Enhanced Solid-State Solubility of Components in Nanosized Au-Ni Film System

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To control structure and properties of binary systems, which are widely used in modern technologies, it's crucial to understand the nature of interaction between components. Such interplay is commonly described by a phase diagram. To this moment, it has been found that main boundaries of a phase diagram shift to lower temperatures with the characteristic size reduction. For instance, eutectic melting temperature lowering and liquidus and solidus lines offset have been predicted for nanosystems. However, there are virtually no reliable experimental data on regularities of formation of solid solutions in binary nanosystems.

In this work we present the results of *in situ* TEM studies of formation of solid solutions in Au-Ni nanoscaled films with entire thicknesses of 140 and 25 nm. This binary is characterized by a cigar-type phase diagram with a minimum and a broad miscibility gap in the solid state at a temperature below 807°C. Besides, the components of the system have the same type of crystal lattice, the parameters of which differ significantly from each other (0.408 nm for Au and 0.3524 nm for Ni). Bilayer film Au (30 ат.%) – Ni was produced in a vacuum of $1\cdot10^{-7}$ torr by sequential electron-beam evaporation of the components from independent sources. The components thicknesses ratio corresponded to the composition with the maximum temperature stability of the two-phase region of the phase diagram. *In situ* TEM heating of the film system was performed in the temperature range 20–850°C with a step of 25°C. At each temperature, the film system was maintained for 3–5 min to reach thermodynamic equilibrium. Then, the system state was registered by means of fast electron diffraction and concentrations of solid solutions were calculated according to the Vegard's rule. Electron diffraction studies during *in situ* TEM heating of the layered films also enabled to trace the kinetics of solid solutions formation in a wide temperature and concentration ranges.

In summary, as a result of performed investigation the curve bounding the two-phase region in solid state on the phase diagram was sketched for Au-Ni film with entire thickness of 140 nm. It was shown that obtained data are in good agreement with published data. Moreover, it was found that the formation of solid solutions based on nickel and gold occurs immediately throughout the entire film thickness during heating. For the system with the thickness of 25 nm the two-phase region on the phase diagram narrows and shifts to lower temperatures. This fact clearly indicates an increase in the mutual solubility of the components with in the characteristic size reduction.