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AlGaN-based MQWs emitting at 280nm for Vertical Cavity Surface Emitting Lasers

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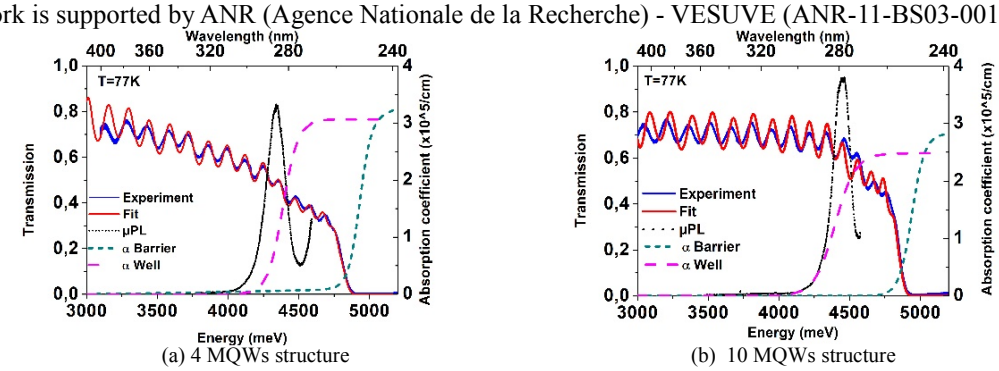
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There is currently much research in deep ultraviolet ((DUV: λ<300 nm) III-nitride based light sources that would enable a wide variety of potential applications such as sterilization and high density storage systems [1]. Indeed, it is necessary to develop emitters that are more compact and more stable than common UV lamps for these applications to become practical. In this context, innovative solutions must be found for the realization of Vertical Cavity Surface-Emitting Lasers (VCSELs) operating in the DUV spectral range. The primary barriers to be overcome in the active region of DUV light sources based on AlGaN/AlGaN heterostructures are: (i) the high dislocation density of Al-rich AlGaN epilayers on sapphire or SiC substrates, (ii) the strong quantum-confined Stark effect (QCSE) which leads to the reduction of the emission efficiency and (iii) the anisotropic optical polarization properties of c-plane AlGaN alloys, which are detrimental to surface-emission [2, 3].

We report on the design, fabrication and characterisation of MQW structures containing four or ten $Al_{0.57}Ga_{0.43}N/Al_{0.37}Ga_{0.63}N$ quantum wells (QWs) grown by Metal Organic Vapor Phase Epitaxy on a relaxed $Al_{0.57}Ga_{0.43}N$ buffer grown on an AlN/sapphire template. For the design of the MQW structure, envelop function simulations taking into account strain and built-in electric fields were performed. The relative oscillator strengths were calculated by evaluating the matrix element between conduction and valence bands. To achieve emission near 280 nm, an Al composition, x_{Al}=0.37 and a thickness of 1.7 nm (negligible field effects) were estimated from calculations. The optimal Al content in barriers was chosen to be x_{Al}=0.57, for which the compressive strain (-0.5%) introduced in the wells is sufficient to enhance TE-polarized optical transition and therefore surface emission [4]. A relaxed AlGaN buffer with the same Al content was used to release strain in the barriers.

Structural and optical characterizations have been performed to optimize growth conditions and to assess suitable optical quality of the DUV MQW structures. Four- (Fig.1.a) and ten-MQW (Fig.1.b) structures exhibit an emission peak at 285 and 278.5 nm respectively, with a sharp linewidth at 77 K. Transmission measurements combined with numerical simulations confirm a sufficient oscillator strength leading to an optical absorption coefficient in the wells as high as $2.5x10^5$ cm^{-1}, which is promising for efficient surface-emitting devices in the DUV region. Complementary time-resolved photoluminescence measurements will be analyzed and further developments related to fabrication of the surrounding cavity will be presented.

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(a) 4 MQWs structure (b) 10 MQWs structure

Fig. 1: Macro-transmission measurements and transfer-matrix simulations of the MQW structures, absorption coefficients (α_{well}, $\alpha_{barrier,\ buffer}$) used in the simulation and micro-photoluminescence spectra for the structures containing 4 (left) and 10 (right) QWs.

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