Innovative Processing and Manufacturing of Advanced Ceramics and Composites II

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With continued discoveries and innovations, the field of materials synthesis and processing remains as it has been for many decades, a vibrant and fertile area for research and development. It comes, therefore, as no surprise that every Pac Rim conference has had considerable emphasis on this topic with many symposia devoted to various aspects of this field.

This Ceramic Transactions volume represents selected papers based on presentations in four symposia during the 10th Pacific Rim Conference on Ceramic and Glass Technology, June 2–6, 2013 in Coronado, California. The symposia and their organizers are:

- **Novel, Green, and Strategic Processing and Manufacturing Technologies**
  Organizers: Tatsuki Ohji, National Institute of Advanced Industrial Science and Technology (AIST), Japan; Mrityunjay Singh, Ohio Aerospace Institute, NASA Glenn Research Center, USA; Shaoming Dong, Shanghai Institute of Ceramics, China; Jow-Lay Huang, National Cheng Kung University, Taiwan; Hai-Doo Kim, Korea Institute of Materials Science, Korea; Eugene Medvedovski, Umicore Thin Film Products, USA; Alexander Michaelis, Fraunhofer IKTS, Germany; Lalit Kumar Sharma, Central Glass & Ceramic Research Institute, India; Richard D. Sisson, Jr., Worcester Polytechnic Institute, MA, USA; Hisayuki Suematsu, Nagaoka University of Technology, Japan; Nahum Travitzky, University of Erlangen-Nuremberg, Germany

- **Polymer Derived Ceramics and Composites**
  Organizers: Paolo Colombo, University of Padova, Italy; Yigal Blum, SRI International, USA; Gian Domenico Soraru, University of Trento, Italy; Ralf Riedel, Technical University Darmstadt, Germany; Philippe Miele, University of Montpellier 2, France; Isabel Kinski, Fraunhofer Institute for Ceramic Technologies and Systems (IKTS), Germany; Raj Bordia, University of Washington, USA; Peter Kroll, The University of Texas Arlington, USA; Yuji Iwamoto, Nagoya Institute of Technology, Japan; Dong-Pyo Kim, Pohang University of Science and Technology, Korea; Yingde Wang, National University of Defence Technology, Changsha, China
• **Advanced Powder Processing and Manufacturing Technologies**
  Organizers: Makio Naito, Joining and Welding Research Institute (JWRI), Osaka University, Japan; Junichi Tatami, Yokohama National University, Japan; Lennart Bergstroem, Stockholm University, Sweden; Yuji Hotta, National Institute of Advanced Industrial Science and Technology (AIST), Japan; C. C. Huang, Hosokawa Micron Powder Systems, USA; Norifumi Isu, LIXIL Corp., Japan; Hai-Doo Kim, Korea Institute of Machinery & Materials (KIMM), Korea; Satoshi Tanaka, Nagaoka University of Technology, Japan; Tetsuo Uchikoshi, National Institute of Materials Science (NIMS), Japan; Sujanto Widjaja, Corning Incorporated, USA; Di Zhang, Shanghai Jiao Tong University, China

• **Synthesis and Processing of Materials using Electric Fields/Currents: A Symposium Honoring Prof. Zuhair Munir**
  Organizers: Javier E. Garay, University of California, CA; Manshi Ohyanagi, Ryukoku University, Japan; Eugene A. Olevsky, San Diego State University, CA; Masao Tokita, NJS Co., Ltd., Japan

The editors wish to extend their gratitude and appreciation to all the co-organizers for their help and support, to all the authors for their cooperation and contributions, to all the participants and session chairs for their time and efforts, and to all the reviewers for their valuable comments and suggestions. Thanks are due to the staff of the meetings and publication departments of The American Ceramic Society for their invaluable assistance. We want to especially acknowledge the help of Mr. Gregory Geiger of the Society. We also acknowledge the skillful organization and leadership of Dr. Hua-Tay Lin, PACRIM 10 Program Chair.

We hope that this issue will serve as a useful resource for the researchers and technologists in the field of processing and manufacturing of advanced ceramics and composites.

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PAOLO COLOMBO
MAKIO NAITO
JAVIER E. GARAY
Novel, Green, and Strategic Processing and Manufacturing Technologies
OPTIMIZED SHAPING PROCESS FOR TRANSPARENT SPINEL CERAMIC

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ABSTRACT

Bulky transparent ceramic, especially spinel (MgAl₂O₄), can be used for applications such as high-energy laser windows and lightweight armor. One of the traditional routes to manufacture transparent spinel plates includes the steps of material preparation, uniaxial pressing, cold isostatic pressing (CIP), de-bindering and hot isostatic pressing (HIP). When larger sizes are required, CIP can become one of the bottlenecks of the process chain. The paper shows how an optimized uniaxial hydraulic pressing process with an evacuated mould allows to avoid the cold isostatic pressing completely. The process is described and the first results of the investigation of transparent spinel properties are discussed. This simplified process will allow to reduce the manufacturing costs for larger sized transparent spinel significantly and/or improve the production capacity.

INTRODUCTION

Spinels are a group of minerals of general formulation AB₂O₄ (where A is a bivalent and B is a trivalent cation), which crystallise in the cubic crystal system with A and B occupying some or all of the octahedral and tetrahedral sites in the lattice. Spinel (MgAl₂O₄), after which the spinel group is named, in its pure form (single crystal) is a colourless, transparent material with high hardness and excellent transmission from the ultraviolet (0.2 μm) to the mid-infrared (5 μm) region. This makes spinel an interesting material for numerous applications such as high-energy laser windows and lightweight armor. However, single crystal spinel is difficult to make in dimensions greater than a few millimeters using traditional high temperature (>2000 °C) melt growth techniques. Various approaches to transparent polycrystalline spinel have been made, e.g. by using sintering aids like LiF or using sub-μm spinel powder and applying different shaping and sintering technologies. One of the traditional routes to manufacture polycrystalline transparent spinel plates includes the steps of material preparation, uniaxial pre-pressing, cold isostatic pressing (CIP), de-bindering and hot isostatic pressing (HIP). When larger sizes are required, CIP can become one of the bottlenecks of the process chain.

Aim of this work was to investigate a more economic route to prepare large-sized transparent spinel plates by optimization of the uniaxial pressing process and eliminating the cold isostatic pressing process completely.

MATERIAL PREPARATION

Commercially available high purity spinel powder, especially developed for transparent ceramics applications, was prepared by IKTS for the tests (see Table I).

Table I. Technical data of spinel powder used as starting material.

<table>
<thead>
<tr>
<th>supplier</th>
<th>BAIKOWSKI, France</th>
</tr>
</thead>
<tbody>
<tr>
<td>product code</td>
<td>S30CR</td>
</tr>
<tr>
<td>BET specific surface area</td>
<td>30 ± 5 m²/g</td>
</tr>
<tr>
<td>d₅₀ (PSD Sedigraph)</td>
<td>0.2 μm</td>
</tr>
<tr>
<td>crystalline phase (XRD)</td>
<td>≥ 99 % spinel</td>
</tr>
</tbody>
</table>