Phase Composition and Structure of Ultrathin Nanocrystalline Cu-Ni Film Alloys

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The abstract is devoted to the study of morphology, crystal structure and phase composition of thin-film Cu-Ni alloys. Films with thicknesses up to d = 10 nm and concentrations 0 < Cu < 100 at.% were obtained in a VUP-5M vacuum unit at a residual gas pressure of $\sim 10^{-4}$ Pa and room temperature (300 K) of the substrate by the method of separate simultaneous evaporation of the components . The resistive heating method was used to evaporate Cu, and the electron-beam method was used to evaporate Ni. The films condensed at a rate $\omega \geq 1$ nm/s. NaCl cleavages with a thin layer of carbon were used as substrates for electron microscopic studies (to eliminate the orienting effect of a single-crystal substrate). The film thickness was measured by the microinterferometric method with an error of 5-10%. The concentration of the film alloy components was determined by X-ray microanalysis. Electron microscopic and electron diffraction studies were carried out using a PEM-100-01 electron microscope.

The resulting ultrathin alloy films have an fcc lattice with a parameter from a = 0.352 nm to a = 0.362 nm, depending on the concentration of the components. The formation of the fcc alloy occurs already at the stage of condensation, which is confirmed by electron diffraction. It's noted that the lattice parameter in films is somewhat larger than in bulk samples. This increase can be explained both by the infiltration of atoms from the residual atmosphere into the crystal lattice of the alloy, and by the fact that the atoms of one of the alloy components during condensation can occupy positions that do not correspond to an ordered alloy.

The investigated ultrathin samples of the Cu-Ni alloy are islands, with the sizes of individual islands 0.5-2 nm in the unannealed state and up to 20 nm in the annealed state, depending on the thickness of the sample. For them, the crystal lattice parameter is 0.002-0.003 nm smaller compared to bulk samples. There are a large number of experimental works in the literature, where it is shown that in island films of pure fcc metals, depending on the conditions of preparation, the lattice parameter can be either smaller or larger compared to the lattice parameter of bulk metal, increasing or decreasing with increasing island size. However, under conditions where the influence of gas impurities is minimized, the lattice parameter always decreases with decreasing particle size.

Keywords: Ultrathin Films, Island Films, Alloy Films, Phase Composition, Crystalline Structure.

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