Laser-Assisted Materials Processing from the Melt

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Photonic heating is increasingly gaining importance in materials preparation due to the possibility to create high temperature gradients, high heating and cooling rates and localized heating, which is virtually impossible with conventional resistive or inductive heating techniques. In materials engineering, laser-heated techniques have emerged due to the incessant search for energy efficiency and the reduction of costs in the preparation of new and conventional compounds and devices. Three main techniques that stand out for preparing compounds from the melt are the Laser-Heated Pedestal Growth (LHPG), the aerodynamic levitation and the surface heat treatment. The LHPG technique has been used to prepare a wide variety of oxide compounds (poly or single crystal form), in a conventional optical fiber shape. Its main feature, the steep temperature gradients at the solid-liquid interface (10^3-10^4 K/cm), also creates the conditions to grow single crystals from incongruently melting compounds, using stoichiometric sources. The aerodynamic levitation technique is a very important tool for the field of oxide glass and glass-ceramics materials. This technique can be used to prepare almost any glass oxide composition due to its high cooling rates and sample sizes (in the order of 10^3 K/s and millimeter range, respectively). Since these techniques are crucibleless, there is also virtually no limit to reach the liquidus temperature, expanding the range for materials exploration, which is usually determined by the crucible´s melting point. The last technique, surface heat treatment, besides its high heating and cooling rates, also enables a very localized heating, which is very interesting for glass and glass-ceramics materials processing. In this work, it will be presented an overview of the three technique and a discussion based on the its thermodynamics and kinetic features. Optical and structural characterizations of several oxide compounds produced from these techniques will be presented and discussed, including $Bi_{12}TiO_{20}$, $LiNbO_3$, $La_{0.56}Li_{0.33}TiO_3$ and Li_2O-CaO-SiO_2 glass system. Among the technological possible applications, the ultra-high temperature thermometry, medical devices and fuel cells will be discussed.