【Grant-in-Aid for Specially Promoted Research】

Science and Engineering

Title of Project： Light emitting synthesizer : aiming to create the ultimate lighting devices

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【Purpose and Background of the Research】

Recent progress in the research of nitride semiconductors has been remarkable, and blue light-emitting diodes (LEDs) with extremely high efficiency have been commercialized using InGaN quantum wells as the active layer. However, the "Droop" phenomenon, in which luminous efficiency decreases with high current injection, the "green-gap" problem, in which the efficiency of green LEDs with increased In content in the active layer is reduced, and the "UV-threshold" problem, in which the efficiency of deep UV AlGaN LEDs with increased Al content in the active layer is reduced, have not been solved. In this project, we propose that the control of high-efficiency, multi-wavelength luminescence is a key issue to be overcome for next-generation lighting applications.

We aim to develop a new functional device (light emitting synthesizer) that can emit light of any wavelength with a high radiation recombination probability, focusing on the synthesis of luminescence wavelengths by a three-dimensional semiconductor structure, polarization control, and plasmonics effects. This enables the realization of the ultimate tailor-made light source with arbitrary color rendering and the deep UV multi-wavelength light source required for advanced processing and environmental sensing. Furthermore, we will demonstrate Li-Fi (light fidelity) wireless communication by multi-wavelength and high-speed switching of light sources, and establish a foundation for next-generation communication systems.

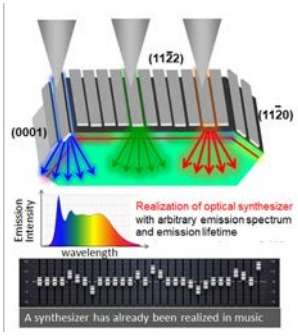

Fig.1 Concept of light emitting synthesizer

【Research Methods】

Towards multi-wavelength control and high efficiency luminescence in three-dimensional (3D) InGaN (AlGaN) structures, it is useful to work on potential fluctuations in micro and nano scales, respectively. In other words, the former leads to multiple wavelengths due to differences in alloy composition and polarization effects in each 3D structure, and the latter contributes to higher efficiency because it can induce exciton localization by potential fluctuations in the nanoscale. Furthermore, we aim to enhance the luminescence transition probability by utilizing the transfer of elementary excitations from excitons to plasmons as well as the control of exciton localization. This enables multi-wavelength luminescence control, increased luminescence efficiency, and faster luminescence switching speed.

【Expected Research Achievements and Scientific Significance】

The evolution of spectral synthesis using a light emitting synthesizer will create a new field of application called tailor-made lighting, in which the emission spectrum of a multicolor LED is tuned according to the circadian rhythm and preferences for color temperature and color rendering, as shown in Figure 2. In addition, there are also significant spillover effects to deep-ultraviolet photonics and high-speed optical communications.

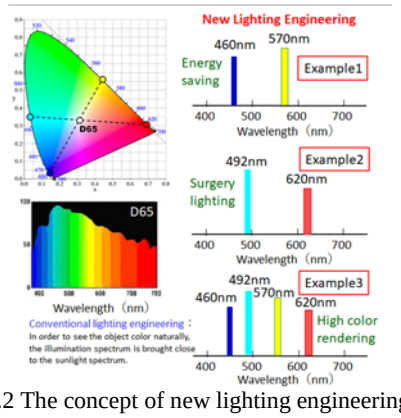

Fig.2 The concept of new lighting engineering

【Publications Relevant to the Project】

· Y. Matsuda, M. Funato, and Y. Kawakami, “Polychromatic emission from polar-plane-free faceted InGaN QWs with high radiative recombination probabilities”, *Appl. Phys. Exp.* **10**, 071003/1-4 (2017).

【Term of Project】 FY2020-2024

【Budget Allocation】 431,500 Thousand Yen

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