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Structural and Morphological Properties of Nanostructured $Y_2O_3:Eu^{3+}$ Phosphor Particles Prepared Through Aerosol Synthesis

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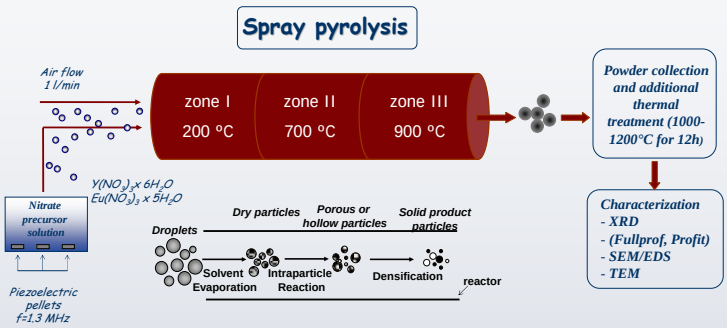
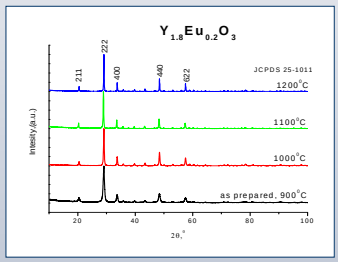
Abstract

Improved phosphor particles of Eu-doped yttrium oxide, a well-known red phosphor, are employed in modern high-resolution display devices such as plasma display panels (PDP) and field emission displays (FED) [1]. Utilization in such devices requires particles with spherical shape, fine size, narrow size distribution and non-aggregation characteristics since it ensures high resolution and high brightness [2]. Spray pyrolysis is a feasible method for obtaining the needed phosphor particle characteristics in view of the fact that when a precursor solution is atomized and fed into a furnace, solvent evaporation, drying, solute precipitation and chemical decomposition occur successively on a droplet level, leading to the formation of particles with required compositional and structural characteristics. In this work yttrium oxide doped with europium (5 at% and 10 at%) was directly prepared by spray pyrolysis at 900°C, additionally annealed and characterized by means of XRD, SEM/EDS and TEM. The effects of different doping concentrations and synthesis parameters were monitored.

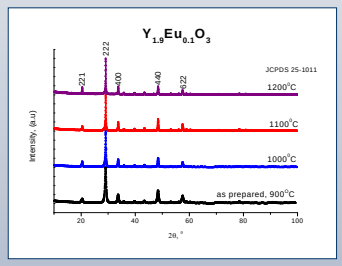
Spray pyrolysis



$(Y_{0.95}Eu_{0.05})_2O_3$
-cubic system
-space group: Ia3 (206)
-lattice parameter: 10.604



XRD



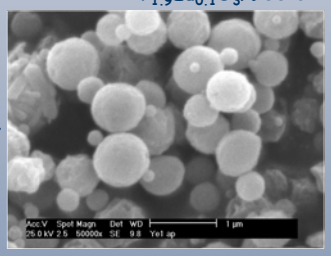
Microstructural data from refinement by program Fullprof [3] and program Profit [4]

Temperature, °C	a, Å		strain		cs, nm	
	S_1	S_2	S_1	S_2	S_1	S_2
900	10,611(1)	10,622(1)	18,70(±1.6)	27,00(±1.9)	19.042	22.548
1000	10,605(1)	10,620(2)	10,70(±1.4)	9,72(±0.8)	23.292	32.436
1100	10,606(7)	10,620(3)	5,99(±1.3)	5,94(±1.3)	45.548	49.378
1200	10,608(5)	10,621(4)	4,99(±1.3)	3,77(±0.7)	74.172	86.847

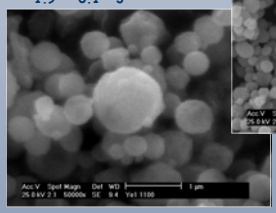
S_1 - $Y_{1.9}Eu_{0.1}O_3$ system; S_2 - $Y_{1.8}Eu_{0.2}O_3$ system

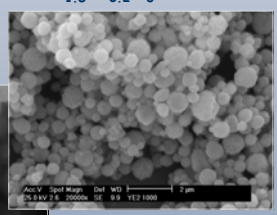
SEM

SEM images reveal that as-prepared particles are spherical, non-agglomerated and with smooth surface although some particles with irregular morphology randomly appear.

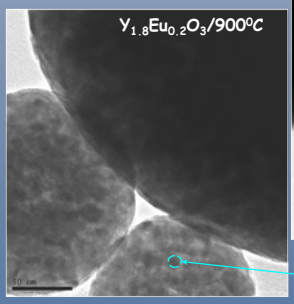


Thermally treated samples show that the spherical particle morphology is maintained throughout the thermal treatment and that the higher temperature regime provokes further crystallization and growth of primary particles.

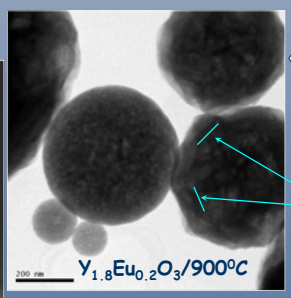




TEM

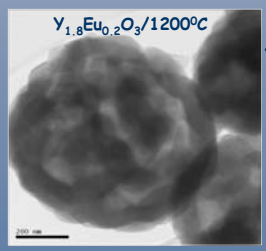


Nanostructures with crystallite size around 20 nm are in good agreement with XRD refinement.



Low resolution transmission electron images of filled, spherical particles ranging between 130nm to 500nm are related to secondary nanoparticles.

Primary particles with longer length in the range of 71.23± 18.4 nm can be resolved



Rougher particle surface evident in the thermally treated samples corresponds to larger primary crystallite size.

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Conclusion

$Y_2O_3:Eu^{3+}$ particles produced via the aerosol route are on the submicronic level with spherical and filled morphology.

All the samples, the as-prepared and thermally treated once, are composed of pure cubic $Y_2O_3:Eu^{3+}$ phase *(Ia3)*. The increase of lattice parameters, related to the incorporation of Eu^{3+} ions into the yttria host lattice is proved.

Microstructural parameters obtained through Rietveld refinement indicate the presence of nanostructures with crystallite size around 20nm. These results are in good agreement with TEM.

References

[1] C.H. Lee, K.Y. Jung, J.G. Choi, Y.C. Kang, *Mat. Sci. Eng.*, B 116 (2005) 59-63
[2] O. Milosevic, L. Mancic, M.E. Rabanal, J.M. Torralba, B. Yang, P. Townsend, *J. Electrochem. Soc.*, 152, (9) G707-G713(2005)