Mechanical study of nano-structured thin films under controlled biaxial deformation

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Abstract

Mechanical properties of thin films are of interest in a variety of technological applications. The mechanical behavior of thin films depends on microstructure (grain texture and size....). In order to mimic the actual loading conditions of those materials in use, we performed controlled biaxial deformation tests on composite such as metallic thin films deposited on polyimide substrate (Kapton). Here, we will present the results obtained for an equi-biaxial deformation test performed on a W/Cu nanocomposite thin film. This thin film elaborated by ion-beam sputtering is 150 nm thick (7 x (6 nm W+18 nm Cu). To perform this experiment, we used a biaxial tensile setup developed during an ANR project on the DiffAbs beamline at synchrotron SOLEIL [1]. During deformation, the applied in plane strains are measured both synchrotron X-ray diffraction (lattice strains) and digital image correlation (DIC macroscopic strains) techniques. The setup allows for plotting elastic lattice strains (in the crystalline phases of metallic thin film) versus macroscopic strains of the polymeric substrate [2].
We have highlighted three domains of deformation [3]:

Domain I : W and Cu thin films' elastic strains are equal to the macroscopic strain of the polyimide substrate. Thus, the strain is transmitted unchanged through the interface metal/polyimide : it corresponds to the elastic domain.

Domain II : The three components of the composite continue to deform but the macroscopic strain of the substrate is larger than the elastic strains of both thin films' components. The W component clearly strains to a larger extent than the Cu component. Does nanometric

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Cu show a plastic deformation? Microcracks initiation ?

Domain III : XRD strains for W and Cu component reach a plateau and/or slight decrease while macroscopic strain still increases : crack propagation regime

References

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