SAND2012-5379C

Origins of Residual Stress in Polycrystalline Thin Films

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During deposition, thin films develop stress that depends on the material and processing conditions. In many metals, the stress goes through a series of states, changing from tensile to compressive as the microstructure evolves. In nanocrystalline materials, the tensile stress can even be large enough to cause cracks to form. We will discuss the evolution of this stress in terms of competition between tensile and compressive stress generation mechanisms that occur at the grain boundary as the film grows. The balance between these mechanisms shifts with the processing conditions and the microstructure, as it evolves through coalescence of islands into a steady state uniform film. Our model predicts that the steady state stress scales with the dimensionless parameter D/LR where D is the diffusivity, R is the growth rate and L is the grain size. It also explains the transition from tensile to compressive stress with thickness. The model results are compared with real-time measurements of stress using wafer curvature.