d-AlCoCu phase formation in alternating Al-Co-Al-Cu multilayers due to ion irradiation

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Ion-beam mixing induced quasicrystalline phases were studied predominantly in binary systems, such as Al-Mn [1, 2], Co-Cu [3], Fe-Cu [4] and Al-Fe [5], in multilayer structures composed of alternating layers of the constituting elements. In this work we focus on the formation and evolution of the d-AlCoCu quasicrystalline phase [6] in a ternary multilayer structure subjected to MeV heavy ion-beam irradiation at different temperatures. The samples were prepared using magnetron sputtering deposition of 26 alternating layers of Al, Co and Cu, with the overall chemical composition $Al_{64}Co_{16}Cu_{20}$, onto a monocrystalline Si (100) substrate, with Al always being the interlayer between Co and Cu as well as the bottom and the top layer. These were then subjected to 30 MeV Cu^{5+} ion irradiation with fluences from 1×10^{13} to 5×10^{14} ions.cm^{-2} at 300°C, 400°C and 500°C. The samples were analyzed by scanning electron microscopy (SEM), x-ray diffraction (XRD) and energy-dispersive x-ray spectrometry (EDS). Ion irradiation at fluences above 1×10^{14} ions.cm^{-1} caused mixing of Al with Co and Cu and dissolving the initial multilayer structure at 300°C. At 400°C and 500°C, however, an interface sharpening at the Co layers was observed, whereby this effect is more pronounced at higher temperature. The Al and Cu layers mixed well in any case. A possible explanation for this behavior is the evolution of the Al_2Cu phase with increasing temperature, which probably slows down Co diffusion into adjacent layers. Presence of the d-AlCoCu phase was confirmed by XRD in all samples irradiated with 5×10^{14} ions.cm^{-2} fluence. XRD peak heights and number of crystallographic orientations is increasing with temperature, which might indicate that increasing irradiation fluence and temperature could lead to a quasicrystalline film.

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This work was supported by the European Regional Development Fund, Research and Development Operational Programme under contracts ITMS:26220120048 and ITMS:2622022079, the Slovak Research and Development Agency under contract No. APVV-15-0049, the Grant Agency VEGA under contracts No. 1/0018/15, 1/0219/16 and 1/0330/18.