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Nitride-based nanocolumns and their application to light emitting

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Abstract – Ti-mask selective area growth (SAG) of rf-MBE [1] was employed to prepare uniform arrays of GaN nanocolumns with InGaN/GaN multiple-quantum-wells (MQWs) on MOCVD-grown GaN templates. The photoluminescence (PL) characterization of 3-period InGaN MQW nanocolumns demonstrated that the emission color was controlled from blue to red with the nanocolumn diameter and period. 8-period InGaN MQW nanocolumn arrays were evaluated under a high laser light excitation as high as 100-800 kW/cm^2, observing a clear stimulated emission at 471 nm with the threshold excitation density of 320 kW/cm^2.

GaN nanocolumn arrays with different nanocolumn diameter and period were grown using different Ti nano-patterns on the same substrate; at the top region of the nanocolumn arrays, three or eight period InGaN/GaN MQWs were integrated. The SAG of GaN nanocolumns occurred at the growth temperatures (T_g) above 900 °C; an excessive increase in T_g to above 900 °C at nitrogen flow rate (Q_{N2}) of 3.5 sccm brought about nanocolumn shape inhomogeneity. Thus uniform nanocolumn arrays are fabricated in a narrow temperature range around the critical temperature, 900 °C. Upon reducing Q_{N2} from 3.5 to 1 sccm, diffusion lenght and desorption of Ga adatoms were enhanced, contributing to successful fabrication of uniform arrays of nanocolumns around the critical temperature of 900 °C. The nanocolumn diameter was precisely controlled from 100 nm to 300 nm at the constant period of 400 nm as shown in Fig.1. The PL peak wavelength of the InGaN-MQW (3-QW) nanocolumn arrays shifted monotonically from 520 nm to 660 nm with increasing the columns diameter from 118 nm to 291 nm (see Fig.2). The high optical excitation of the InGaN/GaN MQW (8-QW) nanocolumn array at room temperature with a 355 nm Nd:YAG laser (pulse width of 5 ns at 20 Hz) caused a stimulated emission at 471 nm with the threshold excitation density of 320 kW/cm^2; the nanocolumn array consisted of hexagonal nanocolumns of 92-nm in side-length and 850-nm in height, which were arranged in a rectangular lattice, with the horizontal and vertical array periods of 230 nm and 245 nm, respectively.

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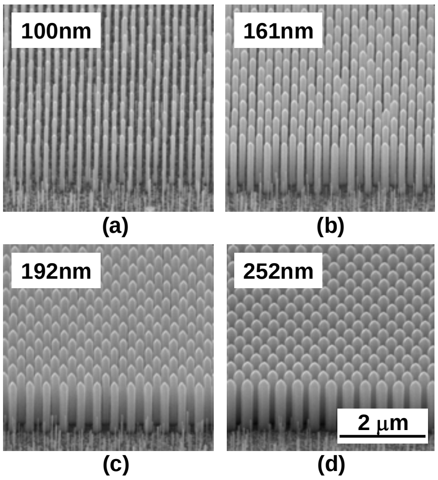

Figure 1: GaN nanocolumn arrays with different diameters from 100 to 252 nm at the nanocolumn period of 400 nm.

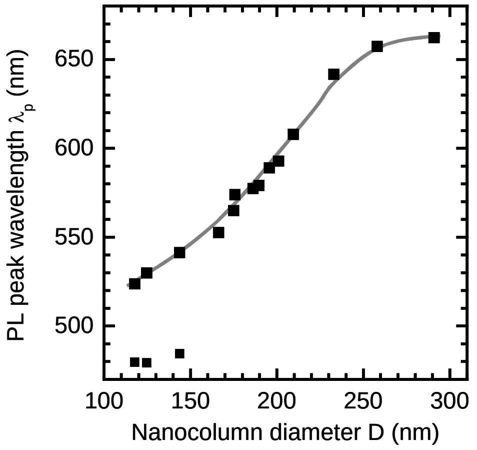

Figure 2: PL peak wavelength of InGaN/GaN nanocolumn arrays as a function of nanocolumn diameter

References

[1] K. Kishino, H. Sekiguchi and A. Kikuchi, J. Cryst. Growth **311**, 2063 (2009).