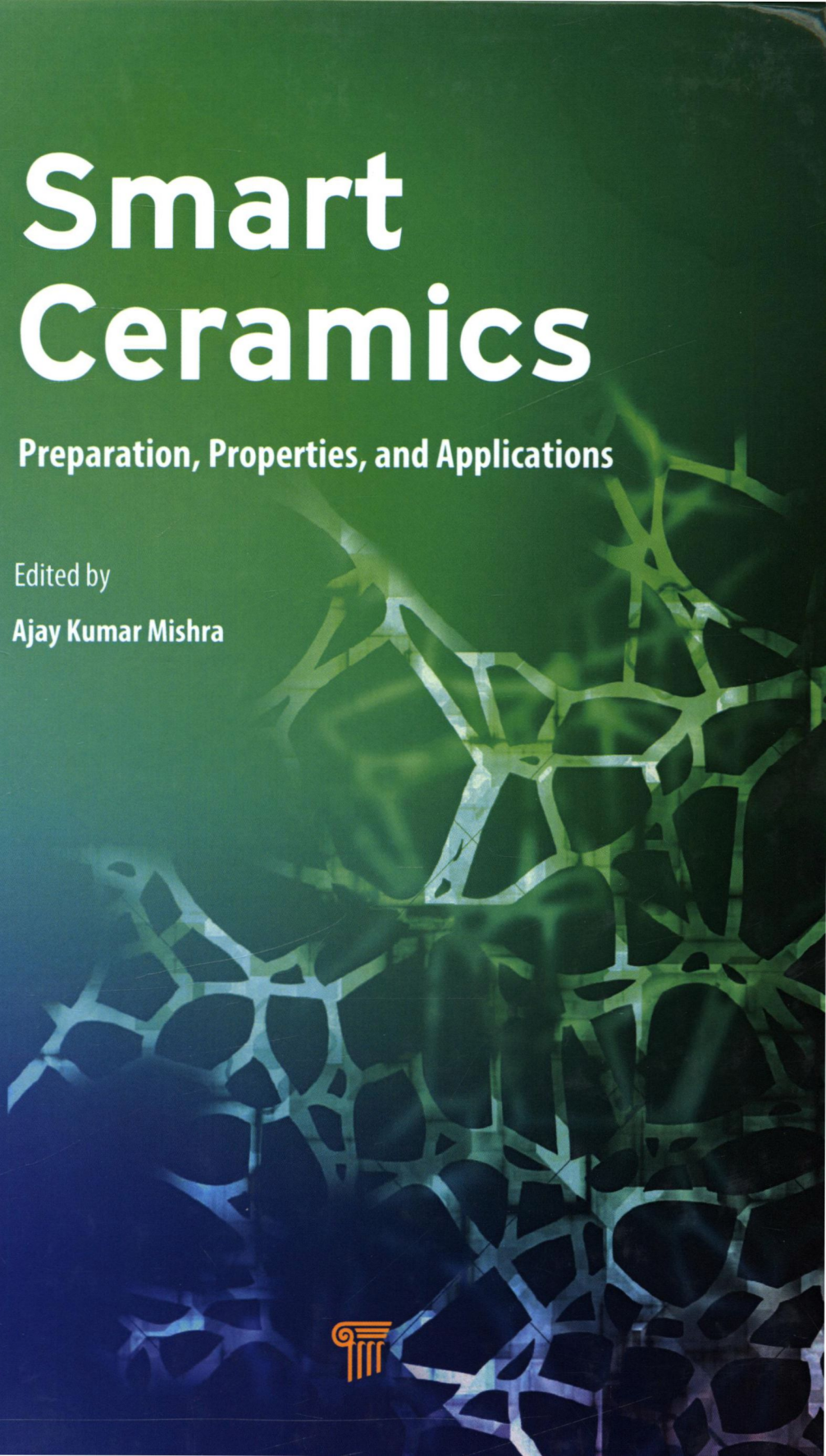
Smart Ceramics

Preparation, Properties, and Applications

Edited by

Ajay Kumar Mishra



Recent advances in nanotechnology have paved the way for the development of new smart materials. The term "smart ceramics" refers to ceramic materials fabricated from ultrafine particles. They have attracted the attention of researchers and scientists thanks to their potential to manipulate the length scale in the nanorange, leading to better and some unusual material properties. Smart ceramics ensure control of particle size, surface contamination, and degree of agglomeration. They play a crucial role in challenging applications such as bone surgery (e.g., the development of substitutes for load-bearing bone parts) and in biomedical science, especially in tissue engineering, dental applications, and drug and antigen delivery using modified ceramics. Porous nanostructured ceramics have potential use in both simple and complex applications, such as bioimaging, sensors, paints and pigments, optics, and electronics, because of their surface- and size-dependent properties. For the synthesis of smart ceramics, the sol-gel route has been mainly utilized because of its ability to produce a large variety of compositions and to ensure homogeneous mixing of the constituent particles at low temperature.

This book describes the innovations in technologies through the development of functionalized ceramic materials for various applications. It also describes recent and expected challenges, along with their potential solutions, in advanced techniques for the synthesis and characterization of nanostructured ceramics and their composites: bioceramics, bioactive ceramics, multifunctional nanoceramics, transparent ceramics, nanocore shells, nanowires, thin films, nanotubes, and nanorods. The applications include the environment, health care, electrochemical sensors, high-temperature superconductors, nuclear reactor fuels, electrical insulators, refractory materials, electrical transformers, and magnetic core memory. The book will benefit researchers, scientists, engineers, and technologists working in the industry and in national and international research laboratories; academics who are interested in traditional and advanced smart ceramic composites; and students pursuing their postgraduate, graduate, and undergraduate degrees in smart ceramics, nanomaterials, nanoscience, and engineering.

Ajay Kumar Mishra is full professor at the Nanotechnology and Water Sustainability Research Unit, College of Science, Engineering and Technology, University of South Africa, Florida Science Campus, South Africa, since 2015, and adjunct professor at Jiangsu University, China. He received his BSc and MSc from Purvanchal University, India, in 1997 and 2001 respectively, and MPhil and PhD from the University of Delhi, India, in 2003 and 2007 respectively. From March 2006 to September 2009 he was a postdoctoral fellow at various South African institutes and/or universities. In October 2009 he joined the Department of Applied Chemistry, University of Johannesburg, South Africa, as senior lecturer, and from November 2011 to December 2014 he was associate professor there. Prof. Mishra's research interests include water research and the synthesis of multifunctional nanomaterials, nanocomposites, biopolymer- and petrochemical-based biodegradable polymers, polymer-based materials/composites, smart materials, and carbon nanotube- and graphene-based composite materials. He has authored more than 100 scientific papers, collaborated with researchers, scientists, and postdocs in his group and worldwide, and delivered many plenary, keynote, and invited lectures. For his outstanding research, he has received a number of international awards. He has served as an associate editor as well as a member of the editorial board of many peer-reviewed international journals, and he has edited several books by renowned publishers. Prof. Mishra also serves as an advisory board member of a number of international scientific societies, conferences, and workshops.

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Cover image, taken by Lingyan Shi from Adrian Rodriguez-Contreras' Lab, shows a trans-cranial image of brain microvessels filled up with Texas red dextran 70 kDa and wrapped with Gcamp-6 GFAP astrocytes, using a multiphoton fluorescence microscope.

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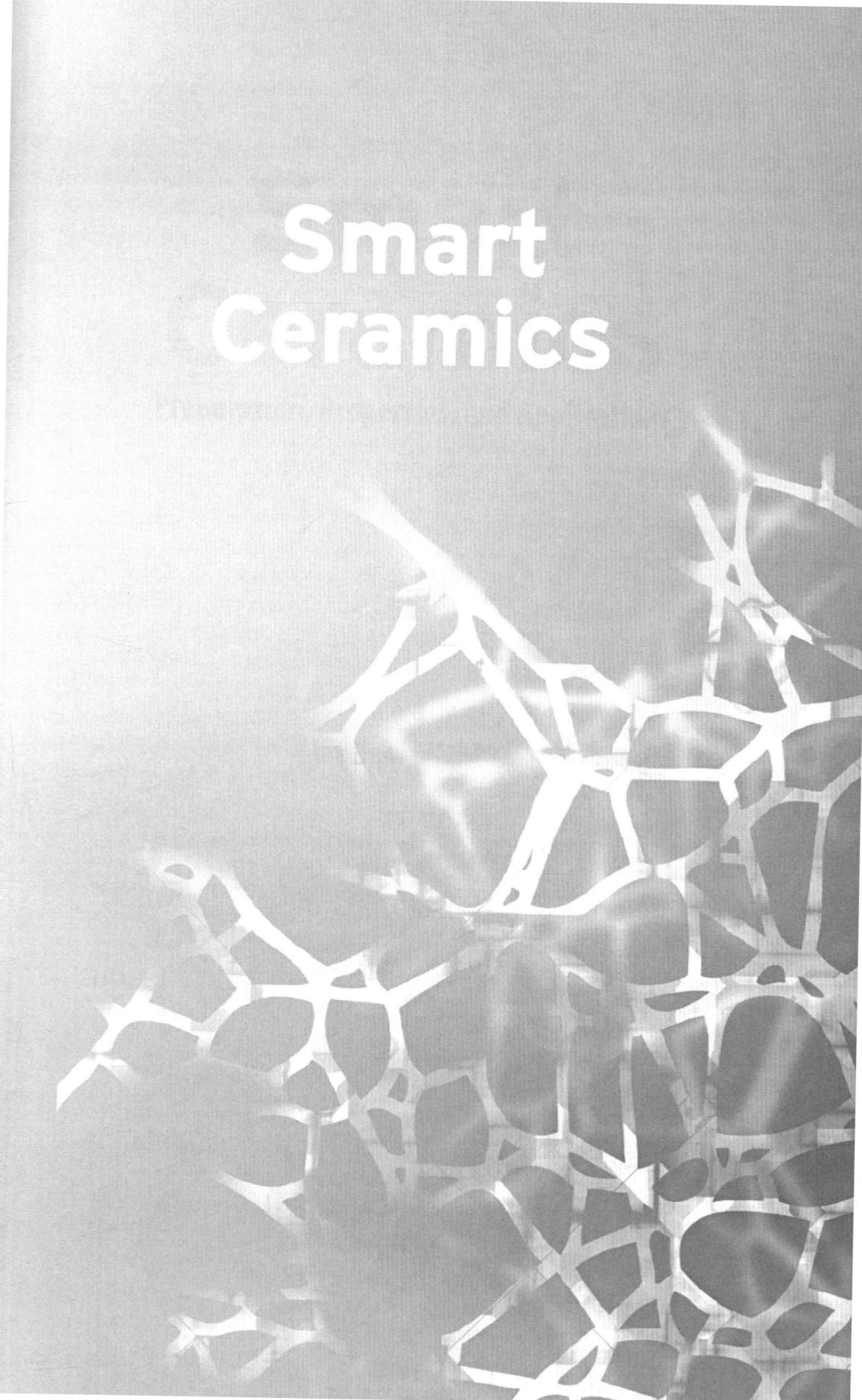

Preface

The term "smart ceramic materials" refers to ceramic materials fabricated from ultrafine particles. These materials have attracted the interest of researchers and scientists because of their potential to manipulate the length scale in the nanorange, leading to better and some unusual material properties. Smart ceramics have been synthesized to ensure control of particle size, surface contamination, and degree of agglomeration. The sol-gel route has been mainly utilized for the synthesis of smart ceramics because of its ability to produce a large variety of compositions and ensure homogeneous mixing of the constituent particles at low temperature.

Recent advances in nanotechnology have paved the way for the development of new smart materials. Sol-gel bioceramics play an important role in the biomedical field because of their superior biological and mechanical properties. Because of their unique physical and chemical properties, various metal oxide nanoparticles have emerged as the materials of choice in the removal of various types of pollutants from air and water. Porous nanostructured ceramics are an attractive class of materials that have found potential in various applications, ranging from simple to complexones, such as bioimaging, sensors, paints pigments, optics, and electronics, because of their surface- and size-dependent properties. Smart ceramics play a crucial role in industrial applications, particularly in the field of bone surgery, for example, the development of bone substitutes for load-bearing bone parts. This represents one of the most challenging applications, especially due to the difficulty of expressing high bioactivity and bone-like mechanical properties. Smart ceramic materials have also attracted researchers from the area of biomedical science, especially in tissue engineering, dental applications, and drug and antigen delivery using modified ceramics.

This book describes innovation in technologies through the development of functionalized ceramic materials from the

perspective of energy, environment, and healthcare applications. It describes recent and expected challenges, along with potential solutions, in advanced techniques for the synthesis and characterization of nanostructured ceramics and their composites: bioceramics, bioactive ceramics, multifunctional nanoceramics, transparent ceramics, nanocoreshells, nanowires, thin films, nanotubes, and nanorods. The applications include environmental applications, healthcare applications, electrochemical sensors, high-temperature superconductors, fuel in nuclear reactors, electrical insulators, refractory material, electrical transformers, and magnetic core memory.

The book will be more beneficial to researchers, scientists, engineers, and technologists working in industry, national/international research laboratories and academia with interest in traditional and advanced smart ceramic composites. Researchers registered for their postgraduate/graduate/undergraduate degrees in the areas of smart ceramics, nanomaterials, nanoscience, and engineering will also be highly benefitted.

Ajay Kumar Mishra
University of South Africa, South Africa
2017

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