Interdiffusion in Sc/Si multilayers

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An understanding of interdiffusion in nano-scale multilayers is of great scientific and practical interest because intermixing is responsible for temporal and thermal instability of EUV and soft X-ray multilayer mirrors. In this paper we study the kinetics of silicide growth in Sc/Si layered coatings. It was found that an amorphous ScSi silicide forms at the scandium-silicon interface. The growth of the ScSi silicide layer obeys diffusion kinetics rather than a chemical reaction kinetics. The silicide growth is limited by the diffusion of Si atoms through the silicide layer towards the silicide-scandium interface where the chemical reaction takes place. As a result of a large asymmetry of interdiffusion the growth of the silicide occurs mainly at the silicide-scandium interface. The diffusion growth of the silicide deviates significantly from the classic parabolic law at the early stage of interdiffusion (Fig. 1). Such a nonlinear growth behavior can be explained with a relaxation model. The growth rate is maximal in the beginning of annealing due to a large amount of excess free volume in the as-deposited multilayer. During the annealing a relaxation processes occurs, and diffusion slows down. Eventually the growth rate is stabilized, and a parabolic regime of the silicide growth is observed.

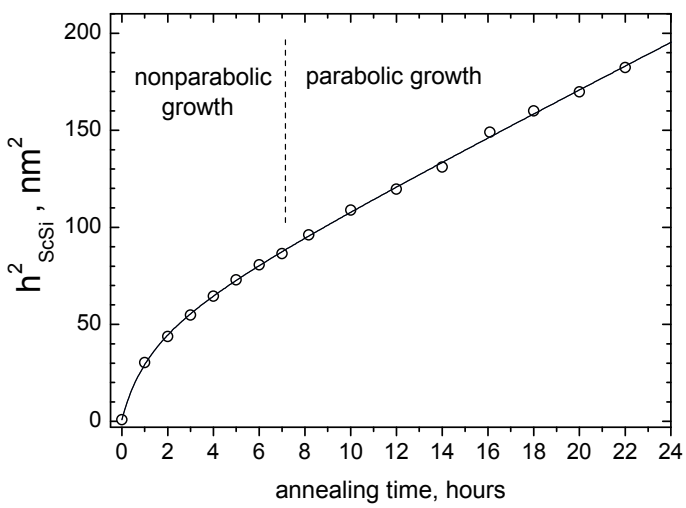

Fig. 1. Kinetics of amorphous silicide growth in Sc/Si layered coatings at 300ºC. The circles are experimental data for squared thickness (h_{ScSi}) of amorphous ScSi silicide; the curve is a fit based on a relaxation model.