Luminescence of morphologically-controlled calcium silicon nitride particles through combined techniques of ultrasonic spray pyrolysis and carbothermal reduction/nitridation

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Abstract

The morphologically-controlled preparations of Eu^{2+}-doped calcium silicon nitride ($Ca_{2-x}Eu_xSi_5N_8$: x = 0.05) particles, *i.e.*, the spherical and columnar particles, were conducted by combined techniques of ultrasonic spray pyrolysis and carbothermal reduction/ nitridation. Relating to the ultrasonic spray pyrolysis, the precursor oxides for $Ca_{2-x}Eu_xSi_5N_8$ particles were prepared by this technique at 600°C in air, using $Ca(NO_3)_2/Eu(NO_3)_3$ solution (total concentration: 2.86×10^{-2} mol·dm^{-3}) with suspended Si_3N_4 particles. The spray-pyrolyzed powder was further mixed with carbon, and carbothermally reduced in N_2 atmosphere. The spherical and columnar $Ca_{1.95}Eu_{0.05}Si_5N_8$ particles could be prepared by controlling the heating rate and temperature for carbothermal reduction/nitridation. The spherical $Ca_{1.95}Eu_{0.05}Si_5N_8$ particles could be obtained when the spray-pyrolyzed powder (or precursor oxides) was heated to 1000°C at the rate of 30°C·min^{-1}and then to 1400°C for 2 h at the rate of 10°C·min^{-1}. On the other hand, the columnar $Ca_{1.95}Eu_{0.05}Si_5N_8$ particles could be obtained when the spray-pyrolyzed powder was heated to 1100°C at the rate of 30°C·min^{-1} and then to 1500°C for 2 h at the rate of 10°C·min^{-1}. The morphological control was conducted by the kinds of liquid phases formed during the heating process. The morphological control of $Ca_{1.95}Eu_{0.05}Si_5N_8$ particles could be achieved by the nitridation of spherical and columnar particles formed at 1000°C or 1100°C. The emission peaks of spherical and columnar $Ca_{1.95}Eu_{0.05}Si_5N_8$ particles appeared at 622 nm and 618 nm, respectively, under the excitation at 375 nm.

Overall, the spherical and columnar $Ca_{1.95}Eu_{0.05}Si_5N_8$ particles could be formed by controlling the heating rate and temperatures for the carbothermal reduction/nitridation of spray pyrolyzed oxide powders. The spherical and columnar particles emitted the lights with the peak wavelength at 622 and 618 nm under excitation at 375 nm.

Image

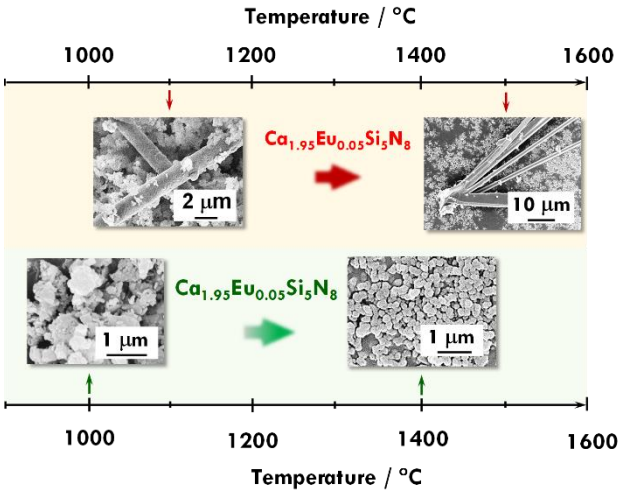


Figure 1. Morphological changes of particles with temperature

Recent Publications

1. Itatani K, Okamoto M, Okada I (2004) Densification and Microstructural Development during the Firing of Compounds in the Si_3N_4-SiO_2-Y_2O_3 System. Key Eng. Mater. 264-268: 249-252.
2. Mihara S, Yamaguchi K, Hitzen H. T, Delsing ACA, Koda S. and Itatani K. (2010) Synthesis and Luminescence Properties of Rare-Earth Doped Gadolinium Silicon Oxynitride with Cuspidine Structure. Adv. Sci. Technol. 62: 95-100.
3. Yamaguchi K., Hintzen HT, Delsing ACA, Kuwahara H, Koda S, Itatani K (2011) Preparation of Eu^{2+}-doped $Ca_2Si_5N_8$ by Carbothermal Reduction/Nitridation of Spray-pyrolyzed Oxide/nitride Powder and Its Luminescence Properties. J. Light & Vis. Env. 35: 207-213.
4. Morishita H, Delsing ACA, Hintzen HT, Kuwahara H, Itatani K (2014) Preparation of Red-emitting Eu^{2+}-doped Barium Calcium Silicon Oxynitride by Solid-state Reaction and Its Luminescence Properties. Key Eng. Mater. 617: 149-152.
5. Zhu XW, Sakka Y, Zhou Y, Hirao K, Itatani K (2014) A Strategy for Fabricating Textured Silicon Nitride with Enhanced Thermal Conductivity. J. Eur. Ceram. Soc. 34: 2585-2589.



Biography

Satoshi Ono is a student of Sophia graduate school. His research interest is preparation and characterization of Si_3N_4-containing nitride ceramics.

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