Surface Evolution of a Stressed Elastic Layer in an Electric Field

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It is known that the interfacial stresses between a thin film and a substrate can introduce an elastic field. To lower elastic energy, the film can break into islands, which usually are uneven in size and spatial arrangement. The phenomenon of stress-induced surface instability of solids has recently received great attention because of its relevance in the formation of islands during heteroepitaxial growth of thin films. The surface evolution of solids in electric field is much more complicated than the stress-induced surface instability of solids and the electric field-induced surface instability of solids, since the deformation introduced by electric stresses must be taken into account.

We examined the surface evolution of an elastic layer subjected to a far-field uniform tensile stress in an electric field using the theory of linear perturbation. The driving force controlling the surface growth was the gradient of chemical potential associated with surface energy, elastic strain energy and electric energy. An analytical expression of the dispersion relation was obtained, which can be used to describe the morphological evolution of the elastic layer in an electric field. It was found that there exists a region, in which any surface perturbation will not lead to the morphological instability due to the confinement of electromechanical interaction. The electromechanical interaction can either enhance or inhibit the growth of surface perturbations.