PECULIARITIES OF OBTAINING NANOSTRUCTURED MATERIALS COMPACTED BY THE METHOD OF HOT PRESSING DUE TO THE PASSAGE OF DIRECT ELECTRIC CURRENT

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Abstract. The aim of this work was to study the regularities of structure formation in composites based on zirconium dioxide nanopowders in the process of hot pressing with direct alternating current. . It was found that the microstructure of the samples in which zirconium dioxide was obtained in different ways strongly depends on tetragonal-monoclinic transitions. Optimal composition of initial mixtures and sintering modes using alumina nano additives was established in order to improve the physical and mechanical properties of the material. To improve the mechanical properties of the samples, sintering temperature and holding time can be raised because alumina grain growth is less rapid at a 30 % content than at lower contents.

1. Introduction

Materials based on partially stabilized zirconium dioxide with various additives nanopowders are promising in designing of hydro abrasive nozzles with enhanced mechanical properties as well as a material for endoprostheses in medicine [1,2]. Formation of microstructure in composites based on chemically synthesized zirconium nanopowders obtained by the method of decomposition from fluoride salts has been considered in this work.

2. Experimental procedure

Samples were proceed via hot vacuum pressing installation. Morphology and structural analysis were performed by scanning microscopy (Nova NanoSEM scanning ion-electron microscope, Quanta 200 3D scanning electron microscope); AFM scanning was performed by the semi-contact method in the air in two modes: at a constant amplitude (topography) and in the mode of phase contrast. Shots of 1×1 μm, 2.5×2.5 μm and 5×5 μm.

3. Results and discussions

It was shown, increasing of the additive of nanopowders of alumina in the content, results in an increase in strength and crack resistance of the samples due to simultaneous inhibition of abnormal grain growth and formation of a finer structure with a high content of tetragonal phase.The microstructure of the samples strongly depends on tetragonal-monoclinic transitions. The nature of the structure and pores formed in the samples of ZrO_2– 10 wt. % Al_2O_3 composition with grains of spherical shape inhibit the formation of Palmquist cracks at the loadof 10 N [3].

The increase in the content of nano Al_2O_3 additives from 10 wt. % to 30 wt. % has improved strength and crack resistance of the samples. At the same time, there was a restraint of abnormal grain growth and formation of a finer structure at high content of tetragonal phase.

Composition marking	ZrO_2 powder type
P–1	Spray drying, spherical shape, d_{av}=70 nm (NANOE Company, France)
P–2	Deposition from fluoride salts, disc- shaped, d_{av}=80 nm (Institute of Monocrystals, Kharkiv, Ukraine)
P–3	Chemical deposition, spherical shape, d_{av}=10 nm (I.M. Frantsevich Institute for Problems of Materials Science, Kyiv

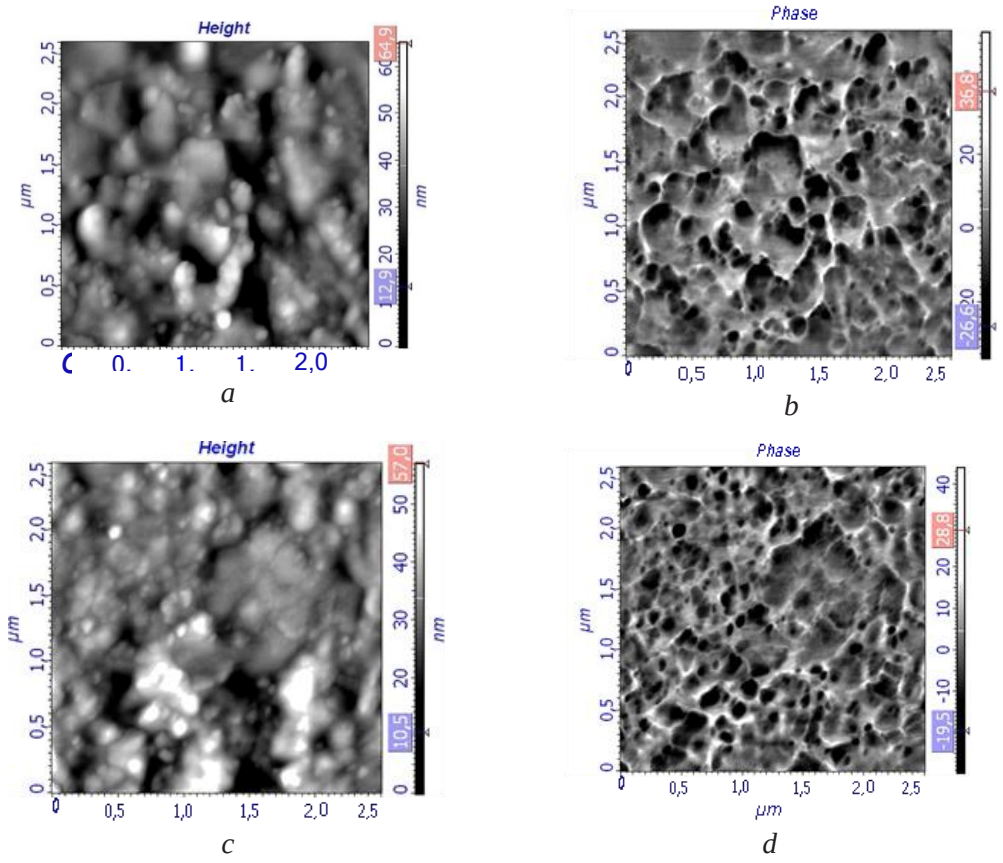

Fig.1. AFM image of chips from samples with ZrO_2–30 wt. % Al_2O_3 composition sintered at 1,200 °C: *a* – fracture height in samples prepared from P–2 powder; *b* – structure of fracture in samples prepared from P–2 powder; *c* – fracture height in samples prepared from P–3 powder; *d* – structure of fracture in samples prepared from P–3 powder

Conclusions

To conclude, study the microstructure of composite materials based on chemically synthesized nanopowders of zirconium dioxide obtained by the method of electric sintering (electroconsolidation) with additives of Al_2O_3 has been investigated in this work. Zirconium oxide, obtained by chemical decomposition from fluoride salts, has crack resistance of 7.8 MPa·$m^{1/2}$ at a strength of 820 MPa. Total density level for the ceramic increases with increasing of electroconsolidation temperature. The combination of different nano additives along with alumina, could increase the physical and mechanical properties of the resulting composites.

References

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