RECENT ADVANCES IN STUDY OF HIGH-TEMPERATURE BEHAVIOR OF NON-STOICHIOMETRIC TaC_x, HfC_x AND ZrC_x IN THE DOMAIN OF THEIR CONGRUENT MELTING POINT

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Melting behavior of nonstoichiometric carbides of tantalum and hafnium remains one of the most challenging tasks in the high-temperature materials science despite the fact that the first studies of melting of these compounds are dated back to the beginning of 60's. However, the data on melting points of tantalum and hafnium carbides in the vicinity of their homogeneity domain are still very contradictory. Zirconium carbide is a more studied compound, which makes him a sort of the reference material for testing the method of investigation, since its melting point is substantially lower. But even for this material, the data on its solidus and liquidus parameters look very incomplete and need to be clarified.

In present study the parameters of the solidus and liquidus line for TaC_x, HfC_x and ZrC_x are studied using laser heating technique similar to what described in [1]. A special emphasis is given on the accurate measurement of temperature and determination of spectral emissivity in course of the experiment using advanced multichannel pyrometry. The phase transitions corresponding to solidus and liquidus are determined by means of the laser-probe reflectometry, peculiarities in spectral emissivity behavior in the vicinity of the phase transitions and by high-speed video recording of the melt formation and freezing. New data on solidus and liquidus parameters for the Zr-C system in the homogeneity domain are presented. The temperatures of congruent melting of super-refractory carbides TaC and HfC are determined along with the data on their solidus and liquidus lines close to the congruent composition. The measured melting point of HfC was found to be close to the value given in a recent paper [2], whereas the melting point of TaC, according to the data of the present study, exceeds the value given in [2] by more than 150 K.

The second part of the study concerns evaporation of UHTC carbides and focused at significant extension of the temperature domain limited earlier to ca. 3000 K. In the present study the method and apparatus used for determination of the composition of carbon vapor presented in [3] were significantly improved in order to make a further considerable extension towards extremely high temperatures. Due to some major improvements in the design of the TOF mass spectrometer, time-shape of the laser pulse and pyrometer time resolution the vapor composition at laser-induced evaporation of zirconium carbide samples of various starting composition within the homogeneity domain ranging from $ZrC_{0.65}$ to $ZrC_{1.0}$ were investigated up to 4500 K. Thus, molecular composition in vapor during evaporation of liquid ZrC_x was obtained for the first time. The conditions of congruent evaporation of liquid zirconium carbide are estimated using the experimental data.

References

1. Manara, D., Sheindlin, M., Heinz, W. & Ronchi, C. New techniques for high-temperature melting measurements in volatile refractory materials via laser surface heating. The Review of scientific instruments 79, 113901, (2008).
2. Cedillos-Barraza, O. *et al*. Investigating the highest melting temperature materials: A laser melting study of the TaC-HfC system. Sci. Rep. 6, 37962, (2016).
3. Pflieger R., Sheindlin M., Colle J.-Y. Advances in the mass spectrometric study of the laser vaporization of Graphite. J. Appl. Phys. 104, 054902 (2008).

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