

Zinc oxide based heterostructures for terahertz quantum cascade lasers

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While mid-infrared Quantum Cascade Lasers (QCL) are widely spread and even commercialized, the operating temperature of QCL in the terahertz range is still limited under 200K. This effect comes from the low LO-phonon energy of materials which are commonly used for this purpose – as GaAs for instance (LO-phonon energy: 36 meV). To overcome this issue, material systems with high LO-phonon energy have been proposed: GaN and ZnO (respectively, 90 meV and 72 meV). The advantage of ZnO compared to GaN is the availability of non-polar native substrates. On one side, non-polar orientations make easier the QCL design because there is no electric field to take into account. On the other side, native substrates improve drastically the crystal quality, which is necessary for electrical injection.

In this study state-of-the-art ZnO/(Zn,Mg)O multi-quantum wells (MQWs) were grown on m-plane ZnO substrates by molecular beam epitaxy. They exhibit a surface roughness under 0.5 nm and thicknesses were determined with a precision of one monolayer. The residual doping is as low as 10^{15} cm^{-3} . The high quality of our MQWs has led to the observation of ISBT at room temperature by absorption experiment in the infrared domain. The dependence of the transition energy with the quantum well thickness perfectly matches the calculations [1,2]. Photoluminescence on coupled quantum wells reveals that tunnel effect is possible through the observation of exciton transfer across the barrier. Thus the two physical effects on which the QCL is based are present in our samples. This study paves the way for the realization of ZnO QCLs.

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[2] M. Montes Bajo, J. Tamayo-Arriola, A. Jollivet, M. Tchernycheva, F.-H. Julien, R. Peretti, J. Faist, M. Hugues, J.-M. Chauveau, and A. Hierro, *Proc SPIE* **10105**, 101050O (2017)