Nanocomposites and nanomaterials

Structural-phase state, magnetic and magnetoresistive properties of three-layer films based on Ni and Dy

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Multilayer film systems based on rare-earth and ferromagnetic metals have been actively investigated since last decade, because of their practical use as high density materials for the information recording and storing, elements of spin electronics and magneto-optical systems.

The three-layer Ni (5) / Dy (x) / Ni (20) / S film systems (S – substrate, x – the effective Dy thickness, which varies from 1 to 30 nm) were obtained by the electron-beam method on a sital substrate and then were made their heat treatment to T_a = 700 K. The structural-phase state and the crystal structure were investigated using a transmission electron microscope (TEM-125K). A vibrating magnetometer was used to research magnetic properties in a parallel measurement geometry.

Researches of three-layer films based on Ni and Dy showed that the phase composition before and after heat treatment was determined by the phase composition of the individual components of the film. So Ni layers had fcc phase composition, which persists after heat treatment to 700 K. Structural-phase state of the Dy interlayer was very sensitive to changes in the effective thickness and they had the kvaziamorphous phase state to $d_{Dy} < 15$ nm and the crystalline phase hcp-Dy with $d_{Dy} > 15$ nm. After the heat treatment to 700 K the oxide phase bcc-Dy_2O_3, formed by the interaction with atoms of the residual atmosphere, was recorded.

The magnetoresistive properties research showed the anisotropic character of the magnetoresistance (MR) regardless of the Dy layer effective thickness value. Values of the MR by changing the effective thickness had oscillating character due to oscillating dependence of the exchange interaction between the magnetic layers through the conduction electrons. After treating the MR value decreased by 5-10 % for all measurement geometries.

The heat treatment to 700 K leads to decrease in the M_r and M_s by 5 and 8%, respectively. The increase in the Dy layer effective thickness leads to a decrease in residual and saturation magnetizations due to the formation the ferrymagnetic amorphous solid solution on the interface, not registered by the TEM.