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ELECTROLUMINESCENCE FROM A ZNCDSE/ZNCDMGSE QUANTUM CASCADE STRUCTURE

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Quantum cascade lasers have matured to be useful and capable light sources through more than a decade of research. Using telecom diode laser materials systems as a foundation, development has been rapid and highly successful for InGaAs/AlInAs and GaAs/AlGaAs structures. Recently, the push to shorter operating wavelengths has incorporated Sb into the materials mix, with record short-wavelength lasing at 2.75 µm [1]. As the QC device concept is not limited only to these III-V materials systems, development of new materials systems may yield performance improvements and broader capabilities. For example, ongoing work has shown intersubband absorption in GaN/AlGaN multiple quantum wells and intersubband electroluminescence from Si/SiGe heterostructures. Here, we present a II-VI quantum cascade structure made from ZnCdSe well layers and ZnCdMgSe barrier layers that shows room temperature TM-polarized intersubband electroluminescence (EL).

The well and barrier layers used in our design—respectively $Zn_{0.43}Cd_{0.57}Se$ and $Zn_{0.20}Cd_{0.19}Mg_{0.61}Se$—have lattice constants equal to that of InP and a conduction band offset of 780 meV. Our structure is a typical QC design, which includes two active region wells that contain third and second energy levels for the 284 meV (4.37 µm) optical transition and a first energy level spaced about one LO phonon below the second for rapid depopulation of the second energy level. Each 122 Å active region is connected by a 412 Å injector region. Ten periods of the active region-injector sequence were grown by molecular beam epitaxy and then fabricated into semi-circular EL mesa structures.

We observed EL centered near 4.8 µm. Emission polarization characteristics were examined to confirm intersubband light generation; intersubband optical transitions in quantum wells are TM polarized. While a small amount of TE light is observed, which we attribute to scattering from within the rounded mesa, the EL is predominantly TM polarized. At low temperatures near 78 K, only a primary emission peak is observed near 4.8 µm. The 4.8 µm emission peak grows with increasing pumping current. We also observed the growth of a secondary, temperature-induced, lower energy emission. This broad emission is more intense for both higher currents and higher temperatures. While the origin of this low energy emission is still under investigation, the 4.8 µm intersubband emission is dominant and persists through room temperature.

Thus, we show a II-VI materials system capable of room temperature QC light generation at 4.8 µm. Shorter wavelength emission energies are possible with further materials and QC design development.

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[1] J. Devenson et al., APL 91, 251102 (2007)