Room-temperature TE-polarized intersubband electroluminescence from quantum cascade structures based on InAs/AlInAs quantum dashes

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The introduction of 3D-confined quantum dots (QDs) or dashes (QDashes) in the active region of Quantum Cascade Lasers (QCLs) would improve their performance by increasing the upper laser state lifetime[1, 2] and allowing for transverse-electric (TE) polarized emission unachievable in quantum-well-based QCLs. Electroluminescence (EL) from QC structures based on InAs/GaAs QDs has already been shown[3, 4], here we demonstrate TE-polarized EL from an in-plane-confined state of InAs/AlInAs QDashes grown in a QC structure based on InAs/AlInAs QDashes[5].

In Fig. 1a, we show the measured TE-polarized intersubband (ISB) absorption from the ground state (|1,1,1>) to the first excited state (|2,1,1>) associated with the lateral confinement due to the width of the dashes (the [110] direction in Fig. 1a insets). The absorption peaked at 89 meV and the extrapolated dipole moment for this transition was 1.7 nm. The QDashes were grown in a QC structure designed to exploit such transition (TEM in the bottom inset of Fig. 1a). The structure was processed as wide ridge lasers and Fig. 1b shows the EL for two devices of the same size but different ridge orientation: one with ridge length along the dash elongation (thick blue line) and the other perpendicular to it (thin blue line). TE-polarized EL was present only for devices processed with ridges parallel to the dash elongation and was centered around 110 meV, in good agreement with the absorption measurements.

The TE EL signal, which was present also at room temperature (inset Fig. 1b), increased with applied bias but no sign of gain could be seen before a negative differential resistance occurred. We will present recent results showing the effect of changes in the active region design.

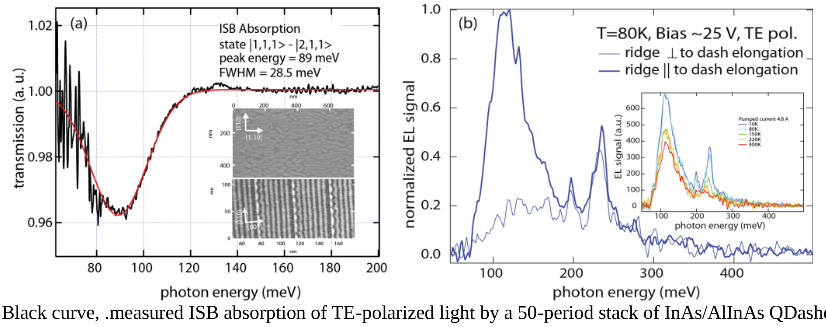

Fig. 1 (a) Black curve, .measured ISB absorption of TE-polarized light by a 50-period stack of InAs/AlInAs QDashes at T=300K. Red curve, Gaussian fit. Inset: (top) SEM of uncapped QDashes, (bottom) TEM image of three periods of the QC structure along the dash width ([110]). (b) 80K TE-polarized EL for the device with ridge length along the dash elongation (thick blue line) and perpendicular to the dash elongation (thin blue line) at a bias of 25 V. Inset: TE-polarized EL measurements up to room temperature for the same current in the device.

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