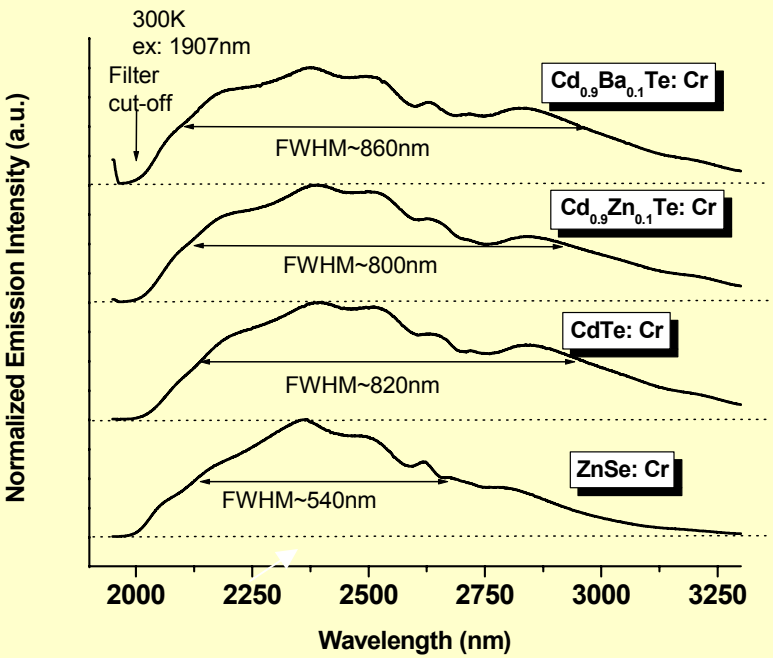
Crystal-Field Engineering of Transition Metal Doped Chalcogenide Laser Materials

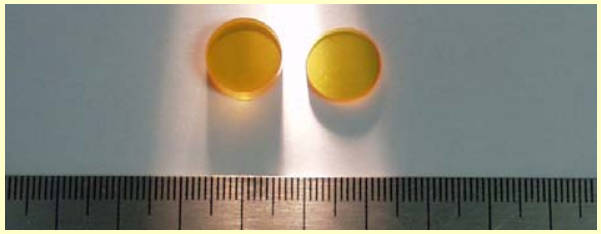
Uwe Hömmerich, Hampton University, DMR-0301951

"New Broad-Mid-Infrared Emitter "

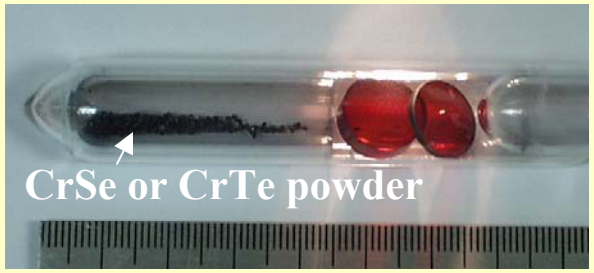


New Cr^{2+} doped ternary II-VI's materials have been developed for mid-IR light source development. The mid-IR emission from these materials extends from 2-3.3µm and covers absorption bands of important gases including NH_3(2.3µm), H_2S (2.7µm), and CH_4(3.3µm).

Cr diffusion doping of binary and ternary II-VI materials



ZnSe windows



Cr: ZnSe

Cr^{2+} diffusion doping experiments were extended from ZnSe to ternary II-VI materials including CdZnTe, CdMnTe, CdSrTe, and CdBaTe. Different dopant sources were employed such as elemental Cr, CrSe, and CrTe. The diffusion temperature ranged from 750°C-950°C.

“Crystal-Field Engineering of Transition Metal Doped Chalcogenide Laser Materials”, DMR-0301951, Hampton University, P.I. U. Hommerich

The development of mid-infrared (IR) light sources (e.g. lasers, LED’s) remains of significant current interest for applications such as remotes sensing, medical surgery, and basic spectroscopy. For example, the detection of atmospheric trace gases and pollutants is based on strong fundamental absorption bands located in the mid-IR spectral region (e.g. CH_4: ~3.3µm; H_2S: ~2.7µm; and NH_3: 2.3µm). Cr^{2+} (and other transition metal) doped semiconductors have recently emerged as a new class of mid-IR luminescent materials for applications in solid-state lasers, random powder-lasers, and optoelectronic devices.

Under support of this NSF award, we are currently exploring the effects of compositional changes in the host material on the optical properties of Cr^{2+} ions. The overall goal of this work is to engineer the absorption and emission properties of Cr^{2+} ions for wavelength tailored applications. Compared to binary II-VI hosts, ternary II-VI materials provide the opportunity to continuously tune the lattice parameters through changes in the composition. Changes in the lattice parameters are expected to alter the crystal-field strength experienced by Cr^{2+} ions and their optical properties. Moreover, ternary II-VI hosts such as CdRTe with R=Zn, Mg, Ca, Sr, Ba offer two different lattice sites for Cr^{2+} incorporation, which can results in broadening of the Cr^{2+} mid-IR emission. During the time period of this report, we have synthesized new ternary Cr^{2+} doped II-VI compounds including Cr: $Cd_{0.9}Zn_{0.1}Te$, Cr: $Cd_{0.9}Ba_{0.1}Te$ and Cr: $Cd_{0.9}Sr_{0.1}Te$ for mid-IR light source development. Intense broad-band emission in the spectral range from ~2-3.3µm has been demonstrated at room-temperature with significantly larger bandwidth then measured for Cr: ZnSe. For example, Cr:$Cd_{0.9}Ba_{0.1}Te$ exhibited an emission bandwidth of ~880nm at full-width half maximum, compared to only ~540nm observed for Cr: ZnSe. A simple diffusion doping technique previously employed for Cr doped ZnSe has been extended to Cr doped ternary II-VI materials. The optimization of the materials synthesis, Cr doping process, and spectroscopic evaluation of new ternary Cr^{2+} doped materials is still in progress.

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EDUCATION & OUTREACH:

Graduate Level:

Ivy Krystal Jones (Physics, M.S. program)

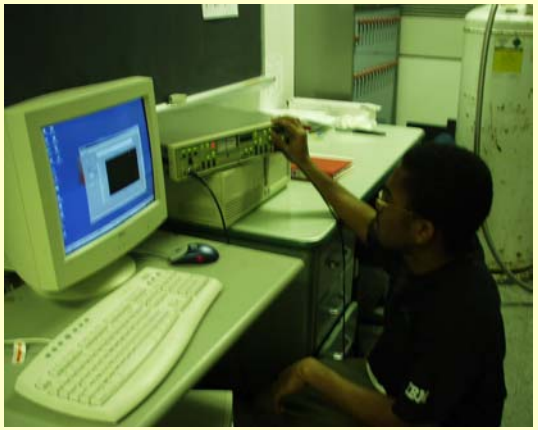
Undergraduate Level:

Osei Poku (Electrical Engineering)

Summer Program:

Marlon J. Walcott (Physics, NSF-REU)

Ivy Krystal Jones is a graduate student pursuing a Masters degree in Physics at H.U. Ivy is currently working on Cr diffusion studies of II-VI materials and optical spectroscopy.



Osei Poku was an undergraduate student in the Electrical Engineering Dept. at H.U. He developed a new data acquisition program for a Lockin Amplifier. Osei received his B.S. degree in 2004 and is now pursuing a Ph.D. degree in Electrical Engineering at Carnegie Mellon.

Marlon Jerome Walcott is an undergraduate student in the Physics Dept. at Benedict College. Marlon was part of a summer NSF-REU program and worked with us on laser materials development.