09.15 CMC3

Optical and Material Studies of Indium Compositional Fluctuations in InGaN/GaN Quantum Well Structures

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Indium compositional fluctuations in InGaN are crucially important for efficient light emission in such compounds. It was claimed that the quantum-dot-like InGaN aggregations trapped carriers for radiative recombination before they were trapped by defects for non-radiative recombination. This argument explained the efficient light emission in a compound of high defect density. In this paper, we report the results of photoluminescence (PL), stimulated emission (SE), X-ray diffraction, and high-resolution tunneling electron microscopy in the studies on InGaN/GaN quantum well structures grown with MOCVD. In material analyses, we observed clear indium aggregation and phase separation structures. With a higher nominal indium content, the indium composition fluctuation becomes more prominent. In optical measurements, we observed the S-shape PL peak variation as a function of temperature. The turning points of the S-shape variation relies on the nominal indium content. Meanwhile, we observed a two-peak feature in the SE spectra. The short- and long-wavelength peaks correspond to the carrier recombination of free-carrier states and localized states. Figure 1 shows the integrated PL intensity and the PL peak wavelength as functions of temperature of a five-quantum-well InGaN/GaN sample with 25 % nominal indium content. We can clearly see the S-shape variation of the PL peak wavelength. Meanwhile, the relatively slower decay of the integrated PL intensity, compared with other samples of lower nominal indium contents (not shown in the figure), indicates the more prominent indium compositional fluctuations in this sample. Figure 2 shows the SE spectrum at several temperatures. We can see that peak A (corresponding to localized states) drops with increasing temperature. However, its peak position is not changed. Meanwhile, peak B (corresponding to free-carrier states) level increases with temperature and its position red-shifts with temperature. All these observations will be explained in this presentation.

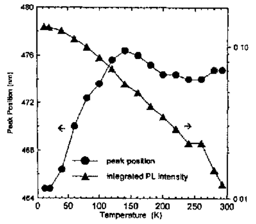

Fig. 1 PL data vs. temperature.

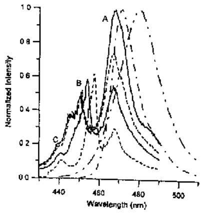

Fig. 2 SE spectra at several temperatures.

09.30 CMC4 (Invited)

High Power Quantum Dot Lasers*

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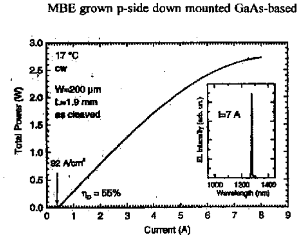
Quantum dot (QD) Lasers have decisive advantages compared to quantum well (QW) lasers [1]. The present technology of epitaxial growth of self-organized QDs allows fabricating QD lasers that realize their theoretical benefits. Among those are very low threshold current density, operation in new wavelength ranges for a given substrate and high power operation. Starting from first results on photopumped [2] and injection lasing [3] in self-organized QDs, very recently remarkable progress has been achieved.

QDs offer particular advantages for high power lasers due to the suppression of *in-plane* diffusion of charge carriers. Reduced non-radiative surface recombination decreases facet overheating and larger catastrophic optical mirror damage (COMD) threshold is expected. This possibility can be further combined with the lower threshold (down to 16A/cm^2 [4]), the higher temperature stability [5], and the extended wavelength range on GaAs substrates of QD lasers [1, 4, 5] as compared to conventional QW lasers.

We present results on MOCVD and MBE grown high power QD lasers based on InGaAs QDs on GaAs substrate. MOCVD devices demonstrated lasing at 1100 nm with 3.5 W in the pulsed regime [6]. The threshold was 210 A/cm^2 and the differential efficiency 57 %. The saturation value of the spectral power density is 200 MW/nm. Therefore each QD produces about 12.5 nW of external optical power, corresponding to 7×10^{10} photons/s and an upper limit for the refill time of 14 ps.

MBE grown p-side down mounted GaAs-based QD lasers demonstrated 2.8-4 W CW operation in a spectral range 0.9-1.3 μm [7-9]. Maximum conversion efficiencies up to 51% are measured at 2 W CW operation [8]. The total output power (up to 2.8 W CW [8]) and the lasing wavelength as a function of the drive current for a laser diode emitting at 1.28 μm under CW operation are depicted in the figure. The threshold current density is 92 A/cm^2. The maximum output power is limited by thermal rollover.



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