Cellular Ceramics

Structure, Manufacturing,
Properties and Applications

Edited by
Michael Scheffler, Paolo Colombo
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Cover Picture

Top left: Periodic cellular structure. Colloidal inks were extruded by robotic deposition. Sub-millimeter filaments of extruded colloidal gel are deposited layer-by-layer to assemble the structure in the z stacking direction followed by drying and sintering. The white-colored x-y-z axes are 400 μm in length (Image courtesy of Prof. J. Lewis, University of Illinois; see also Chapter 2.3).

Bottom left: Hierarchically built porous material. Rattan palm wood was transformed into char and infiltrated at high temperature with liquid silicon retaining its cellular channel structure. The Si/SiC porous material was then used for hydrothermal zeolite crystallisation under partial transformation of the excess silicon. MFI type zeolite was formed in the longitudinal channels of the material. The open channel diameter is 300–320 μm and the zeolite layer is 40–60 μm (Image courtesy of Dr. F. Scheffler, University of Erlangen-Nuremberg, Germany; see Chapter 2.5 and Ref. [29] in Chapter 5.4).

Right: Prototype of a silicon carbide foam heater element. The electrical conductive ceramic foam heats up when electrical power is applied to top and bottom end. Here a power of 750 W was applied. The ceramic foam is 30 mm in diameter (Photo taken by Friedrich Weimer, Dresden. Image courtesy of J. Adler, Fraunhofer-IKTS, Dresden, Germany).

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Foreword

For many years, the presence of porosity in ceramics was often seen to be problematic and a significant scientific effort was made to devise processing routes that produced ceramics with zero porosity. An exception to this philosophy was the refractory industry, in which it was understood that the presence of porosity is critical in controlling thermal conductivity. A sophisticated example of this concept was the development of refractory tiles for the thermal protection system of the Space Shuttle. In other branches of materials science, similar ideas were recognized. For example, rigid and flexible foams had been developed in polymer science and engineering. In these materials, porosity is controlled to optimize the elastic behavior and weight. In more recent times, scientific developments have touched on new areas such as biomimetics, in which scientists aim to duplicate natural structures. There has also been the push (and pull) to design materials and devices at smaller scale levels. Materials are becoming multifunctional with designed hierarchical structures, and porous ceramics can be seen in this light. The challenge now is for materials scientists to produce ceramics with porosity of any fraction, shape, and size. This also leads to new directions in the scientific understanding of porous structures and their properties. For the above reasons and my personal involvement in this field, I am pleased to see this new book on porous ceramics. This book takes a broad view of the field, while still allowing some detailed scientific aspects to be addressed. The book considers novel processing approaches, structure characterization, advances in understanding structure–property relationships and the challenges in all these areas. It is interesting to see the structural variety that forms the "palette" for the materials scientist and the wide range of properties that are controlled by porosity and therefore require careful optimization. Finally, the book gives examples of technologies in which porous ceramics are being exploited and the demands that arise as products move to commercial use. I applaud the editors for their vision and the authors for sharing their insight. I wish you a successful outcome for your efforts.

David J. Green
State College, Pennsylvania, USA
October 29, 2004
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