A Novel sub-10 nm Half Pitch Pattern Transfer Process using Directed Self-Assembly Lithography

Katsutoshi Kobayashi, Naoko Kihara, Yusuke Kasahara, Yuriko Seino, Hironobu Sato, Shinya Minegishi, Ken Miyagi, Katsuyoshi Kodera, Hideki Kanai, Yoshiaki Kawamonzen, Koichi Yatsuda, Tomoharu Fujiwara, Noriyuki Hirayanagi and Tsukasa Azuma
EUVL Infrastructure Development Center, Inc.
16-1 Onogawa, Tsukuba-shi, Ibaraki-ken 305-8569, Japan
katsutoshi.kobayashi@eidec.co.jp

Teruaki Hayakawa
Tokyo Institute of Technology
2-12-1-S8-36 O-okayama, Meguro-ku Tokyo 152-8552, Japan

Directed self-assembly (DSA) technology is one of the promising candidates for next generation lithography[1-3]. DSA lithography has a potential to fabricate sub-10 nm half pitch patterns combined with conventional lithography or new generation lithography technologies. In order to realize sub-10 nm half pitch patterning using the DSA lithography, a combination of DSA materials with high χ (chi) parameter and suitable surface modification processes on substrate such as chemical or physical guide patterns is required[4]. In addition, in order to transfer the sub-10 nm half pitch patterns to the substrate successfully, pattern transfer properties should closely be investigated.

In this work, we report a novel sub-10 nm half pitch pattern transfer process using DSA lithography. As one of the promising DSA materials with high etching selectivity we applied Si containing DSA materials to realize sub-10 nm half pitch patterning. Figure 1 shows a scanning electron microscope (SEM) image of 7 nm half pitch patterns using a poly(methyl methacrylate-block-polyhedral oligomeric silsesquioxane methacrylate) (PMMA-b-PMAPOSS) material with horizontal cylinder structure. We verify effects of DSA materials, guide patterns and surface modification processes on pattern transfer properties for practical sub-10 nm half pitch patterning.

A part of this work was funded by the New Energy and Industrial Technology Development Organization (NEDO) under the EIDEC project.

[1] J. Y. Cheng, et al., "Simple and Versatile Methods to Integrate Directed Self-Assembly with Optical Lithography Using a Polarity-Switched Photoresist", ACS Nano , 4(8), 4815-4823 (2010).
[2] C. Bencher, et al., "Self-Assembly Patterning for sub-15 nm Half-Pitch: A Transition from Lab to Fab", Proc. SPIE , 7970, 79700F-1 (2011).
[3] C. Liu, et al., "Towards an all-track 300 mm process for directed self-assembly", J. Vac. Sci. technol. B 29(6), Nov/Dec (2011).
[4] T. Hirai et al., "Hierarchical Nanostructures of Organosilicate Nanosheets within Self-Organized Block Copolymer Films", Macromolecules 41, 4558-4560 (2008)

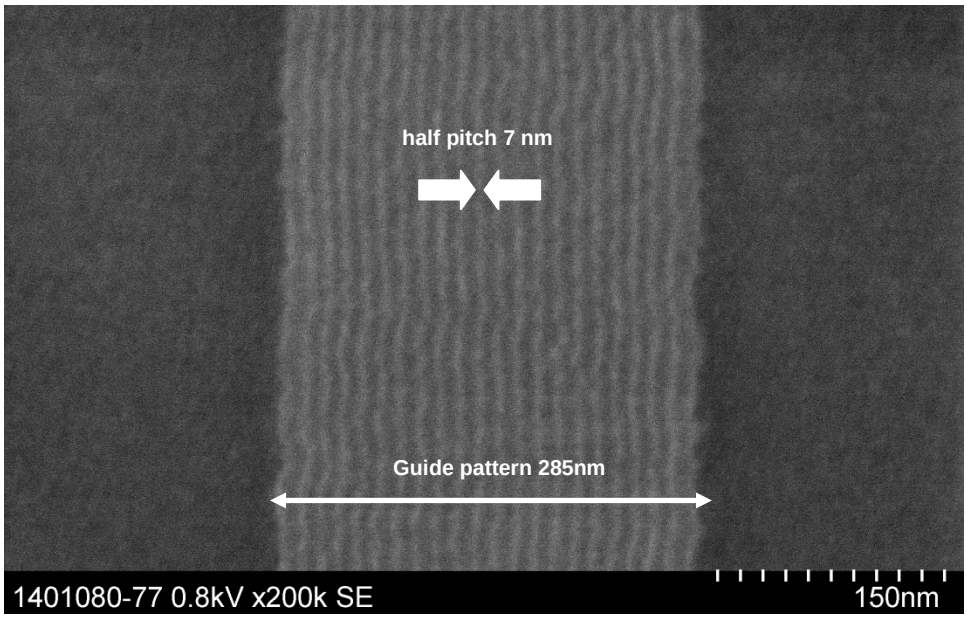

Figure 1: SEM image of half pitch 7 nm lines and spaces patterns using PMMA-b-PMAPOSS with horizontal cylinder structure.