Title: Wide Band Gap II-Selenides for Short Wavelength Intersubband Devices

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Introduction: Short wavelength mid-IR emitters based on intersubband (ISB) transitions are key components for ultra-sensitive trace gas analysis which has very important medical and environmental applications. The short wavelength reach of an ISB device is determined by the available conduction band offset in a material system. $Zn_xCd_yMg_{1-x-y}Se$ with an adjustable band gap from 1.75 eV (CdSe) to 3.7 eV (MgSe) is a good candidate for short wavelength ISB devices. Based on our previous results that 80% of the band offset is in the conduction band, ISB devices made with the II-selenide materials may ultimately reach the optical communication wavelength of 1.55 μm. The enhanced electron-phonon interaction in II-VI semiconductors may make II-VI-based all optical ISB switches work at much higher speed. The widely adjustable band gap also makes the material system a promising candidate for multi-color photodetectors (QWIPs). The difficulties and shortcomings associate with the p-type doping of the II-selenides are eliminated because ISB devices are unipolar devices.
Methods: Several series of samples have been prepared by MBE to explore various potential device applications: a) ZnCdSe/ZnCdMgSe multiple quantum wells (MQWs) lattice-matched to InP substrates; b) asymmetrically coupled ZnCdSe/ZnCdMgSe quantum wells; c) ZnCdSe/ ZnCdMgSe quantum cascade electroluminescence (EL) structures; d) ZnCdSe/MgSe MQWs nearly lattice-matched to InP; e) CdSe quantum dots self-assembled on ZnCdMgSe. High-resolution x-ray diffraction (HRXRD), photoluminescence (PL), and Fourier transform infrared (FTIR) spectroscopy were performed to study the material properties. The EL structures were processed into 400- μm semi-circular deep mesas. EL measurements were carried out at temperatures from 78 K to 300 K.
Results: HRXRD and PL measurement results demonstrated high structural and optical properties of all the samples. Intersubband absorption at wavelengths of 2.5-7 μm has been observed by room-temperature FTIR measurements. EL emission at 4.8 μm was obtained at 78 K. The emission is p-polarized and persists until 300 K.
Conclusion: Our results indicate that the wide gap II-selenides are promising materials for ISB devices, such as quantum cascade lasers, all-optical switches, and quantum-well infrared photodetectors, especially those work at short IR wavelengths.
References:
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