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Effect of Annealing Temperature on Microstructural Evolution of Nanoindented Cu/Si Thin Films

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Abstract : The nano-mechanical properties of as-deposited Cu/Si thin films indented to a depth of 2000 nm are investigated using a nanoindentation technique. The nanoindented specimens are annealed at a temperature of either 160 °C or 210°C, respectively. The microstructures of the as-deposited and annealed samples are then examined via transmission electron microscopy (TEM). The results show that both the loading and the unloading regions of the load-displacement curve are smooth and continuous, which suggests that no debonding or cracking occurs during nanoindentation. In addition, the hardness and Young's modulus of the Cu/Si thin films are found to vary with the nanoindentation depth, and have maximum values of 2.8 GPa and 143 GPa, respectively, at the maximum indentation depth of 2000 nm. The TEM observations show that the region of the Cu/Si film beneath the indenter undergoes a phase transformation during the indentation process. In the case of the as-deposited specimens, the indentation pressure induces a completely amorphous phase within the indentation zone. For the specimens annealed at a temperature of 160°C, the amorphous nature of the microstructure within the indented zone is maintained. However, for the specimens annealed at a higher temperature of 210°C, the indentation affected zone consists of a mixture of amorphous phase and nanocrystalline phase. Copper silicide (η-Cu3Si) precipitates are observed in all of the annealed specimens. The density of the η-Cu3Si precipitates is found to increase with an increasing annealing temperature.

Keywords : nanoindentation, Cu/Si thin films, microstructural evolution, annealing temperature
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