GROWTH OPTIMIZATION OF INP-BASED INAS QUANTUM DOTS FOR HIGH-PERFORMANCE 1.55 µm LASER APPLICATIONS

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Introduction: The InP-material system plays a dominant role in long-wavelength laser applications. InAs-QD lasers were recently researched and exhibit improved properties in temperature stability [1], linewidth [2] and feedback insensitivity [3]. However, the potential of this QD material performance has by far not yet been exploited. This study aims to optimize InAs-QD morphology and optical properties to further narrow the gain spectrum of the ground state transition, improving laser performance.

Methods: Initial phase involves the growth of self-assembled InAs-QDs on InAlGaAs lattice-matched to InP layers using MBE, followed by characterization through AFM and low-temperature PL-spectroscopy to assess size uniformity, emission wavelength, QD density, and reproducibility. The growth parameters were systematically optimized. Subsequently, sub-monolayer nucleation layer (NL) [4,5] is proposed to enhance QD formation and minimize inhomogeneity.

Results: By optimizing growth-rate, temperature and introducing GaAs-NL, PL linewidth of 24 meV at 10 K was obtained. Remarkably, structures with NL exhibited blue shift in peak wavelength compared to QD reference structures. Furthermore, the laser structure comprising six QD layers in the active region separated by 20 nm of InAlGaAs was fabricated achieving low PL linewidths: 27.7 meV (10K) and 51 meV (RT). For broad area lasers with 100 µm stripe width internal efficiency of 72% and a total modal gain of 105 cm-1, i.e. record high 17.5 cm-1/QD layer were achieved.

Conclusion: In this work, the impact of the NL thickness as well as QD growth parameters were investigated. The subsequent steps will involve fine-tuning the laser design including the QD growth.

References:

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