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Magnetic properties and structure of high-entropy $Co_{19}Cr_{18}Fe_{22}Mn_{21}Ni_{20}$ alloy films

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For a long time of the development of metallurgy, the majority of alloys are based on a single and sometimes two or three metals. However, due to the ever-growing needs of technology in improved structural and functional metallic materials, new technologies are steadily being developed, and advanced alloyed steels and alloys are being designed. The first works related to designing and complex study of a new class of materials, the so-called high-entropy multicomponent alloys (HEAs) were published in 2004. As a rule, these compositions comprise 5–13 principal elements, the concentrations of which are equiatomic or close to equiatomic (5–35%). Choosing a number of components and their concentration allows one to achieve an increased entropy of mixing, which remains not only in the melt but after solidification. Because of the high entropy, usually simple substitutional solid solutions with BCC or FCC crystal lattices are formed during the solidification of such alloys. The HEAs are characterized by a number of useful characteristics, such as hardness, wear resistance, resistance to oxidation, corrosion, and ionizing radiation, biocompatibility, and high thermal stability.

In this study, $Co_{19}Cr_{18}Fe_{22}Mn_{21}Ni_{20}$ HEA thin films have been synthesized by ion plasma sputtering of mosaic targets consists of pure metals. The deposition process was carried out at room temperature with pure Ar atmosphere, the working pressure was controlled at $5 \cdot 10^{-2}$ Pa. The deposition rate for the HEA thin film was 0.2 nm/s. The as-deposited HEA film thickness was estimated to be ~ 110 nm. Single diffuse halo is observed on the XRD patterns of the as-deposited films, that confirms their amorphous structure. After the heat treatment in vacuum at 600ºC, the $Co_{19}Cr_{18}Fe_{22}Mn_{21}Ni_{20}$ metallic film transforms from an amorphous form into a crystallized FCC solid solution structure with the lattice parameter a=0.3613 nm. The heating rate from room temperature to designated annealing one was 9 °C/min.

The magnetic properties of the films were measured by a vibrating sample magnetometer at room temperature with the *magnetic field applied* parallel to the film plane. The results clearly reveal a typical ferromagnetic behavior of both as-deposited and annealed films. The coercivity Hc was 5 Oe for the as-deposited, and 110 Oe for the annealed films, so they can be referred to soft magnetic and hard magnetic materials respectively.