18p-PB8-6

Advanced Phosphor Synthesis Using Microreactor Technology and Their Application to Wavelength Conversion Layer

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We developed a microreaction (MR) method for preparing phosphor precursors, because this method can easily be applied to the combinatorial system. We successfully synthesized a rare earth ion-activated phosphor material for the first time by using our newly developed microreaction system. The schematic diagram of this MR system is shown in Figure 1. It consists of liquid sources, syringe pumps, a mixer cell, a mixing/reaction tube, and an auto-sampler. The control of the particle size of $Y_3Al_5O_{12}:Ce^{3+}$ (YAG:Ce) yellow phosphor powder was attempted by changing the reaction space^[1]. The size can be varied between 400-1000 nm while maintaining almost the same photoluminescent performance. An internal quantum efficiency of 85% has been achieved for the YAG:Ce powder samples with an average particle size of 400 nm.

The Bi^{3+},Eu^{3+} co-activated Yttrium Vanadate (YVO₄) red nanophosphor has been synthesized with in-situ pH monitoring^[2]. Figure 2 shows the surface morphology of the YVO₄:Bi,Eu nanophosphor sample, which was observed with a field emission scanning electron microscope. Spherical grains that are less than 50 nm in diameter have been obtained. The internal quantum efficiency is more than 30% under UV excitation, which suggests that nanophosphors encapsulated in appropriate resins could achieve high photovoltability and could thus be applied to practical wavelength converters.

The wavelength Conversion Layer (WCL) is attracting more attention because it has the potential to increase the conversion efficiency of silicon solar cells by 5% or more. The 400 μ m layer thickness is formed by the doctor blade method to optimize the condition. To acquire an accurate value, we created a large WCL that covered all of the solar cells, and measured the I-V data using a solar simulator. We have confirmed the improvement to the positive data by using the WCL for silicon solar cells. The details of this device will be reported at the conference.



Figure 1 Schematic diagram of MR system.



Figure 2 SEM photograph of YVO₄:Eu,Bi nanophosphor sample.

[1] 1) ECS transaction, 33, 95 (2011), 2) Jpn. J. Appl. Phys. 51 (2012) 062602
[2] 1) Phosphor Safari, 5 (2013), 2) The 20th IDW, 797 (2013)