

MASTER recherche
(2^{ème} année)
Proposition de stage 2008/2009

Laboratoire: Unité Mixte CNRS/Saint-Gobain (Surface du verre et interfaces (SVI) - UMR125)
Adresse: 39 quai Lucien Lefranc, BP 135 - 93303 Aubervilliers Cedex
Directeur du laboratoire : Elin SONDERGARD
Responsables du stage: Davy DALMAS et Jérémie TEISSEIRE
Téléphone: 01 48 39 57 55 (D. Dalmas), 01 48 39 57 52 (J. Teisseire), - **Fax :** 01 48 39 55 62
e-mail: davy.dalmas@saint-gobain.com

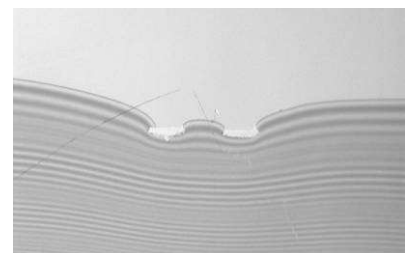
Titre du sujet proposé : Interfacial toughening by patterning in thin multilayer coatings: impact of pinning on adhesion

Projet scientifique :

Thin multilayer films deposited on glass are widely used for flat optical, photoelectric and electrochromic devices. In many applications, adhesion is a crucial issue in particular when mechanical strength is required for further processing or for integration in complex systems. Thus, the increase of interfacial adhesion presents a great interest and an important actual challenge.

Since the pioneer work of Gao and Rice (Gao and Rice, *J. Appl. Mech.*, 1989), the pinning theory has allowed to extend the linear elastic fracture mechanics to heterogeneous materials. Theoretical predictions advance that it becomes possible, with a judicious choice of heterogeneous toughness field, to obtain a material which will have a higher toughness than the simple mean value of the local toughness. The objective of this study is to apply those theoretical predictions to the toughening of thin multilayer coatings. One possible way to increase the adhesion of an interface between two brittle solids is to create a patterned interface in order to modify the crack front morphology due to pinning on region of higher toughness. This toughness modification is the consequence of a pinning regime which is characterised by a rapid change of the toughness in the direction of crack propagation. Some recent works realised in our laboratory (D. Dalmas, publication accepted in *JMPS*) has showed very attractive results.

In this context, the first part of this study will be dedicated to the experimental investigation of pinning by simple patterns. By using masks during magnetron sputtering and by recording crack front evolution during cleavage test (Barthel and al., *Thin Solid Films*, 2005), we will both study the effects of the different physical parameters involved in the toughening processes induced by pinning and develop a local measurement method of adhesion in pattern interface. Then, the second part of the study will be dedicated to the theoretical investigation of patterning effect on crack propagation. By using the values of adhesion between different layers (i.e. Ag, ZnO, Si₃N₄, Ti, Mo...) coming from the previous local measurements and crack pinning concepts, we will be able to propose judicious interfacial patterns (morphology, size, methods...) in order to strongly increase adhesion. A routine, already developed in collaboration with the SPCSI Lab in CEA Saclay, which allows predicting planar crack propagation in an heterogeneous material, will be used and further developed to design and optimize patterning before testing.



Techniques utilisées : Pulvérisation Magnétron, Microscopie (optique, AFM...), Clivage, Matlab, Igor...

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