

Chapter5

Conclusion and Future Work

5.1 Conclusion

Optically pumped GaN-based VCSEL

We have demonstrated the fabrication of GaN-based VCSEL with hybrid mirror. We grew the 3λ nitride-based structure with 25 pairs of AlN/GaN DBR by MOCVD, and then deposited 8 pairs of Ta₂O₅/SiO₂ DBR by E-gun deposition to complete the full structure of GaN-based VCSEL. A narrow PL emission with full width at half maximum of 1.4nm corresponds to the cavity resonant mode at 448nm was observed. The cavity finesse and the cavity quality factor, estimated from the emission linewidth of 1.4nm, are about 53 and 320. The structure was optically pumped by 355nm pulse Nd:YVO₄ laser with laser spot size of 60 μm at room temperature. The stimulated emission was observed from the vertical direction of the structure, and the stimulated emission peak wavelength was about 448nm with spectral FWHM of 0.17nm. The threshold characteristic of semiconductor laser was also observed and the threshold pumping energy was about 53 MJ/cm². The carrier density and gain at the threshold were estimated to be about 3×10^{20} cm⁻³ and 1.45×10^4 cm⁻¹, respectively. The NFP and FFP showed that the beam width and divergence angle were about 3.0μm and 7.6°, respectively. The NFP and FFP also indicated that the shape of laser emission was close to a circle. The laser beam showed a degree of polarization of about 84% suggesting strong polarization property of the laser emission. The characteristic temperature of fabricated VCSEL was about 243K suggesting good temperature tolerance of the VCSEL.

Electrically injected GaN-based MCLED

We also fabricated the GaN-based MCLED following the success of optically pumped GaN-based VCSEL. The device showed the emission wavelength of 458.5nm and the narrowed spectral FWHM of 6.7nm at 20mA injected current. The 20mA forward voltage and resistance of the MCLED were 3.5V and 530Ω, respectively. The optical characteristics of the MCLED were also been discussed and compared with other light emitting diodes, conventional LED and LED with one bottom DBR. We found that the GaN-based MCLED showed relatively stable emission wavelength than other devices. These characteristics

suggest that the structure and process of GaN-based MCLED are good basis for electrically injected GaN-based VCSEL.

5.2 Future Work

The electrically injected GaN-based MCLED has been fabricated. However, there are some obstacles needed to be overcome on the way to realization of electrically injected GaN-based VCSEL. One of the important issues is the optical loss inside the microcavity. The optical loss inside the microcavity is mainly resulted from the absorption of Ni/Au transparent contact layer, used for the current spreading layer. To solve this problem, we will try to use the ITO or tunnel junction to replace the Ni/Au transparent contact layer in the future.

