Elastic analysis of vertical cracking in an epitaxial film/substrate system

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Abstract

The epitaxial thin film is very useful for high-speed semiconductor devices, but offers a number of material processing challenges in its fabrication. Strain relaxation is one of the most important problems encountered in the growth of lattice-mismatched film/substrate materials. So many researches on strain relaxation mechanisms have been reported. Most of strain relief mechanisms are the creation of surface instabilities (surface reconstructions), the formation of misfit dislocations, and cracking phenomena. Since the strain relief mechanism by cracking in III-V compound epitaxy was firstly reported in the 1970s, much attention on the lattice-mismatched epitaxial films has been attracted due to the increasing technological interest in growing highly strained structures.

In this study, a single vertical crack as well as periodically distributed vertical cracks in an anisotropic epitaxial film and substrate structure are analyzed by using Stroh formalism. The film and substrate have different elastic constants. In this analysis, the solution for a dislocation in an anisotropic trimaterial is used as a Green solution and the cracks are modeled by the continuous distributions of dislocations, which yield the singular integral equations of Cauchy-type. Gauss-Chebyshev quadrature formula is used to solve the singular integral equations numerically. Also, cracking phenomena in tensile strained $In_xGa_{1-x}As$ film deposited on InP substrate are investigated, which are compared with the known experimental results. It is conjectured in this study that the crack growing and healing phenomena, occurring when the film thickness increases, result from the interaction of an array of cracks instead of surface diffusion.

Key Words: anisotropic elasticity, vertical cracks, dislocation, epitaxial film