Eutectic Temperature Lowering in Nanoscaled Ag/Ge Films

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Multi-layer and multi-component films are essential to a number of modern technologies. However, for successful application of such systems it's vital to understand the nature of components interaction. This becomes crucial with reduction the components size since it leads to a significant change of multicomponent system properties and to an emergence of new ones. Unfortunately, fundamental understanding of the phase diagrams at nanoscale is currently insufficient. Available experimental data are scant and don't allow to trace phase diagram evolution in an entire size range. Moreover, further investigation becomes actual since our recent studies have shown that below a threshold size of Sn-Bi and Au-Ge binary systems the melting at the eutectic temperature doesn't occur [1, 2].

In this work we present the results of systematic experimental studies of the effect of scale on the eutectic melting in Ag-Ge binary system.

Layered Ag/Ge film is a convenient model object for the phase transitions in binary nanosystems studying. Thus, it was chosen as the object under study. Ag and Ge form the phase diagram of a simple eutectic type with a rather restricted solubility in solid state. The eutectic composition is formed at 24.5 at.% Ge and the temperature of 651°C. Terminal solubility of germanium in silver achieves 9.6 at.% at the eutectic temperature, while at room temperature it doesn't exceed 0.1 at.%. Solubility of silver in a solid germanium is negligible.

We have used two experimental approaches on studying the eutectic temperature in Ag-Ge layered films. The first method involves the study of crystalline structure of the film during *in situ* TEM heating. The second one is based on the detection of abrupt change in the morphology of the film system under melting. The samples were produced at room temperature by sequential thermal evaporation of components from independent sources at a vacuum of $5 \cdot 10^{-8}$ Torr.

In summary, the Ag/Ge eutectic temperature T_E as a function of Ag film mass thickness (1-50 nm) has been systematically measured. Few hundreds degrees lowering of T_E with the thickness reduction was registered. It has been revealed that the liquid-phase formation in the system at the eutectic temperature takes place only if the silver film mass thickness value are greater than the critical one (1.2 nm). While the onset temperature for liquid phase formation at the metal-semiconductor interface was found as 200°C.

1. A.P. Kryshtal, R.V. Sukhov, A.A. Minenkov, *Journal of Alloys and Compounds,* **512**, (2012), 311.
2. N.T. Gladkikh, A.P. Kryshtal, R.V. Sukhov, *Physics of the Solid State,* **52.** (2010), 633.