Homogeneous nucleation in liquid carbon obtained by laser pulse melting of graphite

Lysenko I.Yu., Basharin A.Yu.*, Turchaninov M.A., Dozhdokov V.S.

Joint Institute for High Temperatures, Russian Academy of Sciences, 125412 Moscow, Russia
**e-mail: ayb@iht.mpei.ac.ru*

The homogeneous nucleation in supercooled melts of metals and alloys is known to be a source of metastable solid phases and to be observed in pure melts only. Graphite is the most high-melting of the materials known nowadays, and, additionally the pressure in the first carbon triple point exceeds 10 MPa. That's why there is a limited number of graphite melting methods: in the most cases laser and ohmic heating are used. Both of these methods do not allow to reach uniform sample melting what in turn causes its contamination by unfused graphite. During the melt cooling the presence of graphite leads to the heterogeneous nucleation in the liquid and growing of the only graphite. This paper considers the conditions of the homogeneous nucleation in a melt, which forms metastable carbon phases at a laser pulse melting of high-oriented graphite HOPG. The cooling rate in this process exceeds 10^6 K/s [1].

Melting of HOPG in helium showed the melt formed on the close-packed graphite basal plane face not to be supercooled. It solidifies in a form of layered spiral vicinal hillocks or echelons of elementary steps with step height equal to the ***c*** parameter of the graphite lattice (0.67 nm). They grow on screw dislocations formed in the premelting stage at the graphite plastic deformation caused by thermal stresses

On the contrary, when heating up a loose prismatic HOPG phase there is no formation of dislocations, and the solidification pattern is determined by the surface electromagnetic waves (SEW)[1] appearing on the liquid surface. Appearing of SEW causes the rapid transfer of the laser radiation energy beyond the crater boundaries and the liquid supercooling due to the radiation-convective heat transfer. As a result, together with the heterogeneous crystallization on the melting puddle bottom there is a homogeneous nucleation on the melt surface. This is the only explanation of the appearance of metastable crystal forms, i.e. diamond and carbine found in the LIPSS zone by us in [2]. This suggests the energy barrier for metastable phases formation in a supercooled melt to be lower than that one for graphite. Possible origins of this phenomenon and its practical usage are discussed.

[1] Basharin A.Yu., Brykin M.V., Marin M.Yu., Pakhomov I.S., Sitnikov S.F., *Teplofis. Vys. Temp.* **42**, 64 (2004).

[2] Basharin A.Yu., Dozhdikov V.S, Dubinchuk V.T., Kirillin A.V., Lysenko I.Yu., Turchaninov M.A., *Pis'ma Zh. Tekh. Fiz.* **35**, 84 (2009).

[1]An indication of SEW are periodic surface structures (LIPSS), observed after the sample solidification