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Phase Evolution of Al/Cu/Co Thin Films into Decagonal Quasicrystalline Phases

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Quasicrystals have drawn increased scientific attention during the past decade not only for the purpose of fundamental research, but also due to their possible applications as bulk materials or thin films [1]. In particular, decagonal (d) quasicrystals could be very attractive because of their anisotropic structure being quasiperiodic in two dimensions and periodic in the third. Recently it has been shown that icosahedral quasicrystalline Al-Cu-Fe and approximant Al-Si-Cu-Fe thin films can be prepared by annealing a multilayer thin film on a sapphire or Si substrate, respectively [2]. In this work, multilayered Al/Cu/Co thin films have been deposited by magnetron sputtering onto Al2O3 (0001) and Si (001) substrates. The multilayers were produced with a multilayer period of 100 nm, repeated 3 times to a total thickness of 300 nm. The Al:Cu:Co layer thickness ratios were adjusted to obtain films with global compositions around the ideal decagonal quasicrystalline phase d-Al65Cu17.5Co17.5. The phase evolution during annealing, and the concurrent changes in film microstructure and crystal quality was investigated. The decagonal d-Al-Cu-Co and d-Al-Cu-Co-Si phases were both found by X-ray diffraction, electron diffraction, and high-resolution (scanning) electron microscopy to form at 500 °C on Al2O3 and Si, respectively, and at 600 °C these were the only phases present. Figure 1 shows the HRTEM micrograph of the Al-Cu-Co-Si phase after annealing to 700 °C. At increasing temperatures, the quasicrystal grains grew larger in size, up to 500 nm, and the Al-Cu-Co obtained a preferred orientation with the 10-fold periodic axis aligned with the Al2O3 substrate normal. The d-Al-Cu-Co phase persisted to more than 850 °C, with a complete 00001-texturing, while the d-Al-Cu-Co-Si phase was replaced by other crystalline phases at 800 °C. The d-Al-Cu-Co-Si phase was also observed to grow into the Si substrate by a solid-state diffusion reaction.

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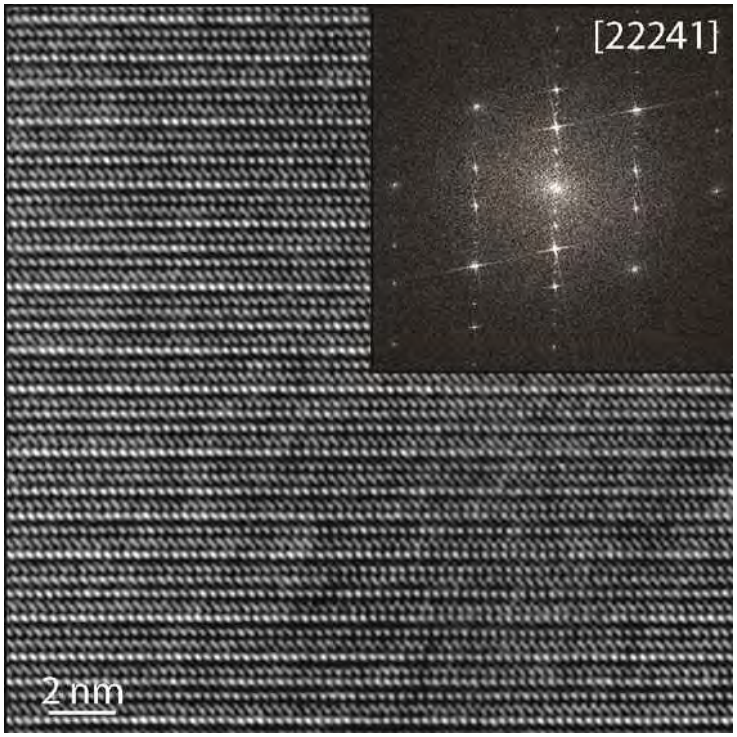

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