Confinement induced ordering of polymer bilayer and blend thin films

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Abstract:

Thin polymer films are important in a host of areas such as multifunctional coatings, smart surfaces, resist layer in lithography, controlling surface wettability, development of exotic metamaterials etc. Ultra thin films (thinner than 100 nm) tend to become unstable due to various meso scale interactions such as van der Waal's forces, rupture spontaneously and dewet on a non-wettable surface. While such instability is undesirable from the stand point of a coating, it is gaining popularity as a viable non lithographic route to engineer meso scale structures. These structures are inherently random which significantly hinders their practical utility. This limitation can be overcome and the structures can be aligned by suitable templating strategies which essentially combine the key concepts of both top down and bottom up fabrication approaches. This thesis reports some advanced experimental issues related to topographic confinement induced dewetting of multi component thin film systems comprising of two immiscible polymers in the form of bilayer and immiscible blends. Ordering of the instability patterns are mostly done by using a topographically patterned substrate, which are soft lithographically fabricated. Classical Soft Lithography requires an original stamp or a master pattern for every separate design of structures. As a part of this thesis, we develop a new nano fabrication technique, which is capable of creating higher aspect ratio and taller structures from a single stamp with lower feature height based on contact instability observed in thin elastic films (chapter 2). These topographically patterned templates are used to investigate ordering and alignment in different multi component systems including dewetting of pre-patterned polymer thin film and instability in a bilayer thin film with a topographically structured polymer-polymer interface (chapter 3), realization of a novel meso scale morphology comprising an alternate equi-sized binary polymer nano droplet array (ADA) using sequential spin dewetting (chapter 4) and dewetting of a thin bilayer on a topographically patterned non wettable substrate comprising array of pillars, arranged in a square lattice (chapter 5). Spontaneous phase segregation of an immiscible polymer blend system has been a major area of research. Spin cast films of these blends show a variety of random structures depending on the composition of the two polymers, the film thickness as well as the nature of the substrate. It is observed that on spin coating blend thin films on topographically patterned substrates, for a specific blend composition, below a certain critical blend concentration, the phase segregation remains no more random and a perfect ordering of the two phases is observed due to the effect of physical confinement (chapter 6). The possible future works are discussed in the final chapter, along with a general conclusion of the work presented in the thesis.