MS43-P2 Investigation of thermal stability of Cu/W multilayers by in-situ x-ray diffraction

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Interfacial effects can dominate multilayer structure and properties leading to unusually large strains and frequently stabilization of metastable structures. The total Gibbs energy of nanomultilayered (NML) systems is indeed strongly governed by the excess energy contributions originating from the very high density of internal interfaces (i.e. grain boundaries and phase boundaries) [1]. Consequently, NML systems are intrinsically thermodynamically unstable, especially towards higher temperatures. Furthermore, the thermal expansion mismatch between the alternating nanolayers and the substrate can impose huge thermal stresses during heating which, if relaxed by plastic deformation, can also cause a degradation of the nano-laminated structure upon heating. In this work, we report on the delicate interplay between the (residual) stresses, texture, grain size and epitaxy in Cu/ W NML upon thermal treatment at different temperatures in a controlled atmosphere. Alternating nanolayers of Cu and W with individual thicknesses varied between 5-20 nm were prepared by magnetron sputter deposition on an Al_2O_3 (C- and R-oriented) and Si-substrate [2]. The thermal tability of Cu/W nano-multilayers up to 900 °C has been in-situ investigated by X-ray diffraction (see Figure). The individual layer thickness and the relative in-plane and out of plane orientations are found to have an important effect in the thermal stability of the system. The initial stress state of the multilayer can change considerably upon thermal annealing. The microstructure evolution upon heating is the result of the interplay between the thermally induced stress, including the role of the substrate, and the growth-related internal stress. Different techniques including high-resolution scanning electron microcopy, X-ray photoelectron spectroscopy were also employed to study the thermal effect on the morphology and microstructure. It follows that the individual layer thickness and (in-plane and out-of-plane) textures in the as-deposited state have a pronounced effect on the thermal stress evolution of the individual Cu and W nanolayers upon thermal annealing; i.e. the accumulated thermal stresses in the individual Cu and W nanolayers are superimposed on the intrinsic growth stresses and become relaxed at around *T*~750°C, which coincides with the thermal activation of W migration along internal interfaces (i.e. phase and grain boundaries) [2].

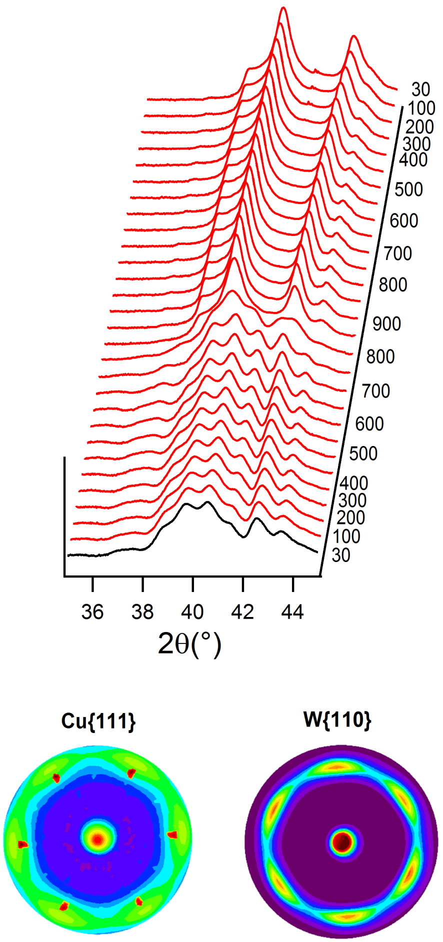

Figure 1. Structural evolution of W(110) and Cu(111) superlattice reflections upon thermal treatment (during heating from room temperature till 900°C and cooling). On the bottom, room temperature pole figures of Cu and W indicating precise crystallographic relation between the layers.

Keywords: X-ray diffraction, Microstructure, Morphological stability