ADVANCED SCIENCE AND TECHNOLOGY OF SINTERING

Edited by
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and Maria Vesna Nikolić

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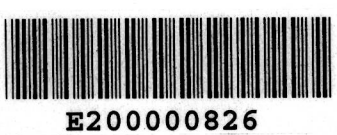

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PREFACE

This volume entitled Advanced Science and Technology of Sintering, contains the edited Proceedings of the Ninth World Round Table Conference on Sintering (IX WRTCS), held in Belgrade, Yugoslavia, September 1-4 1998. The gathering was one in a series of World Round Table Conferences on Sintering organised every four years by the Serbian Academy of Sciences and Arts (SASA) and the International Institute for the Science of Sintering (IISS).

The World Round Table Conferences on Sintering have been traditionally held in Yugoslavia. The first meeting was organised in Herceg Novi in 1969 and since then they have regularly gathered the scientific elite in the science of sintering. It is not by chance that, at these conferences, G. C. Kuczynski, G. V. Samsonov, R. Coble, Ya. E. Geguzin and other great names in this branch of science presented their latest results making great qualitative leaps in the its development.

Belgrade hosted this conference for the first time. It was chosen as a reminder that 30 years ago it was the place where the International Team for Sintering was formed, further growing into the International Institute for the Science of Sintering.

The IX WRTCS lasted four days. It included 156 participants from 17 countries who presented the results of their theoretical and experimental research in 130 papers in the form of plenary lectures, oral presentations and poster sections. The presentation of each contributed paper proved to be a good opportunity for free and informal discussion. This enabled a broad analysis of the current state of the science of sintering and gave perspectives for the further development of the theory and technology of sintering. Fundamental scientific problems were addressed as well as the technological state-of-the-art in sintering and sintering materials, including sintered materials of advanced technology used in a variety of research and industrial applications. In the opinion of the editor, this conference was characterized by the high level and broad scope of reports on the advanced science and technology of sintering.

This volume includes 92 papers selected by the editors and organised into seven sections which comprise this book, as follows: (1) Fundamentals (2) Nanostructured Powders (3) Mechanical Activation (4) Sintering of Oxide Systems (5) Electronic Ceramics (6) Non-Oxide Materials (7) Sintering of Metal Powders.

We would like to acknowledge the useful advice and considerable assistance of the General Secretary of the International Institute for the Science of Sintering and President of the Organization Committee, Academician Momčilo M. Ristić and also the International Program and Organization Committee, Session Chairmen, as well as the creative efforts of the distinguished contributing authors representing

many of the world centres for sintering research. We extend our personal thanks for their cooperative attitudes, timely responses, and many helpful suggestions.

We wish to express our gratitude to the patron of the International Institute for the Science of Sintering, the Serbian Academy of Sciences and Arts, as well as the Centre for Multidisciplinary Studies at the University of Belgrade, and the Institute of Technical Sciences of SASA in Belgrade for their support in the organization of the conference. We also note with gratitude the financial support for the conference organization provided by the principal sponsor, the Ministry for Science and Technology of the Republic of Serbia, Potisje Kanjiža, Kanjiža, the Cement factory, Kosjerić, the Institute of Nuclear Sciences "Vinča", the Institute of Chemistry, Technology and Metallurgy, Belgrade, the Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, the Technical Faculty, Čačak, the Electronic Faculty, Niš, the Faculty for Technology and Metallurgy, Belgrade, the Scientific Research Centre, Užice, IRITEL, Belgrade, ICN Yugoslavia, Petrohemija, Pančevo and RTB Bor, Bor.

We wish to acknowledge a small group of individuals who worked with great dedication behind the scenes: Nataša Nikolić, Bojan Marinković, Mirjana Kosanović and Ljiljana Milošević for their assistance in preparing materials before, during and after the conference; Aleksandar Kosanović and Dragan Tasić for providing technical service; Voja Glavonjić and his staff from the Printing Office of the Serbian Academy of Sciences and Arts for preparing all materials for the conference; Dr Stamenka Radić for translation services, Nikola Čajkanović, Ljiljana Nedeljković, Ivana Sevicki and Vukica Đapa for simultaneous translation during the conference, and Emina Ljutić for efficient typing of the conference materials.

It is also our pleasure to thank Goran Branković and Aleksandar Tucić for their help in the preparation of the proceedings, as well as Tatjana Srećković, Vesna Minić, Lidija Mančić and Zorica Marinković for performing various tasks and preparing materials for the conference.

Lastly, we would like to acknowledge with affection the patience, tolerance, and moral support we have been given by our colleagues and families through those extended periods of time when we had to pay attention to organizing the conference and editing these proceedings.

Biljana D. Stojanović
Valery V. Skorokhod
Maria Vesna Nikolić

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Part I. *FUNDAMENTALS*

INFLUENCE OF EXTERNAL FIELDS ON SINTERING

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ABSTRACT

Two types of driving forces caused by the presence of external fields are described: one type arises due to the evolution of the heat in the volume of a sample (electric contact, hf, inductive heating or penetrating radiation, e.g., neutrons could be the sources of the heat); another type of the driving forces arises due to the energy of the field (electric, magnetic), present in the bulk of a polar material. Influence of these driving forces on sintering, structure and properties is discussed. The role of mobile and immobile dislocations, grain boundaries, and pores is considered. Cycling and pulsing regimes of sintering are investigated.

Porous polar materials are studied on the basis of the Clausius-Mossotti approximation. Equilibrium shape of a pore in a polar material is calculated. It's contribution to the anisotropy of a sample is discussed. Peculiarities of the kinetics of pores in polar materials in external field are regarded.

INTRODUCTION

Directions and rates of diffusional processes of mass transfer are important constituents of the process of sintering. They are determined by thermodynamic driving forces and kinetic characteristics of a system. Kinetic characteristics include magnitudes of kinetic coefficients, e.g., diffusion coefficient, and conditions of realization of different mass transfer mechanisms. A vacancy mechanism of mass transfer is a regular one in crystalline materials. Mean free path of the excess vacancy, which is determined by defect structure of a material and by the distance from a free surface, governs in an essential way rates of diffusional processes.

The process of sintering is usually considered to consist of three parts[1]. Initial stage of sintering is usually regarded to be determined by the processes of connection of separate particles, and a regrouping; plastic deformation and boundary diffusion play a leading role during this stage, while the contribution of the bulk diffusion is negligible. Boundary

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