Bridgman Growth of Germanium and Germanium-Silicon Crystals under Microgravity

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Four different Bridgman growth experiments on Ge:Ga and Ge_xSi_{1-x} were performed under microgravity during the FOTON M4 flight in fall 2014 as joint German-Russian experiments. The experiments were also part of the RDGS/ICESAGE project(s) of ESA/NASA on detached growth of Ge and Ge-Si. Three experiments on Ge:Ga investigated different heat and mass transport regimes, i.e. mostly diffusive conditions, flows driven by a rotating magnetic field, and flows driven by vibration. The fourth experiment on $Ge_{0.98}Si_{0.02}$ investigated detached growth. All four experiments were successful and yielded crystals. Both the Ge-Si experiment and two of the Ge:Ga experiments showed stable detachment from the ampoule wall, although this was not planned for the latter two experiments. The influence of the rotating magnetic field as well as of the vibration was pronounced in the case of the µg experiments, but dominated by buoyancy convection under 1g.

Influencing heat and mass transport by external forces during melt growth is an important tool in crystal growth. Processing under microgravity conditions allows to separate the effects of these forces from natural convective flows and their influence on segregation. Rotating magnetic fields have been used for quite a while whereas vibration is a rather new tool. The vibration experiments showed a very interesting influence on the segregation profile under µg that cannot be explained by either complete mixing profile (fig. 1) or diffusive conditions. Under 1g, the segregation profile essentially followed the Scheil equation, regardless of the vibration.

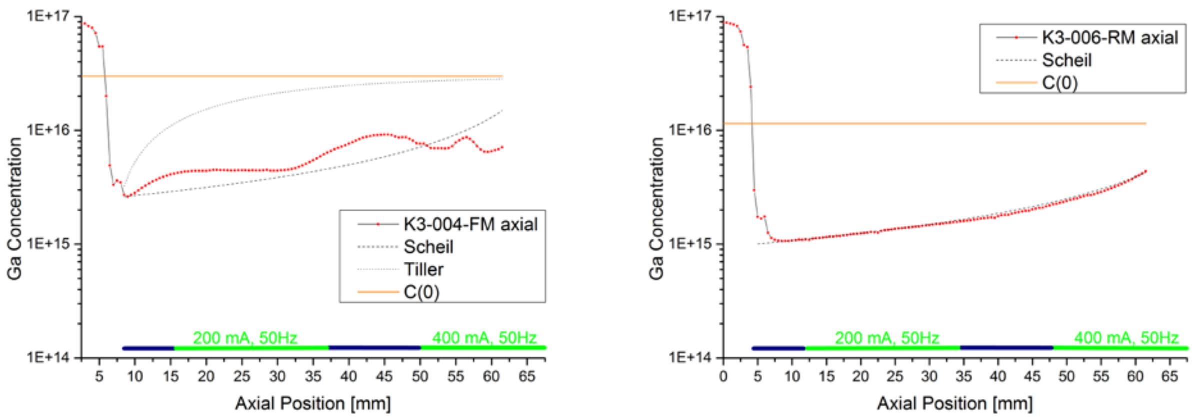

Fig. 1: Axial segregation of Ga in Ge in a Bridgman crystal under vibration. The parts underlines in blue were grown without vibration, the ones marked green with vibration. Left: µg experiment. Right: 1g experiment.

The detached grown crystals showed stable detachment over 14-21mm length. A determination of the dislocation densities by synchrotron topography showed a reduction of one order of magnitude for the detached areas. Further parametric investigations of detachment will be done on the ISS using ten crystal growth samples that are expected to be brought to the ISS in 2017.