【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project : Innovation of energy and environment friendly devices by nanocrystal effect

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Research Area : Applied optics/Quantum optical engineering

Keyword : Opto-electronics, Semiconductor, Optical properties, Laser

【Purpose and Background of the Research】

The luminous efficacy of InGaN-based nitride semiconductors rapidly decreases with increasing wavelength from green to red emission. GaN nanocolumns, i.e., one-dimensional nanocrystals, were developed by the leader of this research project. In this project, using regularly arranged nanocolumn arrays, as shown in Fig. 2(a), we aim to scientifically clarify the nanocrystal effects of GaN nanocolumns. On this basis, the challenges facing the development of InGaN-based devices will be investigated with the aim of developing the fundamental technologies for innovative energy and environment-friendly devices.

【Research Methods】

The nanocrystal effects, which are expected to be enhanced by narrowing the GaN nanocolumns, can contribute to suppressing the In compositional fluctuation, reducing lattice strain, suppressing the generation of crystal defects, and increasing light extraction efficiency (see Fig.1); these nanocrystal effects of GaN nanocolumn arrays will be investigated by reducing the column diameter to the hitherto unexplored range of 10 to 100 nm. Furthermore, periodic nanocolumn arrays are expected to induce a photonic crystal effect and enable control of the emission color by varying the column diameter. Utilizing these effects of nanocolumns, the technologies to surmount the challenges facing the development of InGaN-based devices are expected to be developed.

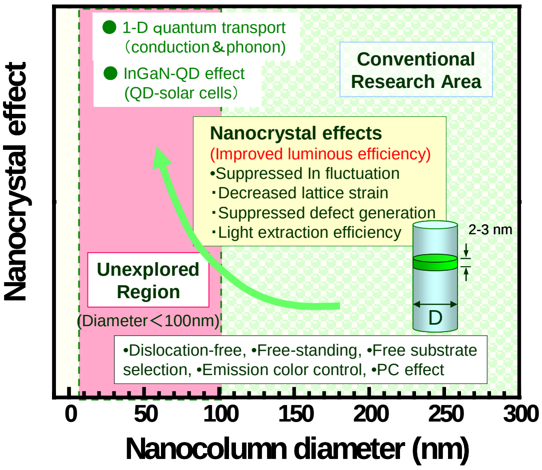

Fig.1 Nanocrystal effects

【Expected Research Achievements and Scientific Significance】

Nanocolumn physics will be properly clarified by the systematic investigation of nanocrystal effects, which should contribute to the increased luminous efficacy of red-emission nanocolumn LEDs, the monolithic integration of nanocolumn LEDs emitting the three primary colors, and the realization of surface-emitting green nanocolumn lasers (see Fig. 2(b)). An InN multiple quantum dot (QD) structure integrated in narrow InGaN nanocolumns is expected to be used as a QD solar cell material.

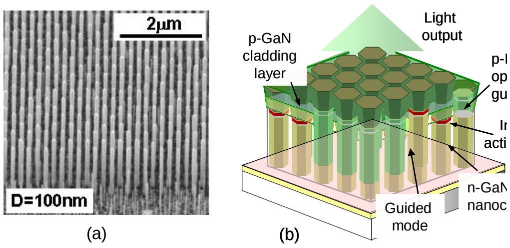

Fig.2 (a) Nanocolumn array, (b) nanocolumn LED/LD

【Publications Relevant to the Project】

H. Sekiguchi, K. Kishino et al., “Emission color control from blue to red with nanocolumn diameter of InGaN/GaN nanocolumn arrays grown on same substrate”, Appl. Phys. Lett. **96,** 231104 (2010).

K. Kishino, H. Sekiguchi et al., “Improved Ti-mask selective-area growth (SAG) by rf-plasma-assisted molecular beam epitaxy demonstrating extremely uniform GaN nanocolumn arrays”, J. Cryst. Growth **311**, 2063–2068 (2009).

【Term of Project】 FY2012-2016

【Budget Allocation】 414,500 Thousand Yen

【Homepage Address and Other Contact Information】

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