

important role played by the hydroxyl groups in the ablation. Repeating the measurements with polystyrene, at this laser power, a long incubation time and little evidence of photo-fluorescence was noted.

#### Selective Ablation in PS-b-PHOST

**[0025]** FIGS. 2A, 2B, 2C and 2D illustrate images of selectively ablated PHOST from a PS-b-PHOST 46 nm in pitch. FIGS. 2A illustrates an AFM image. FIGS. 2B illustrates an AFM line scan of FIGS. 2A. FIGS. 2B illustrates an SEM image. Scale bar is 200 nm. FIGS. 2D illustrates an SEM overview of an ablated area. Lighter area is where ablation occurs.

**[0026]** FIGS. 2A, 2B, 2C, and 2D collectively illustrate the selective ablation process on PS-b-PHOST. The PHOST block is removed in the 46 nm pitch system using powers of 7.5 mW, dwell times of 2 seconds, and pixel size of 333 nm. Selective ablation could be achieved in 40 nm samples under similar conditions. However, smaller pitches could not be selectively ablated. AFM phase imaging showed contrast within one block suggesting incomplete phase separation at smaller pitches. In addition, we found that in ablations studies of the underlayer, a cross-linked mixture of PS, poly glycidyl methacrylate, and polyacetoxy styrene, did not ablate, at similar powers as those used to remove the PHOST block from the bcp. For pattern transfer, this would indicate that a descum would be necessary.

#### Ablation in PS-b-PVP With and Without Platinum Complex

**[0027]** We investigated ablation in the PS-b-PVP system which was expected to occur via a different mechanism than PS-b-PHOST since there are no aromatic-OH groups present. Previous authors found PS had a lower ablation threshold than PVP.

**[0028]** FIG. 3 illustrates AFM images of P2VP-b-PS-b-P2VP with a 20 nm pitch. Relatively high powers were needed to see any ablation (above 21 mW). The ablation was found to proceed with a preference to ablate along the block copolymer fingerprint pattern. As the dose was reduced at constant power, single blocks appeared to be removed but in an inconsistent fashion. Hence optimum conditions were not found for selective removal for the non-metal doped system.

**[0029]** FIG. 4 illustrates a SEM of ablation in the PS-b-PVP system. The SEM image shows ablated 10 nm half-pitch PS-b-PVP complexed with Platinum. Scan lines are the overall light colored areas in the image. Contrast has changed and pattern collapse is apparent in parts of the image.

**[0030]** Powers were much lower than that used in the non-metal doped systems approximately between 10 mW and 15 mW (11.25 mW at the sample), yet the PS block is removed. It appears that the platinum addition may be playing two roles in the ablation process. On the one hand, it enhances the absorption and heat generation in the resist, leading to a photothermal degradation. On the other hand, it also promotes the stability of the PVP block. While RIE etching of the PS-PVP system caused the destabilization of the PVP blocks—the lines were found to be broken presumably due to agglomeration of the platinum as the organic is removed—we found no evidence of this in the laser ablation process. The ablation appears to be gentler on the PVP block

while still allowing the PS to be selectively removed. It is believed that the metal salt acts as a radical quencher.

#### CONCLUSIONS

**[0031]** Laser ablation to selectively remove one block in two types of block-copolymer systems is described. Using a 532 nm CW laser, we confirmed the mechanism that the selective ablation in e-beam patterned resists was consistent with studies in the PHOST system using protected and deprotected PHOST. Selective removal of PHOST is achieved in PS-b-PHOST and removal down to 20 nm half-pitch has been demonstrated. We then investigated P2VP-b-PS-b-P2VP, and P2VP-b-PS-b-P2VP doped with platinum. While poor selectivity was found in P2VP-b-PS-b-P2VP with no platinum, the P2VP-b-PS-b-P2VP platinum doped system allowed the selective removal of the PS block in the 10 nm half-pitch systems investigated. Described embodiments provide a viable path for patterning block copolymers where selectivity is not available with reactive ion etching.

#### REFERENCES

**[0032]** [1] N. D. Jarnagin, J. Cheng, A. Peters, W.-M. Yeh, R. A. Lawson, L. M. Tolbert and C. L. Henderson, "Investigation of high  $\chi$  block copolymers for directed self-assembly: synthesis and characterization of PS-b-PHOST," Proc SPIE 8323, Alternative Lithographic Technologies IV 8323, 832310-832310-832319 (2012).

What we claim is:

1. A process for lithographic development comprising:
  - (i) depositing a layer of a resist material on a substrate, wherein the resist material comprises a block copolymer including a first block and a second block, wherein the second block further comprises a metal;
  - (ii) exposing the resist material to a light source, wherein a region of the resist material comprising the first block exposed to the light source is volatilized and removed and the second block comprising the metal remains.
2. The process of claim 1 wherein the light source is a laser light source.
3. The process of claim 2 wherein the laser light source is a 532 nm wavelength laser.
4. The process of claim 3 wherein the laser light source is operated at a power of between 10 mW and 15 mW.
5. The process of claim 1 wherein the metal comprises platinum (Pt).
6. The process of claim 1 wherein the metal comprises a metal salt.
7. The process of claim 6 wherein the metal salt comprises a sodium platinum chloride ( $\text{Na}_2\text{PtCl}_4$ ) salt.
8. The process of claim 1 wherein the block copolymer comprises polystyrene-b-poly-2-vinylpyridine (PS-b-P2VP).
9. The process of claim 1 wherein the first block comprises polystyrene (PS).
10. The process of claim 1 wherein the second block comprises poly-2-vinylpyridine (P2VP).
11. The process of claim 1 wherein the block copolymer comprises poly-2-vinylpyridine-b-polystyrene-b-poly-2-vinylpyridine (P2VP-b-PS-b-P2VP).

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