Mutual Solubility in Thin Cu-Pb Film

Petrushenko S.I., Dukarov S.V., Sukhov V.N.,. Churilov I.G.

V. N. Karazin Kharkiv National University, Kharkiv, Ukraine

Understanding of changes in the solubility with transition from bulk samples to nanoscale ones is of great practical importance. In particular, the stability of microelectronic devices depends on the mutual solubility of the components from which they are made.

It has been found that small addition of lead (about 0.3 at.%) significantly reduces the disintegration temperature of continuous polycrystalline copper films to the island ones. The observed collapse of continuous copper films is probably caused by the acceleration of the mass transfer of copper, with the appearance of liquid lead on its surface. However, in accordance with literature data the solubility in the bulk is negligible in this system; it is less than 0.09 at.% at 900 K. This work is devoted to studying the mutual solubility in Cu-Pb binary system, in which one of the phases is in a highly dispersed state. Multilayer Cu-Pb films, produced in a vacuum of 10^{-6} torr, have been chosen as an object under study. The films were studied by electron diffraction during heating and cooling directly in an electron microscope. The value of the solubility was determined in accordance with Vegard's law. Such calculation was based on a change of the lead lattice parameter, with respect to the copper lattice parameter. To take into account the influence of the lattice parameter thermal expansion, we used Cu-C-Pb standard, which was produced in the same experiment. The thick carbon layer separated the metal layers and, as a result, served to prevent the interaction between components.

In summary, it was shown that up to temperatures of 400-420 K the lattice parameters of the component in Cu-Pb films and Cu-C-Pb standard are equal. However, with increasing temperature, we observed the solubility rise, which is linear in a first-order approximation. The mutual solubility reached 0.8 at.% near the melting point of lead. This value is at least one order of magnitude greater than one of Cu-Pb bulk.