MAR06-2005-002382

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

Shear Alignment of Hexagonal and Striped Patterns in Block Copolymer Thin Films[1]

RICHARD REGISTER, Princeton University

Diblock copolymers spontaneously self-assemble into nanodomain structures: simple repeating patterns with a periodicity (typically 20-100 nm) set by the polymer molecular weight and a symmetry controlled by the relative lengths of the two blocks. Similar patterns are obtained when block copolymers are deposited onto substrates, as films with thicknesses accommodating only a few or even only one layer of nanodomains: cylindrical nanodomains form a striped pattern when viewed from above, while spheres form a hexagonal pattern. In the absence of any applied field, however, these patterns exist as a polygrain structure, with a grain size which is typically microns at most. Recently, we have developed methods to shear these thin films, producing samples free from grain boundaries and with orientational order extending over centimeters. But while excellent orientational order can be achieved by shearing, translational order is still limited to the micron scale due to isolated dislocations which remain in the sheared films (though at a markedly reduced density compared with unsheared films). Shear can be applied either with an elastomeric pad, or with a viscous fluid; in the latter case, the patterns can be induced to follow the shape of fluid flow channels of arbitrary shape and millimeter-scale width. For the striped patterns, shear alignment is effective on films containing either a single layer or multiple layers of nanodomains, but for the hexagonal pattern, two or more layers are required due to the mechanical isotropy of a two-dimensional hexagonal lattice. A threshold stress is required to achieve the limiting quality of alignment, a stress which decreases as the block copolymer's order-disorder transition temperature is approached. A simple model appears to capture the principal features of the stress, time, and temperature dependence of the alignment quality.

[1]with Dan Angelescu, Mingshaw Wu, Vincent Pelletier, Judith Waller, Andrew Marencic, Douglas Adamson, and Paul Chaikin, supported by the NSF MRSEC Program through the Princeton Center for Complex Materials (DMR-0213706).