

# **Double-diffusive convection during growth of halides and selenides**

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## **Abstract**

Heavy metal halides and selenides have unique properties which make them excellent materials for chemical, biological and radiological sensors. Recently it has been shown that selenohalides are even better materials than halides or selenides for gamma-ray detection. These materials also meet the strong needs of a wide band imaging technology to cover ultra-violet (UV), midwave infrared wavelength (MWIR) to very long wavelength infrared (VLWIR) region for hyperspectral imager components such as etalon filters and acousto-optic tunable filters (AO). In fact AOTF based imagers based on these materials have some superiority than imagers based on liquid crystals, FTIR, Fabry-Perot, grating, etalon, electro-optic modulation, piezoelectric and several other concepts. For example, broadband spectral and imagers have problems of processing large amount of information during real-time observation. Acousto-Optic Tunable Filter (AOTF) imagers are being developed to fill the need of reducing processing time of data, low cost operation and key to achieving the goal of covering long-wave infrared (LWIR). At the present time spectral imaging systems are based on the use of diffraction gratings are typically used in a pushbroom or whiskbroom mode. They are mostly used in systems and acquire large amounts of hyperspectral data that is processed off-line later. In contrast, acousto-optic tunable filter spectral imagers require very little image processing, providing new strategies for object recognition and tracking. They are ideally suited for tactical situations requiring immediate real-time image processing. But the performance of these imagers depends on the quality and homogeneity of acousto-optic materials. In addition for many systems requirements are so demanding that crystals up to sizes of 10 cm length are desired.

We have studied several selenides and halide crystals for laser and AO imagers for MWIR and LWIR wavelength regions. We have grown and fabricated crystals of several materials such as mercurous chloride, mercurous bromide, mercurous iodide, lead chloride lead bromide, lead iodide, thallium arsenic selenide, gallium selenide, zinc sulfide zinc selenide and several crystals into devices. We have used both Bridgman and physical vapor transport (PVT) crystal growth methods. In the past have examined PVT growth numerically for conditions where the boundary of the enclosure is subjected to a nonlinear thermal profile. Since past few months we have been working on binary and ternary materials such as seleniodides, doped zinc sulfides and mercurous chloro bromide and mercurous bromiodides. In the doped and ternary materials thermal and solutal convection play extremely important role during the growth. Very commonly striations and banding is observed. Our experiments have indicated that even in highly purified source materials, homogeneity in 1-g environment is very difficult. Some of our previous numerical studies have

indicated that gravity level less than  $10^{-4}$  ( $\mu$ -g) helps in controlling the thermosolutal convection. We will discuss the ground based growth results of  $\text{HgCl}_x\text{Br}_{(1-x)}$  and ZnSe growth results for the mm thick to large cm size crystals. These results will be compared with our microgravity experiments performed with this class of materials.

For both HgCl-HgBr and ZnS-ZnSe the lattice parameters of the mixtures obey Vagard's law in the studied composition range. The study demonstrates that properties are very anisotropic with crystal orientation, and performance achievement requires extremely careful fabrication to utilize highest figure of merit. In addition, some parameters such as crystal growth fabrication, processing time, resolution, field of view and efficiency will be described based on novel solid solution materials. It was predicted that very similar to the pure compounds solid solutions also have very large anisotropy, and very precise oriented and homogeneous bulk and thin film crystals is required to achieve maximum performance of laser or imagers. Some of the parameters controlling the homogeneity such as thermos-solutal convection driven forces can be controlled in microgravity environments to utilize the benefits of these unique materials.