Creating Patterns on the Length Scale of Macromolecules: Design for Electronics and Biomolecular Applications

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One of the great challenges provided by advances in microelectronics is the ongoing challenge to reduce the critical dimensions of semiconductor devices. To make this possible, photolithography has evolved dramatically to the point that it now produces patterns on the length scale of the macromolecules used in photoresists. The result is a host of new approaches to the patterning of polymer systems and the need for precise characterization of their processing and properties. Block copolymers offer a means to resolve this impasse by removing part of the polymer chain to make small patterns. We have recently shown we can control the self-assembly process by solvent vapor annealing, and by choice of solvent [1]. Approaches using molecular glass and nanoparticle photoresists have also been investigated [2]. The systems have the advantage that they may be used to produce arbitrarily shaped patterns in contrast to self-assembled materials and show prospects of sub-20 nm structure formation. New tools for thermal processing such as laser spike annealing enable thermal excursions above 500 °C in microsecond time regions and will be discussed [3]. Application of patterning to biology is also an important field of study [4]. Examples of polymer brushes used for sensor creation [5] and for investigation of cellular interaction [6] are provided. The importance of surface functionality, non-specific binding and length scale will be discussed.

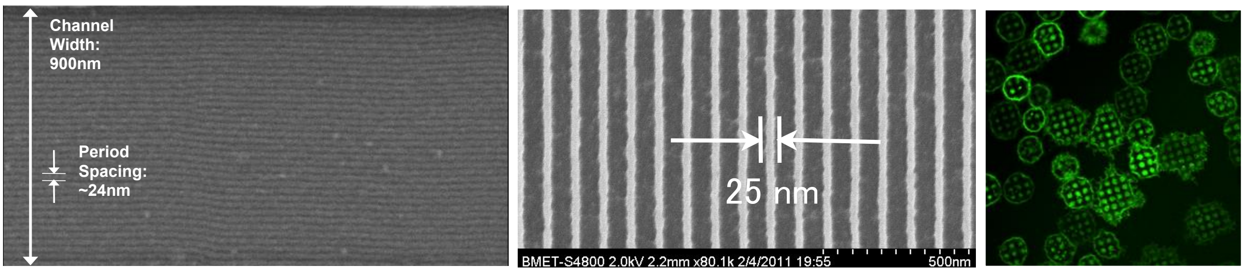

Fig. 1: Nanometer scale features made by (left) self-assembly of block copolymers and (center) direct patterning of nanoparticle photoresists. (right) Cells interacting with patterned surface (array made of 2µm squares)

References

[1] M. Y. Paik, J. K. Bosworth, D.-M. Smilgies, E. L. Schwartz, X. André, C. K. Ober, "Reversible Morphology Control in Block Copolymer Films via Solvent Vapor Processing: An In-Situ GISAXS Study", *Macromolecules*, (2010), 43(9), 4253-4260.

[2] Trikeriotis, M.; Krysak, M.; Chung, Y.S.; Ouyang, C.; Cardineau, B.; Brainard, R.; Ober, C.K.; Giannelis E.P.; Cho, K. *Journal of Photopolymer Science and Technology*, 25(5), (2012) 583.

[3] Jung, B.; Sha, J.; Paredes, F.; Chandhok, M.; Younkin, T.; Wiesner, U.; Ober, C.K.; Thompson, M., *ACS Nano*, 6(7), (2012) 5830-5836.

[4] M. Elizabeth Welch, C. K. Ober, "Responsive and patterned polymer brushes", *J. Polym. Sci.: Physics*, in press.

[5] A. Rastogi, S. Nad, M. Tanaka, N. Da Mota, M. Tague, B. A. Baird, H. D. Abruña and C. K. Ober, "Preventing Non-Specific Adsorption on Polymer Brush Covered Gold Electrodes Using a Modified ATRP Initiator", *Biomacromolecules*, (2009), 10(10), 2750-2758.

[6] E. N. Chiang, R. Dong, C. K. Ober, B. A. Baird, "Cellular Responses to Patterned (Poly)Acrylic Acid Brushes", *Langmuir*, 2011, 27(11), 7016-7023.