Structural and Luminescent Properties of Multi-functional Rare-earth Doped Phosphors

Tzu-Chen Liu (劉子晨) and Ru-Shi Liu* (劉如熹)

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Abstract

The applications of phosphors according to different excitation sources are versatile due to the utilization of rare earth ions. The tunable energy levels of 5d orbital and the large number of energy levels of 4f orbitals can emit photons with different wavelengths. In this thesis, excitation sources from vacuum ultraviolet (VUV), ultraviolet (UV) to visible photons, and electrons are investigated. Emission ranges from UV to visible range and near-infrared (NIR) are also utilized.

The first part focuses on the synthesis of red-emitting oxynitride phosphor. Intraconfigurational 4f → 4f transitions are designed because of the determined environment for 5d → 4f transitions. The high thermal stability reveals that β-SiAlON is a good candidate for white light-emitting diodes (wLEDs). Pr3+ ions show the possibility of an alternative for red emitting activators.

In the second part, comparison of LED- and FED-used phosphors under electron bombardment is made and it suggests a new class of host lattice should be developed. Evidences from solid-state nuclear magnetic resonance (ssNMR) lead to a different explanation of the incorporation of rare-earth ions into AlN host lattice. A new phosphor composition of AlN doped with Si3+ and Ce3+ is synthesized and shows the validity for field emission displays.

The third part includes two proposed quantum cutting (QC) rare-earth combination for enhancing the efficiency of crystalline silicon (c-Si)-based solar cells: (1) adding a sensitizer to transfer the excited energy to the donor with 4f → 4f transitions, and (2) using a broad band donor such as Eu3+ and Ce3+ ions. It is concluded that the high density of photons required for Ce3+ ions, Eu3+-Yb3+ pairs is a better choice.

I. β-SiAlON:Pr3+ for LED

II. AlN:Si, Ce3+ for FED

III. KsPO4 for Solar Cells

I. β-SiAlON:Pr3+ for LED

Background

History & Structure

Cathodoluminescence comparison

XRD

ssNMR

TEM

Photoluminescent analysis

Patents and Publications


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