Polycrystalline Transparent Ceramics

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Research

The mechanical and optical properties of polycrystalline ceramics are controlled by microstructural features such as grain size, porosity and presence of second phases. To achieve high transparency of the polycrystalline ceramics it is important to create a microstructure that contains a minimal fraction of scattering centers. In fully dense single phase ceramics, the transparency increases with the increment of grain size due to the decreasing fraction of grain boundary regions. On the other hand, the mechanical properties (strength and hardness) of polycrystalline ceramics with an average grain size larger than 0.5 μm significantly decrease. Thus, the optical transmittance and the mechanical properties of the polycrystalline ceramic change according to grain size in opposite directions, and an optimal compromise between the functional properties of the ceramics has to be determined and realized. High pressure spark plasma sintering (HPSPS) apparatus allows the fabrication of nano-structured ceramics. The primary focus of our research is to determine the optimal parameters of the SPS process for the fabrication of fully dense polycrystalline ceramics with the appropriate functionality required from the final product.

HPSPS-processed nanostructured magnesium aluminate spinel specimens display a transparency of 82%, 1700HV hardness, and bending strength of about 280 MPa. Nd:YAG specimens fabricated by HPSPS display a very good combination of mechanical properties along with optical properties. The laser performance of the HPSPS specimen is comparable with ceramics fabricated by a conventional two stage method that is much more prolonged and expensive.

Applications & Products

Polycrystalline transparent ceramics (magnesium aluminate spinel and yttrium aluminum garnet) with a unique combination of mechanical and optical properties for armor and laser applications were fabricated through high-pressure spark plasma sintering of nano-size powders.