Density of liquid eutectic Pb–Bi alloy at high temperatures

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Previously [1–3], results were given of measurements of the density of a lead-bismuth eutectic in the condensed state in the range from room temperature to 740 K. The investigated alloy was prepared by the weighing method from highly pure lead and bismuth. The content of its main components was as follows: 44.6 wt. % Pb and 55.4 wt. % Bi. The error of this chemical analysis was ±0.2 % by mass.

The gamma ray attenuation technique was used to investigate the density of molten lead-bismuth eutectic. An improved gamma densimeter made it possible to stir the high-temperature melt and monitor the gradient of its density over the crucible height. A $^{137}$Cs isotope with an activity of about 250 GBq was used as the source of $\gamma$-quanta. The sample temperature was measured by a Pt–Pt+10%Rh thermocouple.

The processing of the experimental data on the density of lead-bismuth eutectic in the solid and liquid phases resulted in finding appropriate approximating equations and in determining the melting point of this eutectic as well as the density change during melting. This was followed by two new series of experiments with the samples of Pb–Bi alloy of the same composition as in works [1–3]: one series – with decreasing temperature, and the other series – with increasing temperature. The investigation was performed in the temperature range from 401 to 1225 K. The confidence error of the measurement results, made up by the systematic and random components, did not exceed 0.3–0.4 %. The new experimental data were processed using the least squares method, and an approximating equation was derived for the density of molten lead-bismuth eutectic in the range from the melting temperature to 1300 K:

$$\rho(T) = 10524.6 - 1.3571 \cdot (T-397.9) + 1.69 \cdot 10^{-4} \cdot (T-397.9)^2$$

where $\rho$ is in kg/m$^3$, $T$ is in K according to the 1990 International Temperature Scale, and $T_{mp} = (397.9\pm0.2)$ K is the melting point of the lead-bismuth eutectic [3]. The standard deviation of experimental points from this equation was approximately 0.1%. The results of high-temperature measurements agree well with the “low-temperature” experimental data of Refs. [1–4].