Striving for Perfect Order in Shear-Aligned Block Copolymer Films

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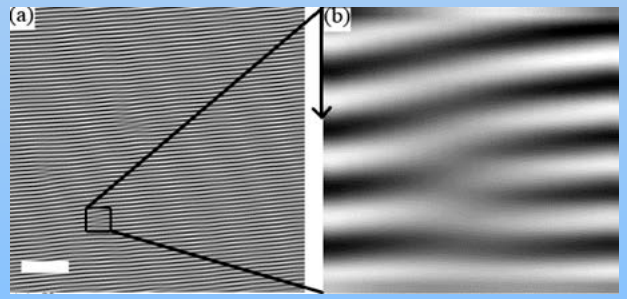
Block copolymer thin films are effective templates for fabricating large arrays of nanoscopic objects; for example, polymers which self-assemble into cylinders lying in the plane of the film yield striped patterns, which can be replicated in metal to yield nanowire grids which effectively polarize the short-wavelength ultraviolet light used in today's advanced production photolithography. But other applications demand more perfect order of the striped-pattern template: perfectly straight and unbroken wires. The most obvious defects in these block copolymer patterns are isolated dislocations–cylinders which start or stop, which would become breaks in wires fabricated from such a template. PPCM researchers have found that tight control of the film thickness and annealing regimen can reduce these dislocations to low levels, but once these defects are largely eliminated, a previously unanticipated factor emerges to limit the orientational order: small-amplitude undulations of the cylinders relative to their axes, limiting ψ_2 to 0.998 (0.2% below the value of 1 for a perfect pattern).



Reference: A.P. Marencic, P.M. Chaikin, and R.A. Register, "Orientational Order in Cylinder-Forming Block Copolymer Thin Films", *Phys. Rev. E*, **86**, 021507 (2012).

Above, (a): filtered atomic force microscopy (AFM) image of a shear-aligned thin film of a cylinder-forming block copolymer, bar = 200 nm, PS cylinders are white in black PEP matrix. Four dislocations are evident in the image, one of which is within the square; (b) blowup of the square, showing the dislocation core (distance between white cylinders = 19 nm). Right: orientational order falls off linearly with dislocation density (•, experiments), at approximately the rate predicted by a simple continuum simulation (◊, image from simulation shown as inset). But even at zero dislocation density, the order is not perfect ($\psi_2 < 1$), due to undulations of the cylinders.