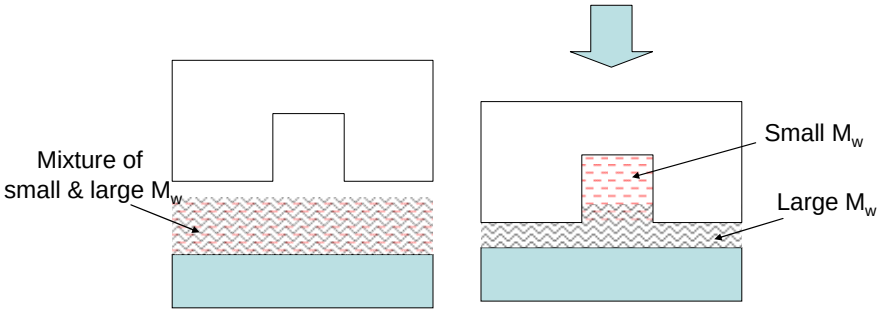

Figure 2. Schematics of the dispersed molecular weights resist system.

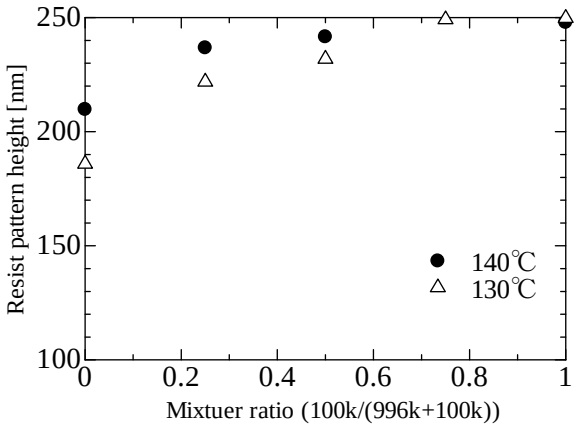

Figure 2. Imprinted resist height for various mixture ratio of PMMA polymers.
(200nm line, 10MPa, pattern depth of the mold =250nm)