Calculations of thermophysical properties of low-temperature carbon plasma

Apfelbaum E.M.

Joint Institute for High Temperatures, Russian Academy of Sciences, Moscow, Russia, [apfel\_e@mail.ru](mailto:email@email.ru)

The thermophysical properties of plasma (equation of state and electronic transport coefficients) play important role in various fundamental tasks and application. Their study for the low temperature plasmas of metals and semiconductors is of especial difficulty, because, contrary to the case of gases, these plasmas are located under relatively high temperatures (higher 5kK), where the measurements are difficult to carry out. There are some obstacles for theoretical models as well, especially when the density is growing up to the values ~0.1 of the density at ambient conditions. For this case the interparticle interaction becomes important [1]. The study of carbon properties on this background is appeared to be even more difficult, because it is the only one element of the periodical table for which the meting temperature has not been measured up to now.

However, there several types of models for carbon and other substances, created to descrive various matter properties (including the thermophysical ones) over the wide range of parameters, captured the region of low-temperature plasma. For carbon it is the region of the temperatures 10–100 kK and the densities lower than 0.5 g/cm3 (the graphite density under ambient conditions is 2.25 g/cm3). The *ab initio* simulations as well as the average atom models and the chemical models belong to this number (see, for instance, [2]). Besides, during recent two dozen years new measurements have appeared exactly for this area [3, 4]. They allow us to specify the existing models and obtain new information.

Earlier we have developed a model to calculate the considered properties (pressure, internal energy, electrical conductivity, thermal conductivity, thermal power) for the low-temperature plasma of some metals and semiconductors [5–8]. It was successfully applied to plasma of such elements as Fe, Ni, B, Si and others. The chemical approach was used to obtain the thermodynamics and ionic composition of considered substances for given density and temperature. The relaxation time approximation, in turn, for known composition have allowed us to calculate the tranport coefficients. Presently this model was modified to apply it to the low-temperature plasma of carbon under the parameters pointed out above. The results of calculations by means of present model were compared with the data of measurements and calculations of other authors.

References

1. Fortov V. E., Yakubov I. T. Physics of Non-Ideal Plasmas. Hemisphere Publishing, New York, 1990.
2. Clerouin J., Noiret P. et. al., Phys. Plasmas, (2012) V. 19, 082702.
3. Haun J., Kunze H.-J., Kosse S., Schlanges M., Redmer R., Phys. Rev. E, (2002) V. 65, 065407.
4. DeSilva A. W., Vunni G. B., Phys. Rev. E, (2009) V. 79, 036403.
5. Apfelbaum E. M., Contrib. Plasma Phys., (2013) V.53, 317.
6. Apfelbaum E. M., Phys. Plasmas, (2015) V. 22, 092703.
7. Apfelbaum E. M., Contrib. Plasma Phys., (2016) V.56, 176.
8. Apfelbaum E. M., Phys. Plasmas, (2018) V. 25, 072703.