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CHEMICAL TECHNOLOGY

Production of High-Flexural-Strength Corundum Ceramics

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Abstract—A new method was proposed to produce high-flexural-strength corundum ceramics from α-Al_2O_3 samples synthesized by heat treatment of boehmite AlOOH at 1300°C for 5 h. It was shown that hydrothermal treatment of MDGA-grade hydrargillite at 200°C in a 0.4 wt % magnesium acetate solution for 3 days gives finely crystalline boehmite, which is a feedstock for synthesizing corundum ceramics with a flexural strength of 400 MPa.

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Corundum ceramics is widely used in machine building, electronics and radio electronics industry, ceramic armor plate production [1–5], metallurgy, and chemical industry. Also of great current interest is the possibility of using high-purity (99.99 wt %) corundum ceramics in medicine for manufacturing hip and dental prostheses [2]. Methods for synthesizing feedstock for producing corundum ceramics can be conditionally divided into physical and chemical [3]. A physical method is solid-phase powder synthesis, which usually does not lead to complete sintering of reagents, thus impairing the performance of the ceramics. Chemical synthesis methods, such as hydrothermal synthesis, can produce finely divided powders of feedstock for obtaining corundum ceramics with given particle shape and sizes [4], which ensures the production of high-density ceramics with homogeneous structure and improved strength characteristics. The creation of high-flexural-strength corundum ceramics is a topical challenge in manufacturing ceramic substrates for electronic and radio electronic applications. Alumina ceramic substrates are the basis for creating hybrid integrated circuits, resistors, ceramic capacitors, and other semiconductor elements and electricals.

In this work, we proposed a new method for producing high-flexural-strength corundum ceramics from α-Al_2O_3 samples synthesized by heat treatment of boehmite AlOOH at 1300°C for 5 h.

Boehmite AlOOH as a feedstock for synthesizing corundum ceramics was obtained in an autoclave from MDGA-grade hydrargillite at 200°C for 3 days in two liquid media: water (sample 1, Fig. 1a) and a 0.4 wt % magnesium acetate solution (sample 2, Fig. 1b). As the scanning electron microscopy images show, boehmite particles produced in each of the media have isometric habitus with an average particle size on the order of 1 μm.

The synthesized boehmite powders were subjected to additional dry grinding in a planetary mill with corundum balls for 5 min. From the ground powders, 40 × 6 × 5-mm beams were produced with a polyvinyl alcohol solution as a binder. Then, the beams were compacted at a pressure of 100 MPa. To remove the binder, the compacted samples were calcined in air at 1400°C for 1 h. The shrinkages of samples 1 and 2 after the heat treatment 1400°C were 3.5 and 5.8 wt %, respectively.

To produce corundum ceramics, the compacted beams were calcined in a vacuum furnace at 1650°C for 2 h. Table 1 presents the characteristics of the ceramics obtained from samples 1 and 2.

One of the surfaces of the each of the samples of the synthesized corundum ceramics was ground and polished to determine the surface roughness with a

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Table 1. Characteristics of the obtained corundum ceramics

Parameter	Sample 1	Sample 2
Total shrinkage, wt %	22.4	18.8
Density, g/cm^3	3.93–3.96	3.75
Flexural strength, MPa	400	185

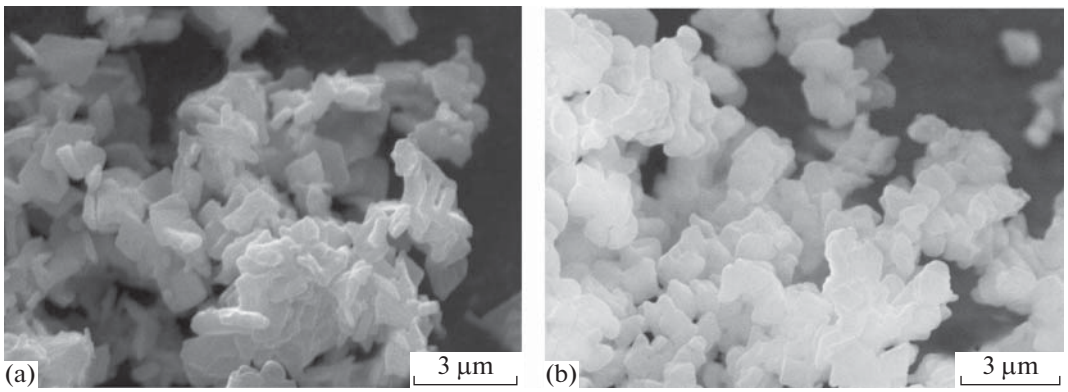

Fig. 1. Scanning electron microscopy images of boehmite obtained by treatment of MDGA-grade hydrargillite in an autoclave at 200°C for 3 days in (a) water and (b) a 0.4 wt % magnesium acetate solution.

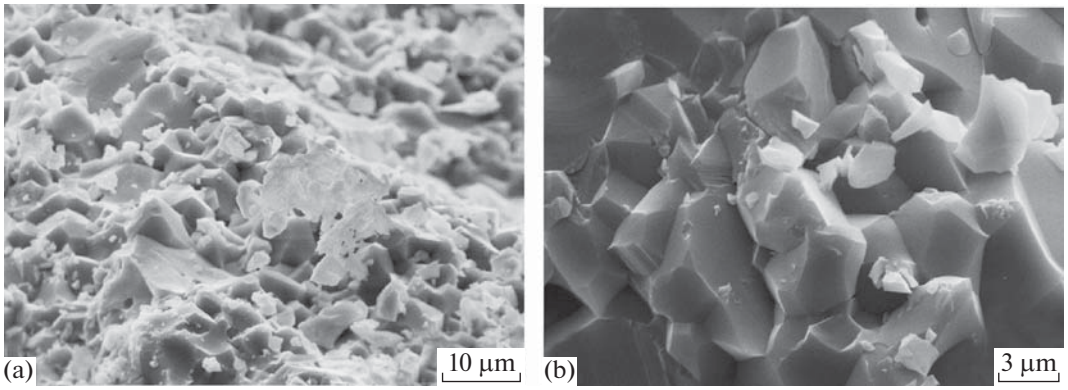

Fig. 2. Scanning electron microscopy images of (a) the surface and (b) the internal structure of corundum ceramics obtained by calcination (vacuum, 1650°C, 2h) of boehmite synthesized by treatment (autoclave, 200°C, 3 days) of MDGA-grade hydrargillite in a 0.4 wt % magnesium acetate solution.

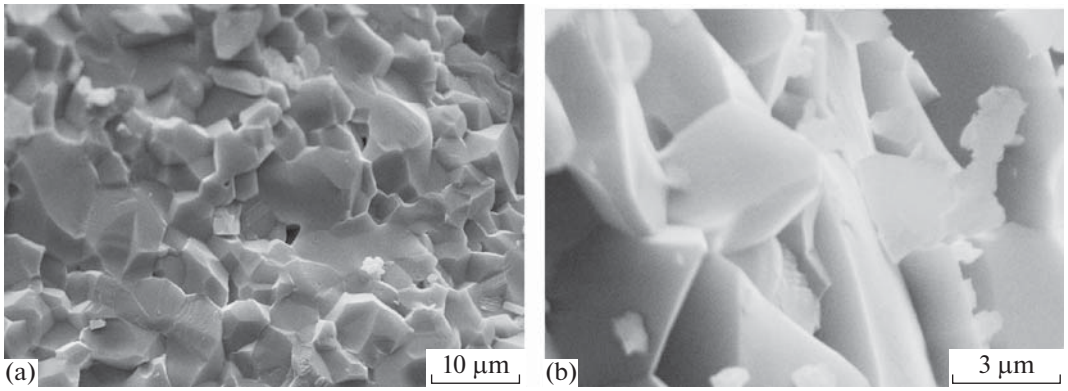

Fig. 3. Scanning electron microscopy images of (a) the surface and (b) the internal structure of corundum ceramics obtained by calcination (vacuum, 1650°C, 2h) of boehmite synthesized by treatment (autoclave, 200°C, 3 days) of MDGA-grade hydrargillite in water.

microprofilometer. For both samples, the surface roughness was the same. The maximum valley depth was 0.05–0.08 μm, which corresponds to surface finish class 13. Figures 2 and 3 present the scanning electron microscopy images of the surface and the internal structure of the synthesized corundum ceramics.

According to the data in Table 1, the flexural strength of sample 1, which was obtained by calcina-

tion (vacuum, 1650°C, 2 h) of boehmite synthesized by treatment (autoclave, 200°C, 3 days) of MDGA-grade hydrargillite in a 0.4 wt % magnesium acetate solution, is 400 MPa. Thus, the addition of magnesium oxide to boehmite and the uniform distribution of MgO in it favors the production of corundum ceramics with high density, fine particle sizes, and good mechanical properties.

Thus, in this work, we proposed a new method for obtaining high-flexural-strength corundum ceramics from α-Al_2O_3 samples synthesized by heat treatment of finely crystalline boehmite AlOOH supplemented with magnesium oxide to 0.4 wt %.

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