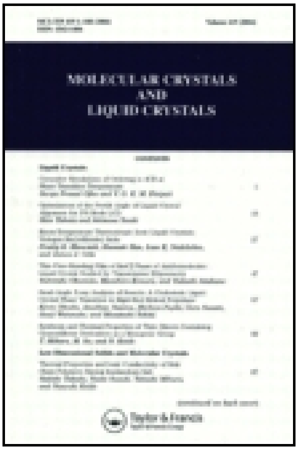

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

New Bilayer Positive Photoresist for 193 nm Photolithography

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Version of record first published: 24 Sep 2006

Mol. Cryst. Liq. Cryst., 1999, Vol. 327, pp. 279-282
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(Received June 30, 1998; In final form July 30, 1998)

We have designed a function-integrated acrylic terpolymer, poly(MMA_x-$BPMA_y$-MAA_z) which has both a dry-etching resistant unit (trimethylsilyl group) and a deprotecting group. A new terpolymer was synthesized by free radical terpolymerization of methyl methacrylate (MMA), 1,3-bis(trimethylsilyl)isopropyl methacrylate (BPMA) and methacrylic acid (MAA). Thermogravimetric analysis (TGA) of terpolymer showed a good thermal stability up to 140 °C. We achieved a minimum feature resolution with 0.17 μm L/S pattern in an ArF exposure system using poly($MMA_{5.9}$-$BPMA_{2.1}$-$MAA_{2.0}$) resist.

Keywords: photoresist; ArF lithography; bilayer resist

INTRODUCTION

Presently, it is widely believed that ArF lithography is the most promising technology for future microelectronics fabrication[1-2]. However, conventional resist materials like novolac or poly(p-vinylphenol) derivatives are inapplicable to ArF lithography because of their poor transparency and poor dry-etching resistance[3]. Therefore, new transparent resist materials with good dry-etching resistance are required for ArF lithography[4].

In this paper, we report on our new approach towards the design of a positive resist system. A newly designed terpolymer has a silicon containing acid labile protecting group which can be deprotected by a photo acid generator (PAG).

EXPERIMENTAL

Materials and Lithographic Evaluation

BPMA was synthesized according to the method described in the literature[5]. The poly(MMA_x-$BPMA_y$-MAA_z) used in the study was prepared by free radical terpolymerization. Figure 1 shows the synthetic scheme of poly(MMA_x-$BPMA_y$-MAA_z).

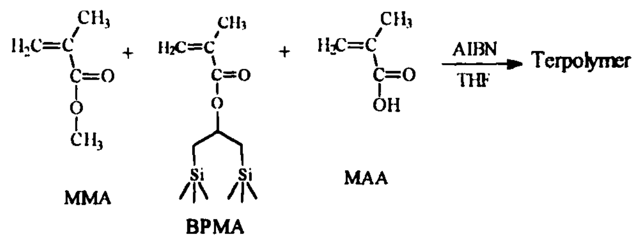

FIGURE 1 The synthetic scheme of terpolymer.

Poly(MMA_x-$BPMA_y$-MAA_z) with 1.3 wt% $Ph_3SSO_3CF_3$ as a PAG was evaluated under ArF exposure. The resist was spun on silicon substrate and baked at 110 ℃ for 90 s on a hot-plate. The resist film was exposed using an ArF excimer laser exposure system. Exposed resist was post-exposure-baked (PEB) at the temperature suitable for the protecting group and then developed in dilute tetramethylammonium hydroxide (TMAH) solution.

RESULTS AND DISCUSSION

Thermal stability of poly(MMA_x-$BPMA_y$-MAA_z) was investigated using thermogravimetric analysis (TGA). Terpolymers are thermally stable upto 140 ℃. Figure 2 shows the UV spectra of poly(MMA_x-$BPMA_y$-MAA_z) with various PAG contents. The UV transmittance of terpolymer without PAG was about 78 % at 193 nm. The UV transmittance of terpolymer with 1 and 2 wt% of PAG were 69 % and 59.6 % respectively. Terpolymer with 1.3 wt% PAG shows a good transparency at 193 nm wavelength. Figure 3 shows the etching resistance ratio of the poly(MMA_x-$BPMA_y$-MAA_z) to novolac resin. Etching resistance ratio of the poly(MMA_x-$BPMA_y$-MAA_z) to novolac resin is 6 when the silicon content is 11.8 wt%.

The lithographic capability of poly(MMA_x-$BPMA_y$-MAA_z) was evaluated by using an ArF exposure system. Figure 4 and 5 show SEM micrographs of poly($MMA_{5.9}$-$BPMA_{2.1}$-$MAA_{2.0}$) after exposure. Poly($MMA_{5.9}$-$BPMA_{2.1}$-$MAA_{2.0}$) resist among of terpolymers resolved 0.17 μm L/S pattern at 15-16 mJ/cm^2 exposure dose. Introducing MAA improved adhesion and high T_g value for the good resist performance. However, concentrated 2.38 wt% TMAH developer must be diluted because of high MAA content in the polymer chain. In the case of poly($MMA_{5.9}$-$BPMA_{2.1}$-$MAA_{2.0}$) resist, the optimized condition of developer concentration was 0.05 wt%. In Figure 4 and 5, 0.17 μm L/S pattern was broaden as compared with the line of original mask size. High contrast and resolution of patterns can be enhanced by controlling the concentration of developer and PAG content.

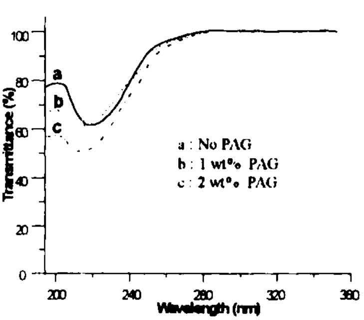

FIGURE 2 UV spectra of poly(MMA_x-$BPMA_y$-MAA_z).

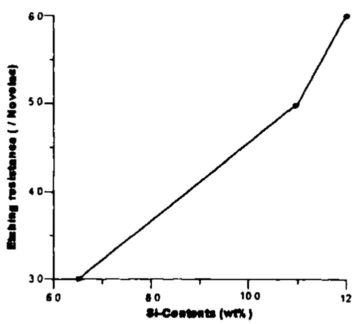

FIGURE 3 Etching resistance of poly(MMA_x-$BPMA_y$-MAA_z).

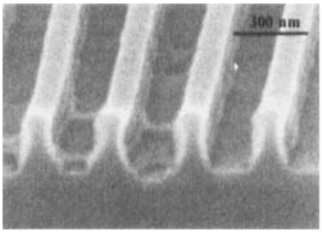

FIGURE 4 SEM micrograph of poly($MMA_{5.9}$-$BPMA_{2.1}$-$MAA_{2.0}$). 0.17 μm L/S at 15 mJ/cm^2

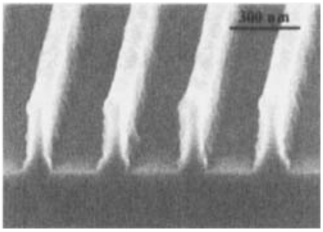

FIGURE 5 SEM micrograph of poly($MMA_{5.9}$-$BPMA_{2.1}$-$MAA_{2.0}$). 0.17 μm L/S at 16 mJ/cm^2

CONCLUSION

New acid labile protecting group was introduced in ArF positive resist. The lithographic evaluations show the resolution capability of 0.17 μm feature. It is expected that newly designed silicon-containing terpolymer is very suitable for the excellent performance as bilayer resist for ArF lithography.

Acknowledgment

This work was financially supported by the Ministry of Education through Research Institute of Industrial Society of Hanyang University (9606-059).

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