NANO HIGHLIGHT
Ordering of Self-assembled Polymers for Nanolithography Applications

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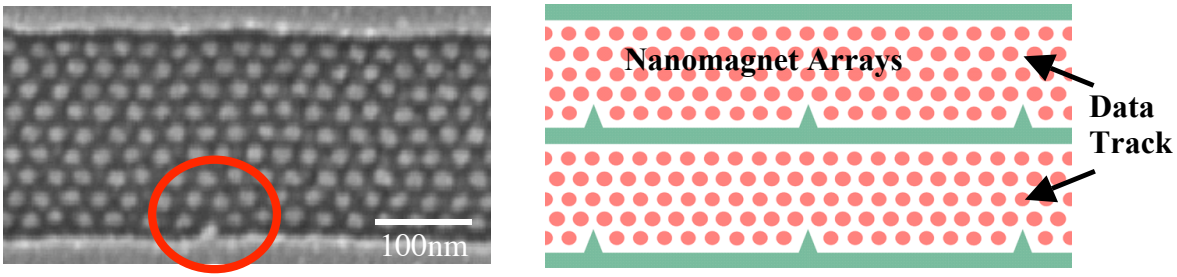
Fabrication of large-area periodic nanoscale structures using self-organizing systems is of great interest because of the simplicity and low cost of the process. Block copolymers consist of polymer chains made from two chemically distinct polymer materials. These can self-assemble to form small-scale domains whose size and geometry depend on the molecular weights of the polymer chains and their mutual interactions. The domains have a very uniform distribution of sizes and shapes. We have been using block copolymers as templates for nanoscale lithography. As an example, we can selectively remove one type of domain and use the remaining polymer domains as a template to pattern a nanostructured magnetic film. We have successfully used this method to pattern arrays of Co, NiFe and multilayer NiFe/Cu/Co 'dots' with 35nm diameter and 5 – 20 nm thickness.

However, for block copolymer lithography to have maximum usefulness, we need to control the positions of the polymer domains on the surface so that the pattern has long-range order. We have done this using shallow surface steps ('graphoepitaxy') which induce orientation and positional ordering of the block copolymer. Well-ordered structures form in grooves on the substrate, with all the close-packed domains aligned within the grooves provided the groove width is comparable to the natural correlation length of the block copolymer. We have found that the number of rows of domains within the groove and the spacing of the rows can be controlled by adjusting the groove dimensions. Recently we have found that defects such as vacancies and dislocations can be deliberately introduced by notches in the substrate steps, and have explored how this depends on the length of the notch. These ordered nanostructures, with designed aperiodicity, may be useful as templates for various applications such as magnetic recording media or photonic crystals. Part of this work was supported through an NSF MRSEC award.



Left: a block copolymer forms an ordered structure in a 260nm wide silica groove. The notch on the side of the groove (red circle) pins the lateral position of the array. Right: a sketch of a magnetic storage medium consisting of nanomagnets arranged in circumferential tracks around a disk. Such a structure could be formed by using the ordered block copolymer as a template.

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J.Y. Cheng, C.A. Ross, E.L. Thomas, H.I. Smith, G.J. Vancso "Templated self-assembly of block copolymers: Effect of substrate topography", Adv. Mater. 15(19) 1599-1602 (2003)