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## **NEW CHALLENGES IN THE CREATION OF RELIABLE CERAMIC NANOCOMPOSITES**

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### **ABSTRACT**

In the present study the multifunctional composite materials based on zirconia doped by zinc oxide and alumina for different applications were synthesized. It was found the decomposition of initial supersaturated solid solution during heat treatment leads to formation of unique multilevel nanocomposite structure of ceramic matrix. It was established that the modification of zirconia by small amount of oxides leads to a significant enhancing of properties of nanopowders and ceramics in comparison with oxide mixing method.

**Keywords:** nanopowders, zirconia, zinc oxide, alumina, ceramics, properties.

### **INTRODUCTION**

The conception of multipurpose materials has been appearing during last several years [1-3]. These materials combine the high fracture toughness and biocompatibility, ionic conductivity and chemical stability. They are used in energetic, technical ceramics, optics, catalysis, etc. Electrical conductivity, catalytic and optical properties of the zirconia based nanocomposites have due to the peculiarities of nanoparticles formation and nanoparticles surface properties. So, controlling the structure of composites and their chemical composition allow demonstrating the different properties of material. On our view, the key step in the zirconia in the nanodimensional state preparation is the creation of metastable supersaturated solid solutions and their decomposition during heating. This process opens a new possibility in creation of different types of inclusions: clusters, grains, boundary enrichments and interfaces. Also we have shown that the traditional ceramic technology processes impose greater restrictions on the chemical composition of materials and parameters of technological process stability. They used in energetic, technical ceramics, optics, catalysis, etc. Electrical conductivity, catalytic and optical properties of the zirconia based nanocomposites are due to the peculiarities of nanoparticles formation and nanoparticles surface properties.

### **RESULTS**

Zirconia (3Y-TZP), zirconia based composites  $ZrO_2$ -3mol%ZnO) and  $ZrO_2$ -3mol% $Y_2O_3$ +n% $Al_2O_3$  nanopowders were synthesized by co-precipitation technique. The amount of ZnO was varied from 3 to 50 wt%, the amount of alumina was varied from 0.5 to 5 wt%. The dried zirconium hydroxides and composites were calcined. at 1000°C. All powders of these formulations were also obtained by mixing in a planetary planetary-mill at 400 rpm for 10 h using YSZ milling balls. X-ray analysis showed a larger amount of ZnO in mixing powder compared to the precipitated powders (Figure 1). In order to compare our results with mixing an appropriate amount of commercially available  $\alpha$ - $Al_2O_3$  powder was mixed with

obtained 3Y-TZP nanopowders in distilled water. The  $\alpha$ - $\text{Al}_2\text{O}_3$  particle size distribution was wide enough with an average size at 1  $\mu\text{m}$ .

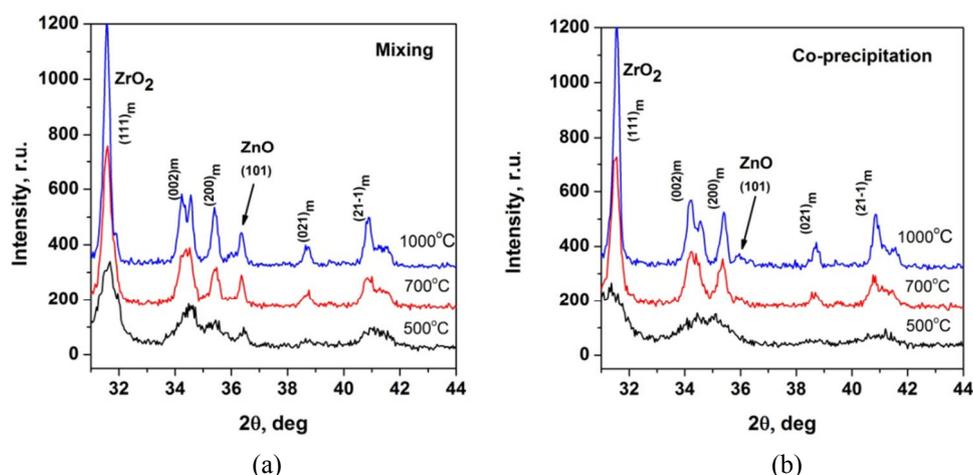


Fig. 1 - The XRD spectra of  $\text{ZrO}_2$  -  $\text{ZnO}$  powders: (a) by mixing technique; (b) by co-precipitation technique.

The process formation of supersaturated solid solutions of  $\text{Al}^{3+}$  ions in  $\text{ZrO}_2$  lattice and  $\text{Al}_2\text{O}_3$  particle were found in  $\text{ZrO}_2$ -3mol% $\text{Y}_2\text{O}_3$ - $\text{Al}_2\text{O}_3$  composite system. In order to compare our results with mixing an appropriate amount of commercially available  $\alpha$ - $\text{Al}_2\text{O}_3$  powder was mixed with obtained 3Y-TZP nanopowder in distilled water. The  $\alpha$ - $\text{Al}_2\text{O}_3$  particle size distribution was wide enough with an average size at 1  $\mu\text{m}$ . The process of formation of supersaturated solid solutions of  $\text{Al}^{3+}$  ions in  $\text{ZrO}_2$  lattice was found in  $\text{ZrO}_2$ -3mol% $\text{Y}_2\text{O}_3$ - $\text{Al}_2\text{O}_3$  composite system. The sintering regime is also of great importance.

## CONCLUSIONS

In the present study has been shown that zirconia materials in nanostructured state have a wide spectrum of properties, which was impossible to achieve in traditional microscopic state. Powders with doping by  $\text{ZnO}$  showed good effect in the processes photocatalysis. The ceramic composite materials sintered from synthesized nanopowders demonstrate higher integrity and reliability: enhanced level of fracture toughness to 1.8-2 times and very high level wear resistance in comparison to composite materials sintered from nanopowders obtained by mixing of zirconia nanopowder with alumina. The resulting composites are not prone to degradation under hydrothermal conditions. The process of dopant migration from grain volume to the grain surface leads to creation of complex multilevel composite structures, such as ion segregation on zirconia grain boundaries, clusters, intra- and intercrystalline inclusions in zirconia grains.

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