Optical Characterization of Fe and Cr Doped ZnS and ZnSe Polycrystals for Mid-IR Lasing Applications

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Because of strong absorption of middle infrared (mid-IR) light by organic molecules in human tissue, mid-IR lasers have applications including laser surgery, tissue ablation, non-invasive medical diagnostics, and molecular spectroscopy. Transition metal doped II-VI chalcogenides and specifically Cr and Fe doped ZnSe and ZnS polycrystals feature a combination of laser spectroscopic, optical, and technological characteristics that make them ideal for direct lasing in the mid-IR. However, the thermal diffusion process through which the crystals are doped can cause degradation of optical quality. The purpose of my research was to identify the degree of this optical degradation and whether subsequent hot isostatic pressing (HIPing) can restore the materials' initial optical quality. This was done via transmission and absorption spectra characterization of ZnSe, ZnS, Cr:ZnSe, Fe:ZnSe, and Cr:ZnS crystals before and after HIPing. For doping, the crystals were annealed in vacuum sealed quartz ampules, after which they were HIPed with or without a Molybdenum wrapping (Mo wrap). After measuring the crystals' transmission spectra, I found unusual absorption features in the spectra of the annealed, un-doped ZnSe sample and the samples HIPed without a Mo wrap. These observations were verified through repeat experiments, and re-annealing the un-doped ZnSe sample in Zn vapor eliminated these absorption bands. I conclude that: the absorption bands in the annealed, un-doped ZnSe sample were caused by Zn vacancies, HIPing with a Mo wrap does not significantly improve the crystals' optical quality, and HIPing without a Mo wrap leads to sample degradation, possibly due to diffusion of chamber contaminants.

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