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Scanning laser sintering: A two step sintering process?

E. Antonelli [(1)*], A. C. Hernandes[(1)]

(1) Instituto de Física de São Carlos/USP, São Carlos-SP, e-mail: antonelli@ifsc.usp.br
* Corresponding author.

Abstract – In this work we present the results for sintering of $Bi_4Ti_3O_{12}$ (BIT) - doped $BaTi_{0.85}Zr_{0.15}O_3$ (BTZ) thick films, deposited by electrophoresis, using as heat source a CO_2 laser. The characteristics of the experimental apparatus were optimized in such a way as to allow the sintering of thick films with high densities (~96%.) and microstructural homogeneity. The related thermal process during the laser scanning acted in a similar way as a two-step sintering. This characteristic allowed the obtained of thick films with a grain size of ~200 nm.

Ceramics materials with grains sizes in the nanometer range promise to have unprecedented optical, mechanical, electrical and other properties for use in lasers, health care, and electrical devices [1]. The study of new techniques for sintering has so far been of great interest as it offers the possibility to optimize the density, grain sizes and others important ceramic characteristic [2]. In particular, the laser sintering has been proposed as new process where the conventional heat source is changed by a laser. The process involve less expensive cost and has made possible the obtained of ceramics materials with small grain growth and optimal characteristics [2]. The goals of this work were the implantation and optimization of the technique of scanning laser sintering of thick films and the kinetic study of the process.

The green thick films (50 μm) were produced through electrophoretic deposition of BTZ nanometric powders (~20 nm) prepared by Pechini method. BTZ thick films were deposited on platinum substrates starting from suspensions prepared by dispersion of the powder into a mixture of acetylacetone (Acac) and ethanol (EtOH) (1:1 volumetric ratio). The experimental apparatus used to make the scanning laser sintering (Figure 1) consists in a high-power CO_2 laser which it is directed upon the pre-heated sample (400^oC) in order to prevent thermal shocks. The system sample/furnace is moved on a xy table thus making possible the scanning of the thick films. Finally, we have used cylindrical lens with the intention to increase the scanned surface. The local temperature in the sample during the scan was studied and the heating rate was determined in each step of the sintering. The maximum temperature that can be achieved in the thick film, during each scan, and for a fixed rated laser power was correlated with the relative density. The related thermal process during the continuous laser scanning acted in a similar way as a two-step sintering. To improve the densification of the films, we started to add the compound $Bi_4Ti_3O_{12}$ (BIT) (1 e 2 mol %) to BTZ during the deposition. The utilization of the system developed for the scanning laser sintering alongwith the adding of the BIT resulted in a grain size decrease and a significant decrease in apparent porosity. For the 2 mol% additivation we obtained films with excellent density (apparent porosity of ~4% (Figure 2)) and reduced grain size (~200 nm).

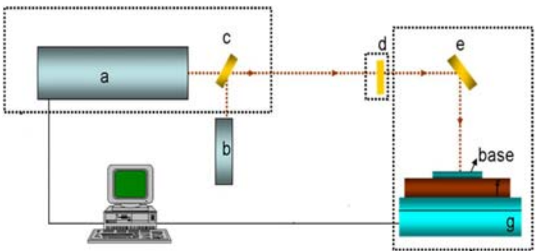

Figure 1: Schematic representation of the laser sintering system. a: CO_2 laser, b: He-Ne laser, c: ZnSe spot divisor, d: KCl cylindrical lens, e: Reflector mirror, f: Pre-heated furnace, g: xy translation system.

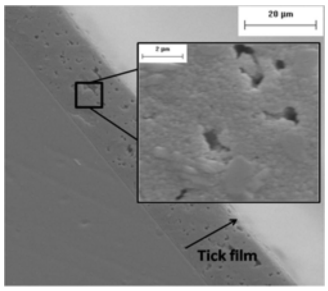

Figure 2: SEM micrographs of the thick film laser sintered.

References

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