Surface instabilities in non-linear soft thin films

Thesis submitted by

Sunita

Abstract

The work titled **'Surface instabilities in non-linear soft thin films'** studies the stability morphology and dynamics of a single soft, thin film on a substrate whose material properties (shear modulus) vary throughout the film thickness. Recently, we have focused on finding different techniques to miniaturize the patterns formed on such soft interfaces at smaller and smaller length scales to enhance surface properties like hydrophobicity, adhesiveness, optical and catalytic. Different techniques like patterned substrates and bilayers have been found to be fruitful where it was possible to decrease the lengthscale by about an order of magnitude than those formed in simple elastic thin films because of antagonistic energies (elastic and interaction) present. These techniques are also more cost-effective than the existing techniques of lithography, and suitable for hard materials. In the present work, we have found the smaller length scale features formed at the interface of these inhomogeneous elastic materials where the inhomogeneity exists only in the normal direction. The influence of the substrate geometry was also studied; as stated patterned substrates were already found to be effective in reducing lengthscales. Thus, it has been observed that the combined effect of patterned substrate and the inhomogeneity in the normal direction are worthwhile to influence further miniaturization. These studies involved numerical energy minimization techniques and finite element schemes to tackle non-linearities. Earlier works have shown that though it is easier to deform a compressible (Poisson's ratio $\vartheta \leq 0.25$) elastic film but the patterns formed were long waved and thus flat for most practical purposes. The current theoretical investigation carried out in thermally graded, soft, compressible and

thin elastic film uncovers that combined destabilizing influences originating from van der Waals and tensile thermal stresses do engender smaller length scales in compressible elastic films. Though some work has been presented in the literature for viscoelastic films, they are mostly from a viscous film perspective. In this thesis, for the first time, a three-parameter linear standard viscoelastic (solid) model has been developed to understand the adhesion debonding mechanism of such films. Also, a combined effect of charge leakage and the elastically graded nature of the film have been observed to be adequate to accelerate the growth rate of instabilities and alter the wavelength from short range to long range in elastic-viscous bilayers.