

**【Grant-in-Aid for Scientific Research(S)】**  
**Science and Engineering (Engineering I )**



**Title of Project : Development of bright red light-emitting devices by elucidation and control of light-emitting mechanism in rare-earth-doped nitride semiconductors**

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Research Area : Electrical and electronic engineering, Electronic materials/Electrical materials  
Keyword : Electrical and electronic materials, Thin film, Control of light-emitting properties

**【Purpose and Background of the Research】**

We have doped Eu to GaN by organometallic vapor phase epitaxy (OMVPE) and succeeded in the first demonstration of bright red emission due to the intra-4f shell transitions of Eu<sup>3+</sup> ions from a LED with the Eu-doped GaN (Fig. 1). The development of the GaN-based red LED enables us to produce a monolithic full-color LED display and a next-generation lighting.

In this project, based on the interactive combination of these achievements and computational materials design, we aim at developing bright red LEDs with Eu-doped nitride semiconductors, using artificially-controlled energy-transfer from the host to Eu ions.

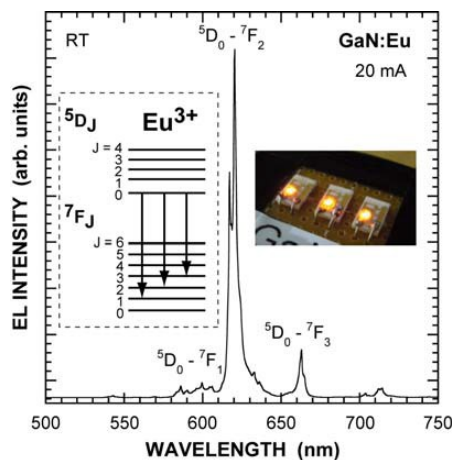


Fig. 1 Electroluminescence spectrum in Eu-doped GaN red LED.

**【Research Methods】**

- (1) The excitation mechanism of Eu doped in GaN under above-bandgap excitation is generally recognized as a trap-mediated process. It has been found in Eu-doped GaN that there are several Eu centers coexisting in one sample and some of the Eu centers are silent under the above-bandgap excitation. We understand what happens in the silent Eu centers because it gives a clue to control the energy-transfer.
- (2) We have already found that the intensity of the Eu emission is drastically enhanced in Eu,Mg-codoped GaN. The elucidation and

improvement of the enhancement is necessary for brighter red LEDs. The confinement of electron-hole pairs should be also effective for the control of the energy-transfer. We dope Eu to quantum structures prepared by bottom-up and top-down techniques and investigate the luminescent properties.

**【Expected Research Achievements and Scientific Significance】**

Research on rare-earth (RE)-doped materials has been based on experience obtained through trial and error, not on materials design by the precise control of RE doping and understanding of the energy-transfer mechanism. This project can give a guiding principle to design the RE-doped materials.

**【Publications Relevant to the Project】**

- A. Nishikawa, Y. Fujiwara *et al.*: “Room-temperature red emission from p-type/europium-doped/n-type gallium nitride light-emitting diodes under current injection,” *Applied Physics Express* **2**, 071004 (2009).
- D. Lee, Y. Fujiwara *et al.*: “Eu luminescence center created by Mg codoping in Eu-doped GaN,” *Applied Physics Letters* **100**, 171904 (2012).

**【Term of Project】** FY2012-2016

**【Budget Allocation】** 163,600 Thousand Yen

**【Homepage Address and Other Contact Information】**

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