Université
franco-allemande
Deutsch-Französische
Hochschule

Title: Synthesis, structure and properties of zirconium-based binary alloy thin films

Abstract: In this thesis, we demonstrate that original nanostructures can be obtained by working around the crystalline-to-amorphous transition in sputter-deposited thin films. In particular, we study two systems, Zr-Mo and Zr-W, in which such transition occurs. By decreasing the Mo content in the Zr-Mo system, a structural transition from a nanocrystalline solid solution of Zr in the bcc lattice of Mo to an amorphous structure can be achieved around 60 at% Mo. The films obtained present high hardness H, low Young's modulus E and, consequently, high H/E ratio compared with bulk Zr and Mo. Furthermore, we demonstrate that a self-separation of the nanocrystalline and the amorphous phases occurs at the composition intermediate to those necessary to form single-phased amorphous and nanocrystalline films. The particular geometry in which the nanocrystalline phase grows in competition with the amorphous phase is exploited to achieve a thickness-controlled surface morphology which allows to tune the film reflectance. A model was developed to describe the kinetics of the competitive growth between the nanocrystalline and the amorphous phases. Furthermore, it allows to construct a thickness-composition phase diagram evidencing that the nanocrystalline/amorphous competitive growth is easily hidden experimentally. Finally, we demonstrate that massive monocrystalline grains with lateral size larger than 1 µm can be obtained by working at low Ar pressure if the composition of the films approaches to the edge of the amorphous transition. Our results suggest that the phenomena reported here for Zr-Mo and Zr-W can be extended to other systems.