【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Interdisciplinary Science and Engineering)

Title of Project : Achievement of Tailor-made Lighting Sources by the Control of Nanoscopic Carrier Localization in Nitride Semiconductors

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Research Area : Engineering
Keyword : New functional light emitting devices

【Purpose and Background of the Research】

Recent progress in the research of nitride semiconductors has led to the achievement of light emitting diodes (LEDs), active layers of which are composed of InGaN-based quantum wells (QWs), and blue LEDs are now in practical uses with extremely high efficiency. However, droop phenomena (decrease of efficiency under higher injection currents), green-gap problem (low efficiency in green spectra) and UV-threshold problem (low efficiency in ultraviolet spectra) are still unresolved, and they are important subjects which should be solved for the development of LED-based solid state lightings.

The concept of the research project is originating from our former intensive studies on fundamental optical characterizations related to carrier localizations to nanoscopic radiative centers. In this project, we intend to make a paradigm conversion, namely from understanding to control, where the synthesis of emission spectra can be achieved by the control of carrier localizations. Our goal is to make tailor-made lighting sources through the establishment of technology to generate highly efficient emissions with arbitrary wavelengths from micro and/or nano structures based on (Al,Ga,In)N semiconductors.

【Research Methods】

A special feature of our project is the approach to contribute to illuminating engineering in the next generation where desirable objective colors should be obtained. This can be attained by the newly developed light emitting devices such as three-dimensional structures composed of InGaN-based multi-facets (Fig. 1).

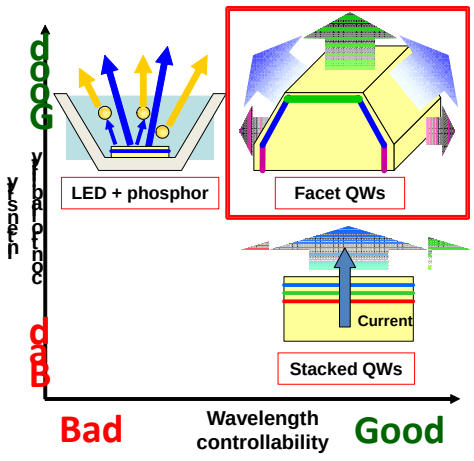

Figure 1 Pros and cons of various types of white LEDs.

(1) High quality micro and/or nano structures based on In-rich InGaN (or Al-rich AlGaN) will be grown by melalorganic vapor phase epitaxy utilizing homoepitaxy on semipolar oriented substrates or three-dimensional multi-facet structures.
(2) Radiative and non-radiative localized centers in InGaN (AlGaN) nano structures will be studied in detail by employing scanning near field spectroscopy, by which luminescence and heat generation are visualized with high spatial and temporal resolutions.
(3) Positive feedback will be made by applying (2) to (1), through which guiding principles ought to be clarified related to appropriate growth -conditions and device-structures. The next generation illumination sources capable of multi-wavelength emissions with high efficiencies will be realized, by making special efforts on controls of alloy compositions, internal electric fields and plasmonic effects.

【Expected Research Achievements and Scientific Significance】

The control of droop phenomena will contribute to highly efficient power lightings based on LEDs. The solution of green-gap problem will lead to the realization of ultra-small displays and high-quality illumination, and that of UV-threshold problem will open new applications such as sterilization, processing and catalysis.

If tailor-made lighting is accomplished, it contributes not only to the energy saving illuminations capable of high color-rendering but also to the new innovations such as biomedical applications and optical information processing.

【Publications Relevant to the Project】

・M. Funato, T. Kondou, K. Hayashi, S. Nishiura, M. Ueda, Y. Kawakami, Y. Narukawa and T. Mukai, “Monolithic Polychromatic Light-Emitting Diodes Based on InGaN Microfacet Quantum Wells toward Tailor-Made Solid-State Lighting”, *Applied Physics Express*, **1**, 011106 (2008).
・T. Oto, R. G. Banal, K. Kataoka, M. Funato and Y. Kawakami, “100 mW deep ultraviolet emission from aluminum nitride based quantum wells pumped by an electron beam”, *Nature Photonics*, **4**, pp.767-771 (2010).

【Term of Project】 FY2015-2019

【Budget Allocation】 146,300 Thousand Yen

【Homepage Address and Other Contact Information】

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