

Preface

This year is a 40-th anniversary of discovery for so-called *Self-propagating High-temperature Synthesis* (SHS), which was invented by Prof. A.G. Merzhanov and coworkers (Institute of Chemical Physics, Russian Academy of Sciences) in 1967. SHS is an effective energy saving method for the synthesis of a variety of advanced materials. This approach is characterized by the fact that once the initial exothermic reaction mixture is ignited by means of an external thermal source, a rapid (typically from 0.1 to 10 cm/s) high-temperature (1000–3000°C) combustion wave propagates through the heterogeneous mixture in a self-sustained manner leading to the formation of the solid material without involving any additional energy.

Since this time the development of SHS led to the manifestation of a new scientific field that combines both aspects of *heterogeneous combustion* and *materials sciences* and attracted the attention of the international scientific community as an innovative method for the synthesis of ceramics, intermetallics, metal alloys, composites, functionally graded and other advanced materials. Currently this unique approach is widely investigated and used in many scientific laboratories and Universities of USA, Russia, Japan, Italy, France, Spain, South Korea, China, India and other countries.

A great deal of fundamental theoretical and experimental works has been performed to describe the complex phenomena of rapid reaction propagation in heterogeneous reactive media. Obtained essential results in many cases allow precisely control the synthesis process and thus produced materials with desired microstructure and properties. Several examples are available on the successful application of SHS-method on the industrial level (China, Japan, Spain, and Russia).

A main goal of this book is to present the recent important findings in the field of combustion synthesis, from both the fundamental and technological points of view. First, it is shown (Chapters 1 and 2) that novel theoretical approaches for modeling and computer simulation of the combustion process allow *direct comparison* of theoretical predictions and experimental observations. Second, a special attention is paid for novel approaches for SHS of *nano-materials* (Chapters 3-5). Finally, state of art combustion-densification methods to produce pore-free ceramic composites, as well as different techniques for combustion joining of refractory materials are also discussed (Chapters 6-8). Briefly:

Chapter 1: A novel mathematical model of SHS processes, which accounts the heterogeneous nature of mass transfer phenomenon in powder mixture, is developed. The model allows one to simulate *microstructural evolution* in

combustion wave using suitable population balances and the different driving forces coming from the relevant phase diagrams. The comparison of theoretical results with related experimental data is also presented. *Chapter 2:* The overview and discussion of *basic principles for different combustion models* are presented. The analysis enables explanation of many experimental results, which could not be understood within the classical homogeneous theory of combustion wave propagation. *Chapter 3:* A novel process, which is referred to as *Carbon Combustion Synthesis of Oxides (CCSO)*, and allows effective synthesis of *nano- and submicron* complex oxides powders is described. The main features of CCSO process, including velocity of the combustion front and its temperature-time history, micro-structural and phase transformations, as well as product morphology, electro-magnetic and catalytic properties have been discussed. *Chapter 4:* Recent results in synthesis of *nanopowders* of the transition metals (Ti, Ta, W, and Mo) and carbides (TiC, WC) by SHS method are reviewed and compared with other synthesis methods. The morphology and a phase composition of nanoparticles as a function of the reaction conditions are also discussed. *Chapter 5:* The effect of the mechanical activation (MA) of the reactants on the SHS in different systems (e.g. Ti-Si, Ti-Ni, Al-Ni, Mo-B and others) was investigated. It was shown that MA improves the contact between reactants and increases the concentrations of the volume and surface defects in the treated heterogeneous powder media. All above significantly increase the systems reactivity. *Chapter 6:* *Novel method for one-step* synthesis and densification of titanium diboride based composites by using SHS + quick pressing approach is presented. *Chapter 7:* Thermal explosion SHS-mode coupled with the simultaneous application of a moderate uni-axial pressure, so-called *Reactive Forging*, is demonstrated. It is shown that this approach is an effective method for processing of dense near-net-shape monolithic and composite ceramics. *Chapter 8:* A number of issues which determine the technical feasibility and economic viability of a novel process for joining of refractory materials using heterogeneous reactive systems and principals of SHS is widely discussed and analyze.

We are very thankful to all authors of the chapters in this book. Without their time, energy, and commitment to excellence, this book would not have been possible. We also sincerely hope that this book will be interesting and useful for chemical and materials science engineers and graduate students, who are involved in the design and development of high-temperature processes for synthesis of novel advanced materials.

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