

Size and structure dependent ductility, strength and toughness of thin hybrid Al/Al₂O₃ nanolaminated films

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The improvement of the thermomechanical performances of coatings is more than ever a major challenge in, among others, energy production, transportation, environment and biomedical engineering fields which many components undergo severe tribological solicitations. The durability of coatings often controls the durability of the devices and structures, hence their safety, efficiency and environmental impact. In this context, the emergence of 2D nanostructured coatings “nanolaminates” offers new degrees of freedom to produce high strength / high toughness films combined to other performances such as corrosion or irradiation resistance [1], [2]. The alternate combination of crystalline and amorphous layers has been proposed as one option to enhance the global wear resistance of thin films [3]. By carefully designing the mechanical properties mismatch as well as the interface strength between the materials' layers constituents, new combinations of ductility, strength and toughness can be attained offering ways to optimize the scratch, erosion and wear resistance under different operating conditions.

In this research, the focus is put on nanolayered Al/Al₂O₃ (crystalline/amorphous). The relationship between the film composition/structure and its mechanical properties is investigated through nano-indentation, micro-scratch, in-situ scanning and transmission electron microscopy (TEM) and lab-on-chip testing combined with numerical simulations. The mechanical behavior of individual layer is confronted to the tri-layers and n-layers systems to highlight the cooperative effects regarding the deformation and fracture mechanisms. In particular, we will show and explain the excellent ductility that can be attained with Al/Al₂O₃ stacks while maintaining high strength.

References

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