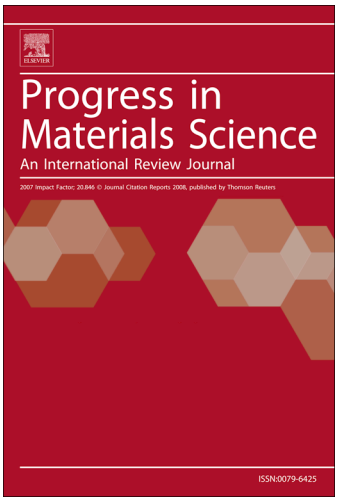

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Kinetics of Interface Alloy Phase formation at nanometer length scale in Ultra-thin Films: X-ray and polarized neutron reflectometry

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Abstract

Multilayer thin films of various metal pairs present model systems for studying intermetallic alloy phase formation at interfaces of these heterostructures on annealing and help to understand the kinetics of phase formation. Formation and study of these phases at the interfaces is of deep interest with respect to application and for understanding microscopic kinetics in ultra-thin layers. Also intermetallic phases are known to have extraordinary functions and characteristics that are not observed in bulk metals and alloys. Many intermetallic alloys exhibit attractive combination of physical and mechanical properties, such as high melting point, low density, high strength, good oxidation and creep resistance. In the past two decades x-ray and neutron reflectometry have been established as important non-destructive tools for obtaining physical and magnetic properties in thin film multilayers with sub-nanometer spatial resolution. All the major neutron and synchrotron sources at present provide variants of these techniques, dedicated to studies related to layered structures. This article reviews very slow diffusion at the interfaces of heterostructures, discerning kinetics of intermetallic phase formation at the interfaces in thin films and multilayers on annealing at relatively lower temperatures, primarily using x-ray and neutron reflectivity techniques. It highlights the strength of X-ray reflectivity (XRR) and neutron reflectivity (NR) to measure very low diffusivity (typically ~10^{-19} – 10^{-23} cm^2/s) in thin films. We will specifically discuss interdiffusion and formation of binary intermetallic alloys on annealing of several Ni based multilayers, with special emphasis on Ni/Ti, Ni/Al and Ni/Ge multilayers to demonstrate the strength of these techniques. These are well known systems for technological application in the field of shape memory alloys, in aeronautical industries and as corrosion resistant low-resistance contact on semiconductor surface. Especially Ni/Al has been studied at length by