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Strong Carrier Localization and Diminished Quantum-confined Stark Effect in Ultra-thin High-Indium-content InGaN Quantum Wells with Violet Light Emission

Suk-Min Ko,[1] Ho-Sang Kwack,[1] Chunghyun Park,[1] Yang-Seok Yoo,[1] Euijoon Yoon,[2] and Yong-Hoon Cho[1,*]

[1]Department of Physics and KI for the NanoCentury, KAIST, Daejeon 305-701,
[2]Department of Materials Science and Engineering, Seoul National University, Seoul 151-744, Korea

Over last decade InGaN alloy structures have become the one of the most promising materials among the numerous compound semiconductors for high efficiency light sources because of their direct band-gap and a wide spectral region (ultraviolet to infrared). The primary cause for the high quantum efficiency of the InGaN alloy in spite of high threading dislocation density caused by lattice misfit between GaN and sapphire substrate and severe built-in electric field of a few MV/cm due to the spontaneous and piezoelectric polarizations is generally known as the strong exciton localization trapped by lattice-parameter-scale In-N clusters in the random InGaN alloy. Nonetheless, violet-emitting (390 nm) conventional low-In-content InGaN/GaN multi-quantum wells (MQWs) show the degradation in internal quantum efficiency compared to blue-emitting (450 nm) MQWs owing higher In-content due to the less localization of carrier and the smaller band offset. We expected that an improvement of internal quantum efficiency in the violet region can be achieved by replacing the conventional low-In-content InGaN/GaN MQWs with ultra-thin, high-In-content (UTHI) InGaN/GaN MQWs because of better localization of carriers and smaller quantum-confined Stark effect (QCSE). We successfully obtain the UTHI InGaN/GaN MQWs grown via employing the GI technique by using the metal-organic chemical vapor deposition. In this work, 1 the optical and structural properties of the violet-light-emitting UTHI InGaN/GaN MQWs grown by employing the GI technique in comparison with conventional low-In-content InGaN/GaN MQWs were investigated. Stronger localization of carriers and smaller QCSE were observed in UTHI MQWs as a result of enlarged potential fluctuation and thinner QW thickness compared to those in conventional low-In-content MQWs. We hope that these strong carrier localization and reduced QCSE can turn the UTHI InGaN/GaN MQWs into an attractive candidate for high efficient violet emitter. Detailed structural and optical characteristics of UTHI InGaN/GaN MQWs compared to the conventional InGaN/GaN MQWs will be given.

Reference

[1] S, -M. Ko et al., Applied Physics Letters 103, 222104 (2013)

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