CHARACTERIZATION OF YAG:Ce POWDERS THERMAL TREATED AT DIFFERENT TEMPERATURES

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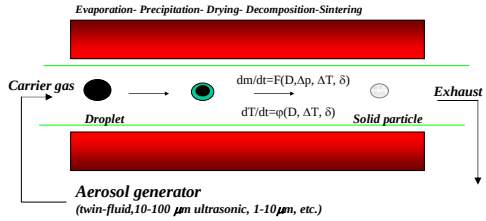
INTRODUCTION

The homogeneity of materials obtained by synthesized through aerosol create process of energy transfer well defined that contribute in the quantum efficiency of luminescent materials. The objective was to establish the relations between composition, structure and morphology of powders. A comparative study of the characteristics of the powders treated at different temperatures 1000-1200ºC helps to understand the evolutions of the system with the temperatures.

YAG:Ce is considered to be interesting for several applications: (e.g. field emission display (FED), cathode-ray tubes (CTRs), LED and pigments and thermal barrier coatings (TBC).

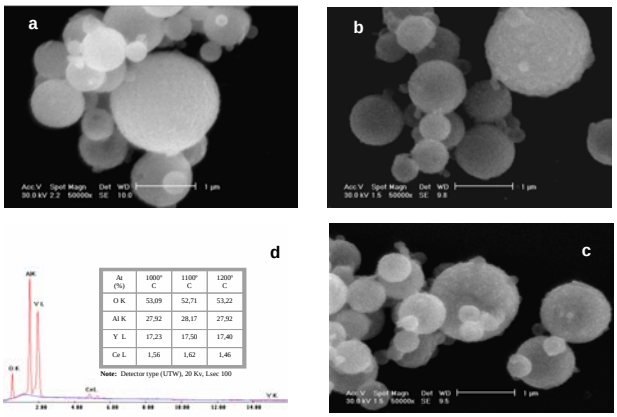
EXPERIMENTAL INSTALLATION



High surface reaction. Stoichiometry retention to the droplet scale. Molecular level of compositional homogeneity

RESULTS AND DISCUSSION

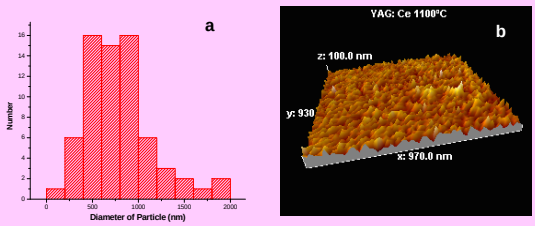
Morphological characterization by SEM



At (%)	1000° C	1100° C	1200° C
O K	53,09	52,71	53,22
Al K	27,92	28,17	27,92
Y L	17,23	17,50	17,40
Ce L	1,56	1,62	1,46

SEM photomicrographs of powder after thermal treatment at 1000ºC (a), 1100ºC (b) and 1200ºC (c). EDS spectra and quantitative analysis of YAG-Ce powder (d)

Statistical analysis of the particle sizes. The equivalent surface and volume were estimated based on the average particle diameter. The histogram of frequency, fig a, reveals uniform in their shape for this sample in comparison to the samples treated at 1000 and 1200ºC.



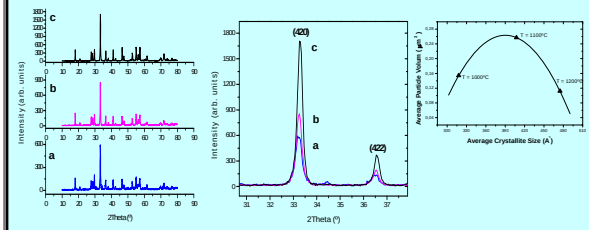
a) Histogram of the diameter distribution of YAG : Ce powder at 1100ºC.
b)Reconstruction in 3D of the surface of a particle treated to 1100ºC

The roughness parameters give information about the average surface of particle, fig. b. These results are summarised in the following table. The growth of the surface in the sample treated to 1100ºC, implies higher reactivity and provides better uniformity of layers.

Treatment (°C)	Diameter Mean (nm)	Se (yEr±)	Average Volume (μm³)	Roughness Average surface Sa (nm)	Surfaces Area Ratio Sdr (%)	Area surface (m²)	Mass by particle (g)	Relation (m²/g)
1000ºC	664	32	0.154	68.0	37.9	$52.6\ 10^{-12}$	$7.0\ 10^{-13}$	74.5
1100ºC	788	44	0.257	78.9	73.9	$144.3\ 10^{-12}$	$1.2\ 10^{-12}$	122.3
1200ºC	599	36	0.112	71.6	32.1	$36.2\ 10^{-12}$	$5.1\ 10^{-13}$	71

Note: Se is standard error of the mean
Used density: *(Dx-YAG) 4.553 g.cm⁻³ (JCPDS- International Centre for Diffraction data. 33-0040)*
(Dx-Ce) 6.814 g.cm⁻³ (JCPDS- International Centre for Diffraction data. 78-0638)

X-Ray diffraction analysis. The average crystallite size of the powder heated to different temperatures was determined from the broadening observed for the peak corresponding to the (420) reflection using the Scherrer formula. The diffracted intensity is function of the volume irradiated and the crystallite sizes grow with the temperature, it was possible to correlate these values, that have parabolic form with maximum at 1100°C.

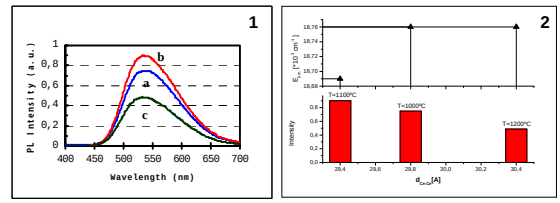


XRD pattern of YAG:Ce powder after thermal treatment at 1000ºC (a), 1100ºC (b), 1200ºC (c). Details of crystallographic directions 420 overlap pattern and the results of the crystallite size calculated for: (a) 318 Å, (b) 407 Å and (c) 474 Å.

Luminescence properties. The curves exhibit broad emission in the range from 450-700 nm with the luminescent peak maximum at 533nm (~18.76x10^3 cm^{-1}), attributed to the Ce^{3+} intershell transition ($5d \rightarrow 4f$) in YAG lattice. The average distance (d_{Ce-Ce}) between centers of luminescence is calculated from the average volume that Ce atom occupies, assuming ideal dispersion.

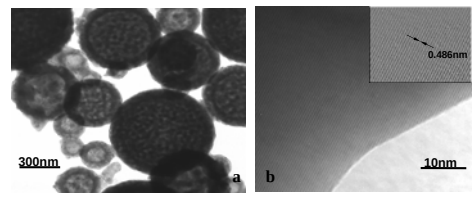
$$d_{Ce-Ce} = 2[V_{Ce}/(4/3\pi)]^{1/3}$$

where: $V_{Ce} = (1/N_a)(V_m/X_{Ce})$ V_m: is a molar volume calculated from the weighed-out composition. (YAG = 130.38 cm^3/mol). N_a: is Avogardo number. X_{Ce}: is molar fraction

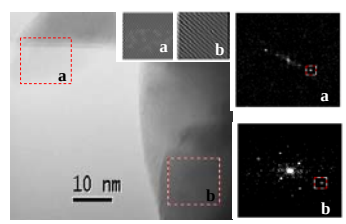


1) PL spectra for powders of YAG-Ce treated to: 1000ºC (a), 1100ºC (b), 1200ºC (c).
2) The distance of luminescent centers (d_{Ce-Ce}) as a function of energy emission (E_{em}) and intensity normalised emission for a wavelength fix of 533 nm.

TEM analysis, was applied in order to evaluate the changes of crystallinity with temperature. Fig.a, show inner particle structure, composing of differently oriented primary particles (< 60nm) with nanoporosity, is revealed.



TEM images of powder samples. a) Low magnification show particles transparent to electron beam. b) High-magnification image of sample treated at 1100 ºC.



Structural image of a particle treated to 1000ºC, show two zones with different orientations and interplannar spacing. Details of these zones make clear these differences. SAED patterns denoted cubic symmetry in both zones.

CONCLUSIONS

The most relevant change was observed at 1100 ºC, increasing luminescence properties. The tendency of the phase $Y_3Al_5O_{12}$ to order crystalline with the temperature is confirmed by the high growth rate of crystallite size (0.78 Å.ºC^{-1}). TEM analyses provides details of inner part of the particle and XRD confirms the cubic symmetric structure of the predominant phase observed. The homogeneity of the structure is obtained to temperature up to 1000ºC.

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