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CALCULATION OF THERMOPHYSICAL PROPERTIES OF LOW-TEMPERATURE TIN PLASMA *)

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Investigations of thermophyical properties (thermodynamical and electronic transport coefficients) are necessary for very different fundamental and applied problems in various area of physics, including the plasma physics as well [1]. That is why corresponding studies are continued for more than in century. So presently there are necessary data for many substances in different areas of the phase diagra. including the problematic for measurements regions, such as the plasma region [2]. However there are the substances for which appropriate data are still absent in simr regions of the phase diagram. In particular, tin is an example of such a substance and namely in the low-temperature plasma (LTP) region.

Tin (Sn) has a relatively low melting temperature T_m =505.08 K. So the considered properties for Sn in the liquid state had been measured with good accuracy already half-century ago [3] up to approximately the boiling temperature T_{Boil} =2875 K. There are also the most modern and recent calculation data, including the *ab initio* ones, which give rise to the very accurate phase diagram of Sn at high pressures (crystal phases and melting) [4]. But under elevated T there are much less both calculation and experimental data. In particular, there are the shock wave measurements at the densities of the order of the normal one, i. e. $\rho \sim \rho_n$= 7.265 g/cm^3 [5] and the data of the spectroscopic measurements [6]. But the binodal position is still unknown, whilefor the critical point (CP) there is only separate estimates: T_{CP} ~ 7-8 кК, ρ_{CP} ~ 2-3 г/см^3 [7]. After all, in the range T = 5-100 кК и $\rho \le \rho_{CP}$ (i. e. within LTP area for the most of metals) there are no any published data both in measured and calculated. Moreover, Sn gets namely in LTP region in lithography (the technological process!), where one should still use the semi-empirical correlations to describe the necessary thermophysical properties - the equation of states and the thermal conductivity [8].

Previously we have developed a model to calculate the considered properties in LTP. It is constructed on the chemical approach for thermodynamics and the relaxation time approximation for the electronic transport coefficients. The modes was successfully applied to a number of metals and semiconductors, see, for instance, [9]. In present study we have modified the parameters of the model to use it for Sn. We have carried out corresponding calculations. Due to the absence of any other data we have compared the results of our calculations with the results of semi-empirical models and good agreement was obtained.

References

[1]. Fortov V.E., Yakubov I.T., Khrapak A.G. Physics of strongly coupled plasma. Oxford : OU:, 2006.
[2]. Stanek P.E. et. al. Phys. Plasmas 2024, V. 37,100905.
[3]. Crawley A.F. Int. Met. Rev. 1974, V. 19, 32.
[4]. Chen T. et. al. Phys. Rev. Mat. 2023, V. 7, 053603.
[5]. Zhernokletov M.S. et. al. Combustion. Explosion and Shock Waves 2012, V. 48, P. 112.
[6]. Harilal S.S., O'Shay B., Tillak M.S. J. Appl. Phys. 2005, V. 98, 013306.
[7]. Fortov V.E., Dremin A.N., Leont'ev A.A High Temp. 1975. V. 13,. P. 984.
[8]. Basko M.M., Novikov G., Grushin A.S. Phys. Plasmas 2015, V. 22, 053111.
[9]. Apfelbaum E.M., Phys. Plasmas. 2023, V. 30, 042709.
[10]. Khishenko K.V., J. Phys.: Conf. Ser. 2008, V. 128, 022025.

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