Study of Features of Producing Nanopowders of Refractory Oxides by Laser Technology

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There are many different methods for producing various nanopowders. However, obtaining nanopowders of refractory oxides of spherical forms with narrow size distributions is a complicated problem. In the present paper, the process of forming nanoparticles of refractory oxides (UO_2, Al_2O_3, Y_2O_3, CeO_2) in an electromagnetic field has been experimentally studied by a laser heating technique. The sample investigated was located in the center of the working chamber filled by inert gas and heated by a powerful laser beam to high temperatures. The heating curves of the sample have been recorded by a high speed micropyrometer. Spectral reflectivity and emissivity of the sample surface have been measured by the probing flash method. In studying the laser evaporation of the samples in the chamber filled by inert gas, the following features of this process have been discovered for the first time: a) the spherical nanoparticles with determined sizes are formed in the small zone above the sample surface in its laser evaporation; b) the limitation in sizes of the nanoparticles are connected with the features of the homogeneous condensation of the evaporating particles in the electromagnetic field; c) size distribution of the nanoparticles depends on the following factors: pressure level of the inert gas in the chamber, power density of the laser radiation and the size of the heating zone on the sample; d) the process of forming the nanoparticles are manifested on the heating curves as a sharp drop in sample temperature due to the avalanche growth of the nanoparticles above the sample; e) forming the nanoparticles is exhibited as a threshold process occurring at the temperature which depends on the rate of laser heating and the pressure level of inert gas in the chamber. Heterogeneous condensation of these particles on the sample surface is observed during the sample cooling after the laser switching off and manifested as the exothermal peak on the cooling curves. The vapor condensation takes place at various temperatures depending on the experimental conditions and the “floating” of the condensation peak on the cooling curve has been observed. It has been discovered that there is a correlation between the process of the sample cooling after the laser switching off and the conditions of laser heating the sample investigated. The true temperatures of these “floating” phase transitions depend on the sample heating and its cooling rate. Upon increasing the heating rate, the temperature of the heterogeneous condensation increases as well. The possibility of changing the temperature of the heterogeneous condensation enables one to regulate and control the process of modification of the sample surface. A model describing the above mentioned features of forming and behavior of the nanoparticles in an electromagnetic field has been presented.

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