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Nano- and Submicrocrystal-line Transparent Ceramics

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Transparent polycrystalline ceramics are harder, stiffer, and more resistant, both to thermal loads and to corrosion than conventional optically transparent materials such as glass, glass ceramics and polymers. They can also be used under extreme environmental conditions. The Research and Development Center for Transparent Ceramics at the IKTS site in Hermsdorf covers the entire ceramic process chain for the production of transparent ceramic components (Perlucor[®]), from the laboratory through to pilot and production scales. Contact: Dr. Martin Drüe.

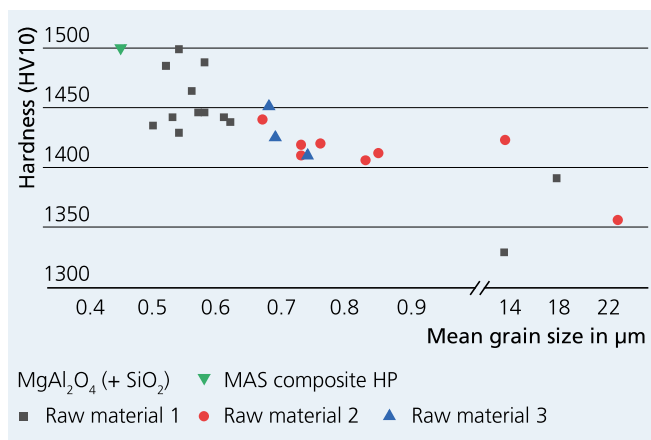


Fig. 1: Samples of transparent $MgAl_2O_4$ ceramic produced from different raw materials via the powder route, compared with a nanoscale high-pressure sample (MAS composite HP).

In the IGF project TransCeram (funding code: No. 01IF22506N), the ceramic route was compared with two other methods for producing transparent materials in order to investigate the influence of grain size. These were the glass-ceramic route using amorphous powder (Fraunhofer ISC) and high-pressure-assisted crystallization (Christian-Albrechts-Universität Kiel).

Using the powder route, it was possible to produce transparent ceramics with grain sizes of approximately 600 nm, while the crystallization routes (glass-ceramic and high-pressure routes)

resulted in a nanoscale microstructure and, in the latter case, a pore-free ceramic. In order to minimize grain size, starting materials and the temperature (pressure) profile were investigated and raw materials were doped (metal oxides, e.g. SrO). Fig. 2 shows the microstructures of the three processing routes.

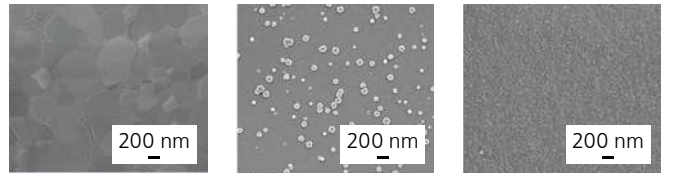


Fig. 2: Different microstructures of samples made from transparent $MgAl_2O_3$ ceramic.

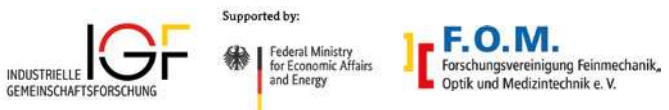
Up to a certain grain size, the hardness increased (Hall-Petch relationship, Fig. 1). The result of the high-pressure experiment (MAS composite HP) with grain sizes $< 0.45 \mu m$ is not yet fully crystalline. Another increase in hardness can be predicted once the amorphous phase is eliminated through optimized process control: this is the focus of further development. The transparency of these samples was highly dependent on the temperature-pressure profile, which affected both grain size and the phase composition of the material (Fig. 3). The three processes enable the production of transparent ceramics for different requirement profiles (e.g. hardness, density, optical quality, size, cost).



Fig. 3: Transparent ceramics produced via the high-pressure route at different pressures and temperatures, diameter approx. 3–5 mm.

Services offered

- Manufacturing of transparent ceramic components
- Optical characterization (transmission with and without scattering, reflection, wavelengths from UV/Vis to IR, fluorescence, color measurements)
- Material development for translucent, transparent, colored, and fluorescent ceramics



Editorial notes

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