

Study of buckling and delamination of ductile thin films on rigid substrates

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Amphitheater Jean Besson (Phelma Campus)

Jury :

M. Damien FAURIE, (MCF HDR, Université Paris 13)	Rapporteur
M. Patrick MCGARRY (Pr. associé, NUI, Galway)	Rapporteur
M. Benoit ROMAN (DR CNRS)	Examineur
M. Christophe COUPEAU (Pr., Institut PPRIME)	Examineur
M. Guillaume PARRY (MCF HDR, Grenoble INP)	Directeur de thèse
M. Rafael ESTEVEZ (Pr. Université Grenoble-Alpes)	Co-directeur de thèse

Abstract : Thin film coatings submitted to high compressive stresses may experience a simultaneous buckling and delamination phenomenon called "blistering". The mechanism of formation and propagation of blisters in the form of straight wrinkles and circular blisters has been extensively studied in the literature considering a linear elastic behavior for the film. However, the effect of plasticity on the propagation and mechanical equilibrium of such blisters, although experimentally observed, had not been systematically studied to date.

In this work, we are interested in the observation and characterization of buckling structures observed on gold films deposited on silicon substrates. The effects of plasticity on the morphology or critical buckling load of buckled structures are quantitatively demonstrated using small scale surface observation techniques such as AFM, as well as mechanical testing by nanoindentation tests and stress measurement methods.

A mechanical model is developed in order to model the film as a geometric nonlinear plate with elastic-plastic behavior in unilateral contact with a rigid support representing the substrate. In addition, a cohesive zone model is introduced between the plate and the support in order to take into account the delamination of the film, with a separation work depending on the mode mix of the interface loading.

This model allowed us to highlight the effect of plasticity on the equilibrium profiles resulting from elastic-plastic blistering, for both straight and circular blisters morphologies. The effect on the offset of the critical buckling load has also been studied. Finally, the influence of plastic deformation on the propagation mechanism of the interfacial fracture itself has been studied. In particular, a stabilizing effect of the circular blister form, which has been observed experimentally in various studies, has been demonstrated through calculation.