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High-throughput optimization of adhesion in multilayers by superlayer gradients

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For adhesion measurements, the superlayer method has recently been developed: an overlayer under high compressive stress (Mo film in our case) provides the loading and drives interface delamination and buckling. We combined the superlayer method with thickness gradients for high throughput adhesion measurements. In this way, the effect of small modifications of interface chemistry on adhesion in multilayers can be assessed in a single test through the identification of the threshold thickness. We used this methodology for an optimisation of the Ti interlayer thickness for adhesion at the SiO_2/Ag interface (see figure 1a). An improvement of the adhesion could be observed in the range from 0 to ~ 3 A of Ti (figure 1b). At higher thicknesses of Ti the adhesion has become stronger than the range of the test. Similar tests have been performed on the Mo/SiO_2 interface with Ag interlayer. In this case, the increase of Ag thickness weakens the interface and causes the adhesion to decrease (figure 1c). The adhesion drops abruptly at an equivalent thickness of Ag of ~ 6 nm, corresponding to the Ag islands coalescence. Thus, the method has become a tool not only to measure the adhesion but to study film's growth as well.

Another important film property is the residual stress. Using the wide range of buckle sizes generated by the thickness and adhesion gradients, we investigate the buckle morphology in details. The results indicate that the ratio between the height and an in-plane width of a telephone-cord like blister can be used to assess the value of the biaxial stress in the compressed layer. Finally we suggest that further understanding of the relation between buckle morphology and interfacial toughness is highly desirable.

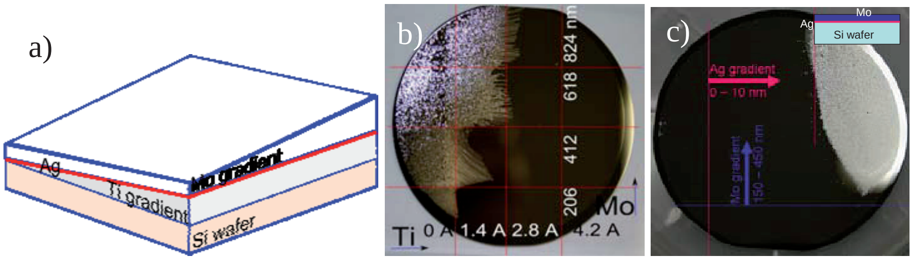

Figure 1. Cross-gradients to study adhesion. a) The scheme of the cross-gradient Mo(gr)/Ag/Ti(gr)/Si wafer; b) the delamination pattern obtained in the cross-gradient geometry in scheme a); c) the delamination pattern in the cross-gradient geometry Mo(gr)/Ag(gr)/Si wafer.