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ZnO/$Zn_{1-x}Mg_xO$ vs. GaN/Al$xGa_{1-x}N$ quantum cascade lasers for THz emission

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Abstract

We present a comparison of III-nitride and Zn-based material as possible candidates for the realization of high power and efficient QCL THz sources. Theoretical study has been undertaken to determine the effect of bias voltage and mole fraction of GaN/AlGaN and ZnO/ZnMgO heterostructure based QCLs on lasing frequency. In addition, the impact of polarization which affects the band energies on generated THz radiation is explored. The combined effects of piezoelectric polarization and spontaneous polarization are addressed in the simulations; total polarization is calculated to be 0.0785 C/m^2 for $Zn_{0.95}Mg_{0.05}O$ and 0.0336 C/m^2 for $Al_{0.05}Ga_{0.95}N$ based material. THz frequency output resulting from LO-phonon assisted fast depopulation for intersubband transitions is likewise analyzed, and the conduction band offsets profile is determined by two-dimensional biaxial strain as a function of Al or Mg mole fraction. Simulation results of wall plug efficiency (WPE) as a function of Al and Mg mole fraction show significantly higher WPE for the ZnMgO system (21.95%) compared to that of the AlGaN system (12.33%). The calculated peak optical output power, which is proportional to the ratio of radiation frequency to optical confinement factor, is 2.95 mW for the Zn-based system and 2.39 mW for the nitride-based system; this can be attributed to the smaller refractive index (~1.65) and higher calculated radiation frequency (4.23 THz) of the former. Radiation frequency is observed to increase with increasing Al and Mg mole fraction due to variation in the eigenstates, which in turn affects the WPE.

Biography

John Zeller received B.S. degree with honors in electrical engineering from Trinity College, Hartford, CT, in 2002. He received M.S. and Ph.D. degrees in electrical engineering from the University of Connecticut in 2007. After graduation he began a postdoctoral fellowship the Naval Undersea Warfare Center (NUWC), Newport, RI. Dr. Zeller joined Magnolia Optical Technologies in 2011, and is primarily involved in the development of ZnO nanowire arrays for UV sensor applications.