

SHEARING OF ISLANDS AND HOLES IN BLOCK COPOLYMER THIN FILMS

ABSTRACT

Shearing refers to the occurrence of a shear strain, which is the deformation of a material substance in which parallel internal surfaces slide past one another. It is induced by a shear stress in the material. This project focuses on developing a detailed understanding of underlying polymer physics responsible for block copolymer ordering in thin films under the effect of shear stress. To observe the shearing phenomenon in microscale, the polymer film is annealed such that it has a lamellar morphology with islands and holes. The idea here is to track shearing by juxtaposing the AFM scanned pre sheared and post sheared images to note the increment in area and decrement in height of islands and holes. PDMS, a silicone elastomer, is placed on the polymer film that is intended to be sheared. PDMS is a vital tool in this operation because it expands when the polymer film is passed through hot zone and contracts when exposed to cold zone. As PDMS is placed on the polymer film, the expansion and contraction poses a shearing effect on the polymer film. Block copolymers under a stimulus self-assemble to make different morphologies, having applications in nanolithography, membranes, photonics and energy storage devices. Shear ordered block copolymers have minimum defects and high degree of alignment, the criteria needed for use of block copolymers in energy storage and other technological applications.

EXPERIMENT

- PS(19k)-PMMA(17k), PS(33k)-PMMA(33k), and PS(45k)-PMMA(44k) are taken separately into three different vials. Toluene is added to the vials such that the concentration in each vial is 2% (wt/vol).
- Polymer films are made from these solutions on a quartz substrate using flow coater. They are then annealed at 200°C for 24h under 30 psig vacuum. This step leads the films to gain lamellar morphology.
- PDMS is prepared using a mixture of silicone elastomer base and curing agent. The two products are taken in 10:1 ratio, mixed thoroughly in a PTFE cup, vacuumed for 20 mins to obliterate air bubbles and drop casted on a glass plate. PDMS is now annealed at 60°C for 12h.
- The PDMS layer is now trimmed into appropriate dimensions and placed on the polymer film as represented below.



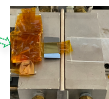
The sample on the left is polymer film on quartz substrate and the sample on the right is PDMS



PDMS is placed on the polymer film which is on quartz



This setup is called cold zone annealing. The red motor facilitates movement of the substrate through hot and cold zones at the rate of 50 $\mu\text{m/s}$

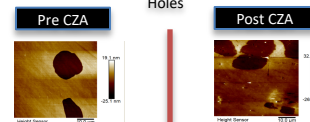
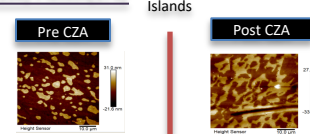


The two steel bars are the cold zones maintained at 20°C and the white rod in between them is at 230°C which is the hot zone. When the substrate is in contact with the hot wire then the PDMS expands and contracts when in contact with steel bar. This expansion and contraction creates a shearing effect on the polymer film which lies beneath the PDMS.

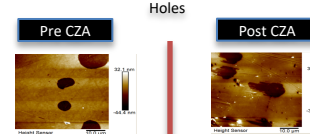
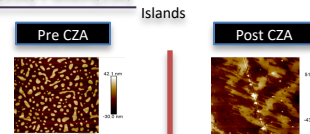
RESULTS

We will be comparing AFM scanned pre and post sheared films from the three polymer films that have been experimented to see how the islands and holes have been sheared.

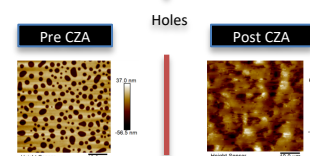
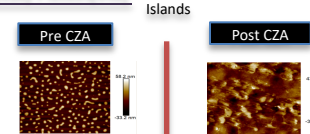
PS(19k)-PMMA(17k)



PS(33k)-PMMA(33k)

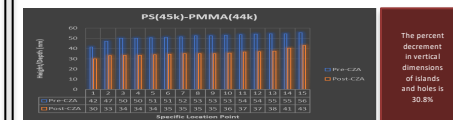
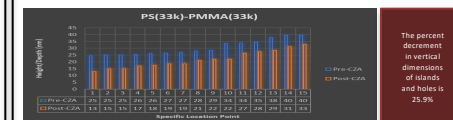
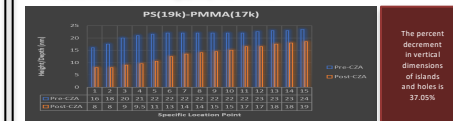


PS(45k)-PMMA(44k)

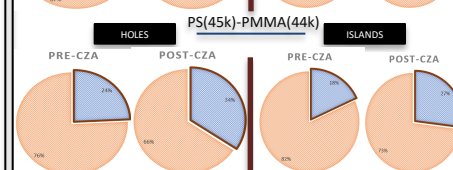
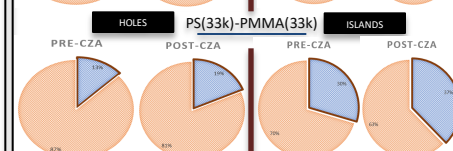
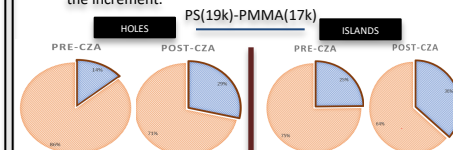


ANALYSIS

- Height/Depth Analysis: This analysis takes into consideration the change in height of islands and depth of holes after shearing polymer films.



- Area Analysis: Areas of Islands and Holes have been compared pre and post CZA for all the films to observe the increment.



ACKNOWLEDGEMENT

I would like to extend my gratitude to Dr. Alamgir Karim and Maninderjeet Singh for guiding me throughout the project.