Sphere-Forming and Cylinder-Forming Block Copolymer Thin Films Aligned Under Double Shear

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Studies have shown that stress transmitted through a viscous layer to a sphere- or cylinder-forming block copolymer thin film will orient the microdomains in the direction of the imposed shear [1,2]. A melting-recrystallization model was introduced which satisfactorily described the observed phenomena. For creation of complex patterns, reorientation of these unidirectionally oriented films is necessary. Here we present work that looks at the ability of shear to reorient domains after the initial alignment.

We used a controlled-stress rheometer with a parallel plate attachment to impose the shear [1]. Between the first and second shear, the sample was translated so a portion of the first sheared region was sheared a second time. This geometry allows for a continual angular difference ($\delta\theta$) between the initial orientation of the film (caused by the first shear) and the new shear direction. Results show that realignment is possible; however, the threshold stress (minimum stress required to cause melting of microdomains) was larger for both the sphere- and cylinder-forming block copolymers when compared with the single shear experiments (orienting a film from the polygrain state). This stress increase is caused by the need to nucleate a "melted" region which will then "recrystallize" with the microdomains oriented along the shear direction. Shearing from the disordered state does not have this nucleation barrier. We also observed grain boundary generation within the transition region between alignment with the first shear direction and alignment with the second shear direction, which is expected in this model.

[1] M. W. Wu, R. A. Register, P. M. Chaikin, *Phys. Rev. E* 74, 040801 (2006).
[2] V. Pelletier, D. H. Adamson, R. A. Register, P. M. Chaikin, *Appl. Phys. Lett.* 90, 163105 (2007).