Identification and Control of Gravity Related Defect Formation During Melt Growth of Bismuth silicate ($Bi_{12}SiO_{20}$)

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In the light of strong indications that a majority of critical defects formed in BSO during growth is related directly or indirectly to gravitational interference, it is suggested to use the reduced gravity environment of outer space for experimentation directed at the identification and control of these defects. The results of these experiments are expected to lead to advances in our understanding of crystal growth-related defect formation in general and will establish a basis for effective defect engineering, the approach to efficient achievement of application specific properties in opto-electronic materials.

Program Details for Year 1

(1) Establishment of procedure for reproducible, seeded Bridgman-type growth of undoped and doped BSO single crystals (ground-based BSO standards);

(2) Determination, in a microgravity environment, of the wetting behavior of doped and undoped BSO melts in a Pt crucible confinement [it is considered essential that non-wetting conditions ($Q<90^o$) be established for a study of confinement related contamination and stress effects]; and,

(3) Implementation of comprehensive micro- and macro-scale crystal defect analysis for BSO.

Charge confinement system for vertical Bridgman growth of BSO

The confinement (crucible) system for BSO must provide for accommodation of a seed, reproducible geometry, chemical compatibility with the charge, and minimized thermal conductance along the crucible wall. The corrosive nature of BSO melts dictates charge confinement through an appropriately shaped platinum ampoule. Preliminary experiments showed that such crucibles without support structure are substantively deformed during removal of grown crystals and thus preclude reproducibility of growth conditions. Preliminary experiments with vacuum deposited Pt liners and Pt paint liners in silica shells were negative, exhibiting pinholes and inadequate adhesion, respectively. It is concluded that (solid) Pt-liners (0.2 mm thick) are to be used in cylindrical configuration, with single crystal charges of constant diameter.

Exploratory Space Experiments

Determination of the wetting behavior of molten charges in a microgravity environment

It has now been established that the wetting behavior of molten charges is sensitive to the oxygen partial pressure and for space experiments not predictable from charge confinement interaction in ground-based tests. Therefore, the chemical compatibility between crucible and charge, the wetting behavior in a microgravity environment, is to be investigated for doped BSO in atmospheres of various oxygen partial pressures. The application of a dissolution retarding electrical potential between the crucible and the molten charge may be considered in ground-based studies, if conventional confinement is found to be “wetting” for the proposed systems. Results of space experiments and theoretical studies [R. Duffar *et al*., *J. Cryst. Growth*, 100, 171 (1990)]

suggest, moreover, consideration of profiled crucible surfaces to minimize the crucible-melt contact area.

The proposed experiments can be conducted in a sealed cartridge using a tube furnace at about 1000 °C minimum temperature stabilization and power-off cool down ramping.

Data thus obtained on the wetting behavior of BSO (and on heat pipe action if available) will provide fundamental viability criteria, and together with data from growth experiments on the ground, will provide the basis for optimized experiment design. It is re-iterated: emphasis at this stage is not placed on the achievement of superior perfection in the solid state; rather, it is placed on the optimization of space experiments.

Ground-based vertical Bridgman growth of BSO

A heat pipe-based vertical Bridgman-Stockbarger crystal growth system has been developed which permits growth interface demarcation, stabilization of the crystal melt interface position, growth at fixed axial thermal gradients, and is compatible with the infrastructure of NASA's CGF system. It is proposed that this system provide the basis for the ground-based research program. The requirement of a Pt liner for charge confinement does preclude the application of current pulsing for interface demarcation in ground-based experiments. Verification of the functionality of the heat pipes (equality of the growth rate with the charge displacement rate, establishment of radially symmetric growth interface morphologies) is therefore to be established (at decreased resolution) through thermal pulsing and the post-growth identification of related growth striations, which are revealed through interference contrast microscopy (reflection mode) in the wavelength range from 450 to 500 nm.