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Influence of patterned substrates on miniaturization of surface patterns in soft elastic films

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The advantages of diminutive-size surface-patterns have been harnessed by various industries, such as semiconductor, integrated circuits, nano-devices, nano-sensors, optoelectronics etc. Patterning the soft thin elastic films through self-organization is found to be a cheaper alternative route for fabricating meso/nano length scales at such soft interfaces compared to conventional lithographic techniques. Self-organization involves surface reorganization of a polymeric film resting on a substrate, due to the application of a force field created by an external contactor. The film reorganizes itself to attain the minimum energy state that leads to the surface-patterning. For elastic thin films cast on smooth substrates, the instability length scales between the contact zones have been reported to be ~2.96*h (h being the mean thickness of the elastic film). Linear stability analysis and numerical simulation studies on soft elastic thin films show that much smaller pattern length scales can be obtained for sinusoidal-patterned-substrates when used in lieu of flat substrates. Inspired by the theoretical work, we have performed soft film adhesive experiments on three patterned substrates created from naturally occurring water lily leaves, low-cost commercially available compact disks and EBM created cubic patterns. The morphological surface patterns of columns, labyrinths and cavities formed at different stages of the adhesion-debonding cycle in these experiments do indeed reveal minuscule length scale formation that is much less than 2.96*h. Thus, the present work experimentally and through numerical simulations demonstrates a simple and uncomplicated method to create miniaturized patterns, which have extensive applications in fabricating lab-on-chip devices, self-cleaning materials, scaffolds for tissue engineering etc.

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