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Effect of synthesis methods on the powder characteristics and luminescence properties of nanophosphors

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Nanosized luminescent powders have applications in lighting, medical and optical communications industries [1-3]. In order to achieve high efficiency, phosphor particles should have a small and narrow size distribution, spherical morphology and be non-agglomerated [4]. High packing densities are required for some applications and low scattering loss of light can be obtained by using spherical, nano-sized powders [5]. In nanophosphors, the microstructure of the particles, the presence of the surface defects, the activator distributions, and the aggregation of the particles affects significantly the luminescence properties such as luminescence output, optimal activator concentration and quantum efficiency of the phosphors. Since the particle morphology and the microstructure of the particles are greatly affected by synthetic methods, these methods play an important role in determining the luminescence properties [6]. In this work, we examined various synthesis methods for oxide and silicate phosphors and compared the resultant luminescence properties.

We have explored five different synthetic methods: sol-gel, co-precipitation, hydrothermal, combustion, and spray-pyrolysis having the same post-annealing condition. Fig. 1 shows SEM micrographs of a green/yellow-emitting phosphor, $Sr_2SiO_4:Eu^{2+}$ prepared by these methods and compared to powders produced by a solid state reaction [7,8]. A needle-like morphology is found for the co-precipitation, sol gel and combustion synthesis and a spherical morphology is obtained by hydrothermal and spray pyrolysis, indicating the latter are the preferred methods. The particle shown for solid state reaction is much larger and more irregular than the others. However, the sol gel powders were the most luminescent, compared to the other chemical synthesis methods [7], so there is a competing factor between uniform morphology and light output

Another composition, $LaPO_4$ activated with rare earth elements, is used as the green-emitter in fluorescent lamps, scintillators and have potential as the blue-emitter in solid state lighting, due to the high quantum efficiency and excellent thermal stability [4].The luminescence output of the powders prepared by different synthetic methods in response to the optimal activator concentration and crystallite size, the aggregation of the particles will be presented.

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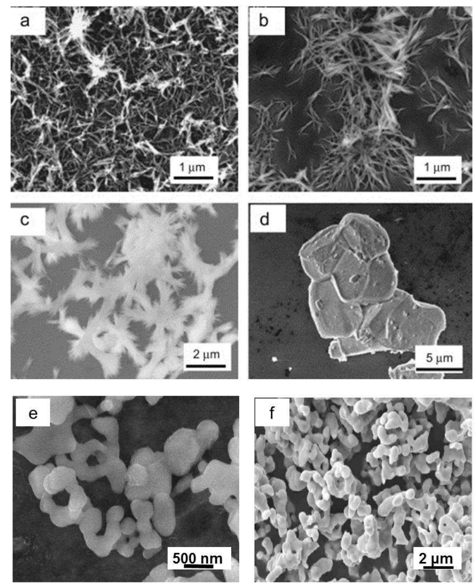

Fig. 1. SEM micrograph of $Sr_2SiO_4:Eu^{2+}$ prepared by (a) co-precipitation, (b) sol-gel/Pechini, (c) combustion, (d) solid state reaction, (e) hydrothermal and (f) spray-pyrolysis. Taken from [7,8].