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Experimental Investigation of the Thermal Conductivity of Neodymium and Samarium Melts by a Laser Flash Technique

Authors : Igor V. Savchenko, Dmitrii A. Samoshkin

Abstract : The active study of the properties of lanthanides has begun in the late 50s of the last century, when methods for their purification were developed and metals with a relatively low content of impurities were obtained. Nevertheless, up to date, many properties of the rare earth metals (REM) have not been experimentally investigated, or insufficiently studied. Currently, the thermal conductivity and thermal diffusivity of lanthanides have been studied most thoroughly in the low-temperature region and at moderate temperatures (near 293 K). In the high-temperature region, corresponding to the solid phase, data on the thermophysical characteristics of the REM are fragmentary and in some cases contradictory. Analysis of the literature showed that the data on the thermal conductivity and thermal diffusivity of light REM in the liquid state are few in number, little informative (only one point corresponds to the liquid state region), contradictory (the nature of the thermal conductivity change with temperature is not reproduced), as well as the results of measurements diverge significantly beyond the limits of the total errors. Thereby our experimental results allow to fill this gap and to clarify the existing information on the heat transfer coefficients of neodymium and samarium in a wide temperature range from the melting point up to 1770 K. The measurement of the thermal conductivity of investigated metallic melts was carried out by laser flash technique on an automated experimental setup LFA-427. Neodymium sample of brand NM-1 (99.21 wt % purity) and samarium sample of brand SmM-1 (99.94 wt % purity) were cut from metal ingots and then ones were annealed in a vacuum (1 mPa) at a temperature of 1400 K for 3 hours. Measuring cells of a special design from tantalum were used for experiments. Sealing of the cell with a sample inside it was carried out by argon-arc welding in the protective atmosphere of the glovebox. The glovebox was filled with argon with purity of 99.998 vol. %; argon was additionally cleaned up by continuous running through sponge titanium heated to 900–1000 K. The general systematic error in determining the thermal conductivity of investigated metallic melts was 2–5%. The approximation dependences and the reference tables of the thermal conductivity and thermal diffusivity coefficients were developed. New reliable experimental data on the transport properties of the REM and their changes in phase transitions can serve as a scientific basis for optimizing the industrial processes of production and use of these materials, as well as ones are of interest for the theory of thermophysical properties of substances, physics of metals, liquids and phase transformations.

Keywords : high temperatures, laser flash technique, liquid state, metallic melt, rare earth metals, thermal conductivity, thermal diffusivity
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