Flying bubbles—condensed products of alumina laser ablation

Larichev M N[1,@], Velichko A M[1], Belyaev G E[1,2] and Stepanov I G[1]

[1] N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences, Kosygina Street 4 Bldg 1, Moscow 119991, Russia
[2] Joint Institute for High Temperatures of the Russian Academy of Sciences, Izhorskaya 13 Bldg 2, Moscow 125412, Russia

[@] mlarichev@chph.ras.ru

The incongruence of evaporation of aluminum oxide under heating by a high-power pulsed CO_2 laser allows it to transform into a metastable superheated melt with a stoichiometry different from that in the unheated state. Of extreme interest are the relaxation processes occurring during cooling of the overheated melt. These processes have been studied at a specially constructed experimental vacuum setup equipped with a several diagnostic tools. Laser pulse irradiation ($\lambda = 10.6$ μm, $\tau = 1.2$ μs, the energy in the pulse up to 3 J) of sapphire samples in vacuum and at low pressures of Ar lead to the formation of the overheated melt. At that the temperatures of gaseous products of ablation (suboxide AlO) can reach 5000 K and of the glowing particles flying out from the laser crater—3000 K. The radiation of the particles may be continuous or oscillating. The trajectories of their flight are not always described by the laws of kinematics. It was found for the first time that the glowing particles can be either the droplets of overheated melt or the bubbles with the thickness of the wall up to 10–20 nm and the diameters from microns to several millimeters. The analyses shows that such bubble can be filled with volatile aluminum suboxides. One of the features of these bubbles is the increase of their dimension during fly. This indicates that at cooling of the shells the additional amount of suboxides is emitted. The discovered phenomenon can form the basis of a technology for the production of metal aluminum and oxygen on the Lunar surface by laser ablation of aluminum oxide from the lunar soil. It can be used to develop a new environmentally friendly technology for the production of metal aluminum on Earth.