DEFORMATION BEHAVIOR OF GOLD/COPPER MULTILAYER SYSTEMS

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Two sets of Au/Cu multilayers with a total thickness of 2 µm were deposited with magnetron sputtering onto Si/SiO_2 with an individual layer thickness of 250 nm and 25 nm. Subsets of the samples were treated with rapid thermal annealing (RTA) at temperatures of 300°C and 400°C for 60 s each to allow inter-diffusion and alloying at the Au/Cu interfaces. The mechanical behavior was evaluated by nanoindentation with a Vickers indenter at maximum loads of 20 mN to 500 mN. Cross sections of the nanoindentations were prepared by focused ion beam technique to investigate the deformation phenomena of the multilayer structure by scanning electron microscopy. In comparison of both, the 25 nm and the 250 nm structure, respectiveley, the latter shows a delamination near the indenter edge normal vector to the substrate surface, whereas the thin layers show buckling and shear banding as deformation mechanisms and no delamination occurs. The Martens hardness HM determined at a depth of 10 % of the total multilayer thickness increases from 1.8 GPa to 2.2 GPa with the annealing at 300°C for the 250 nm layers and to 2.9 GPa with the reduction of the layer thickness to 25 nm. X-ray diffraction patterns reveal a strong texture in <111> direction normal to the substrate surface and the formation of a Au-Cu solid solution phase during annealing. The decrease in individual layer thickness leads to a classic increase of the Martens hardness due to dislocation pile-up and a significant change in deformation behavior from dislocation plasticity to shear banding, which Li et al. [1] describe as buckling-assisted grain boundary sliding. After annealing, a notable increase of the hardness is observed for the 250 nm layers, while for the 25 nm layers it does not change significantly. Subsequent TEM investigations shall provide information on the processes in the layers and at the layer interfaces.

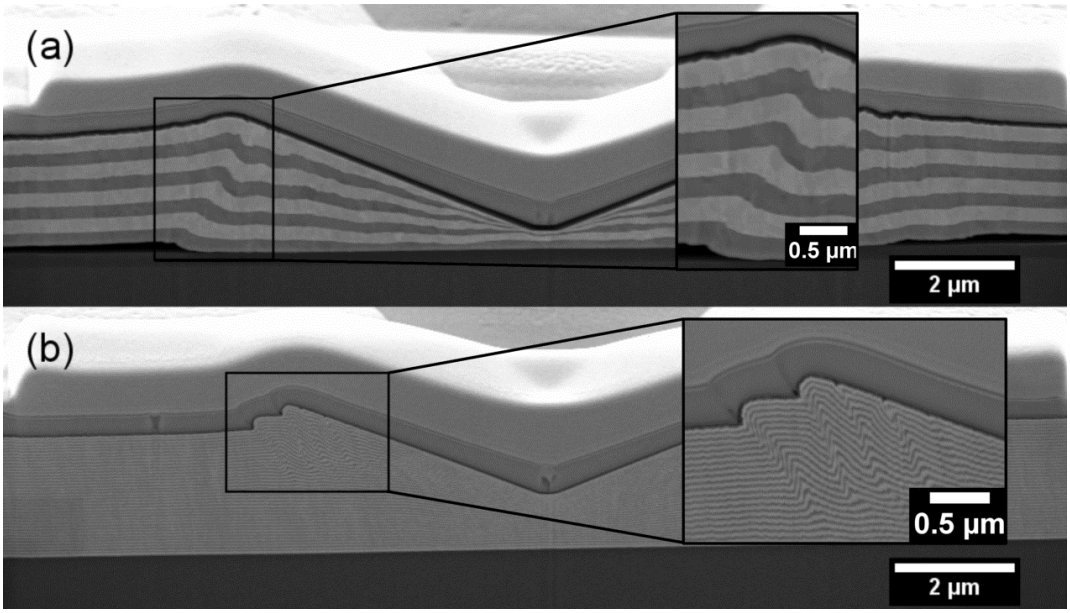

Figure 1 – FIB cross sections of Vickers nanoindentations with a maximum load of 200 mN in as deposited Au/Cu multilayers with individual layer thicknesses of (a) 250 nm and (b) 25

[1] Li YP, Zhu XF, Zhang GP, et al. Investigation of deformation instability of Au/Cu multilayers by indentation. Philos Mag. 2010;90:3049–3067