Aging effect of YSZ transparent ceramics obtained by SPS

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Highlights

- Transparent ceramics of 3YSZ and 8YSZ were obtained by SPS
- Oxidation states of Zirconia before and after sintering investigated
- Aging effect on the properties of YSZ transparent ceramics studied

1. Introduction

Zirconia (ZrO_2) is one of the materials that attracts the wide attention of researchers due to its multifunctionality. A few applications of ZrO2 are in the domains of refractories, oxygen sensors, fuel cell membranes (due to the high O_2 diffusivity), and structural and biomedical applications (due to its high strength and toughness). ZrO_2 has a comparatively higher birefringence than alumina, which makes it a viable candidate for miniature optical devices. Yttria-stabilized zirconia (YSZ) has wide applications such as thermal barrier material, windows for anvil cells, infrared windows, laser host materials, armor applications, optical lenses, tooth-like esthetics, thermal insulating transparent windows, scratch-resistant electronics, bar scanners, and high-pressure sodium and mercury halide lamps. Initially, YSZ single crystals were widely known for their use as artificial gemstones and high thermal shock behavior. Nevertheless, owing to the advantages in terms of time, cost, size, shape, and mechanical strength, the transparent polycrystalline ceramics have recently been studied to replace single crystals. Due to the inherent birefringence, additional light scattering will be experienced in addition to the grain boundaries in YSZ. In the present work we have fabricated transparent ceramics of 3YSZ and 8YSZ [1] by spark plasma sintering. We have analyzed the aging effect of the sintered YSZ ceramics based on their microstructure, transparency and ionic conductivity. The oxidation state of Zr in YSZ before and after sintering were investigated in detail.

2. Methods

Commercial powders of 3YSZ and 8YSZ from M/S TOSOH were used for fabrication of transparent ceramics by using spark plasma sintering. To sinter we employed commercial DR. SINTER LAB Spark Plasma Sintering system, Model SPS-511S / SPS-515S equipped with high vacuum system capable of reaching 10^{-3}Pa. The fabricated transparent ceramics of YSZ were tested for optical characterization, ionic conductivity and microstructure with respect to time (1- 3 years) on their influence of oxidation state.

3. Results and discussion

The aim of this work was to understand the influence of sintering by SPS on phase transition from the tetragonal (t) to cubic (c) and monoclinic to tetragonal phase and influence of the t/c phases on the optical, microstructural and ionic conductivity properties of YSZ. Samples of YSZ sintered by SPS may undergo reduction and it is important to study the oxidation state of Zr in the sintered transparent ceramics of YSZ. Aging effect has a strong influence on the inherent properties of zirconia. Hence in the present work, we studied the sample sintered by SPS after different time periods ranging from 1 month to 3 years.

4. Conclusions

Spark plasma-sintered transparent YSZ optical ceramics without the addition of any dopants/additives or high pressure were obtained. We have shown the possibility to obtain highly transparent YSZ optoceramics at 100 MPa, 1250-1350°C for the 20-min dwell time. The influence of heating and cooling rate of the phase

transformation monoclinic (m) to tetragonal (t) and tetragonal to cubic (c) phase was investigated. We demonstrated the possibility of increasing the mechanical, optical, and thermal conductivity due to the coexistence of m, t and c phases due to the slow heating rate in comparison with currently employed methods/doping in YSZ. This process is viable to be employed in industries due to the purity (no dopants) and nonrequirement of complex high-pressure die set-up. The further increase in high pressure and the slow heating rate could help in studying the high-temperature cubic phase of YSZ. The oxidation of Zr after sintering in YSZ compositions and aging effect on microstructure, optical, hardness and ionic conductivity were analyzed. The results will be discussed in detail.

Acknowledgements:

The authors acknowledge that the work is a part of Collaboration in Photonics between University of Bordeaux and Huazhong University of Science and Technology.

References

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Keywords

Transparent ceramics; Zirconia; optical properties; Aging effect