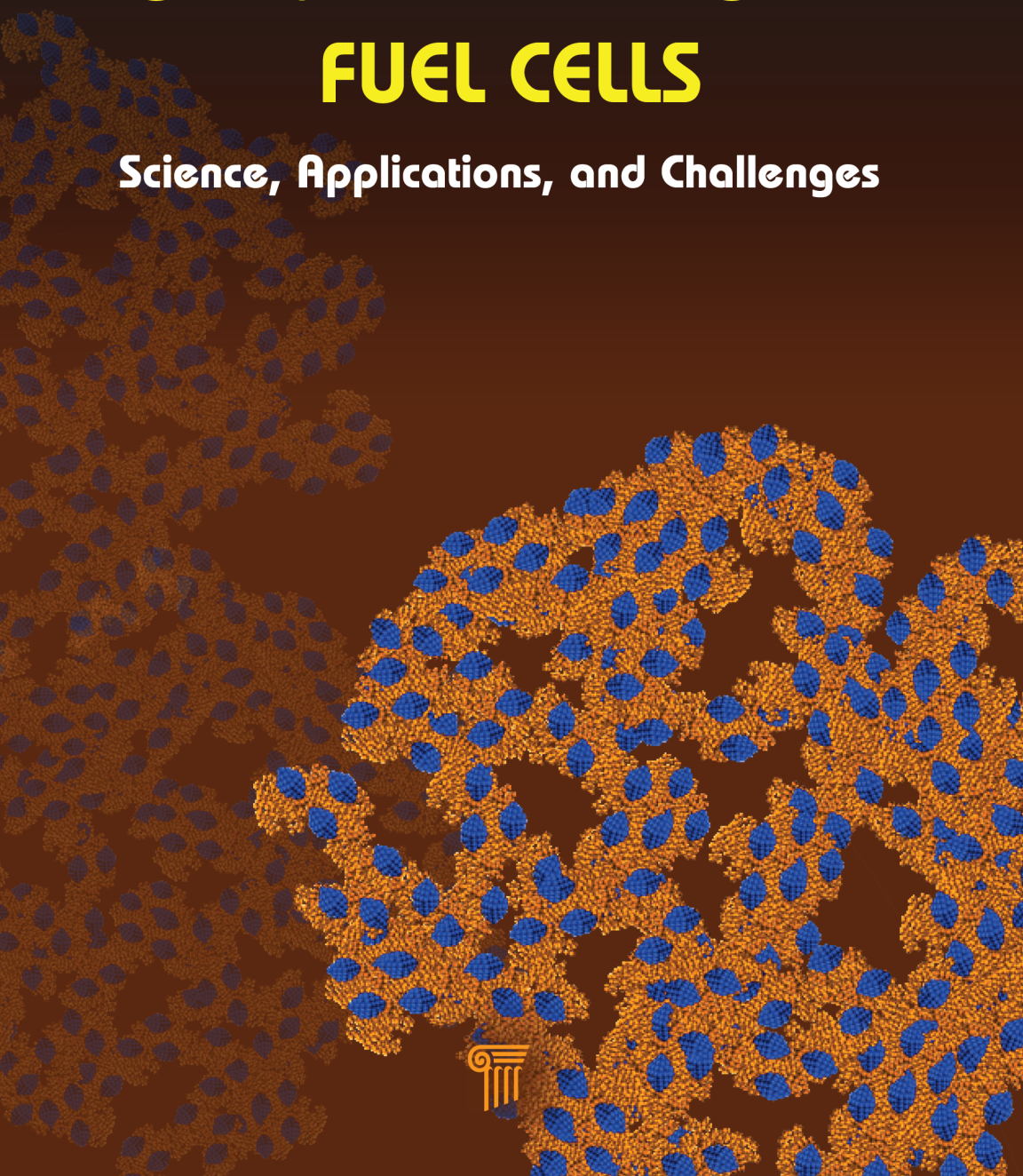
edited by
Alejandro A. Franco

POLYMER ELECTROLYTE FUEL CELLS

Science, Applications, and Challenges



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Preface

Since the second half of the twentieth century, hydrogen-fed polymer electrolyte (membrane) fuel cells, or PE(M)FCs, have attracted much attention because of their potential as a clean power source for vehicle traction. The market introduction of PEMFC vehicles is of the highest priority for many countries owing to their possible significant contribution to the reduction in energy consumption and greenhouse gas emissions.

Since the first PEMFCs developed by Grubb and Niedrach in the 1950s, there has been remarkable technological progress toward the increase in their efficiency and reduction in platinum catalyst loading, through the development of new membranes and electro-catalytic nanoparticles or the improvement of the electrode structure thanks to the growing understanding of the fundamentals in modern materials and porous media science. On the other hand, the research efforts for platinum loading reduction have resulted in an increase in the components' structural complexity, especially of the electrodes: From this, even if the overall operating principle of a single cell remains relatively simple, complex mechanisms at different spatial scales strongly interplay during the PEMFC operation, limiting the effectiveness of the catalyst activity.

Thus, PEMFC technologies have not yet reached the required potential to be competitive, as far as their high cost and low durability are concerned. In addition to the electrochemical reactions, reactants and biphasic water transport, other mechanisms limiting optimal platinum utilization are charge transfer, thermo-mechanical stresses and irreversible material degradation. For instance, microstructural degradation leading to the aging of PEMFC components is attributed to several complex physicochemical phenomena not yet completely understood, such as the dissolution and redistribution of the catalyst, corrosion of the catalyst support, loss of or decrease in hydrophobicity, membrane thinning, and pinhole formations.

These spatiotemporal nano/microstructural changes translate into irreversible long-term cell power degradation. Moreover, the ways in which aging mechanisms occur are expected to be strongly sensitive to the PEMFC operation mode. Understanding the relationship between the operation mode and the degradation mode remains a challenging task. The PEMFC response can be even more complex if the reactants are contaminated with external pollutants (e.g., carbon monoxide in the anode or sulfur oxides in the cathode).

It is extremely important for automotive applications to accurately analyze and predict the PEMFC's state of health and remaining lifetime. For that , it is necessary to develop diagnostic schemes that can evaluate the PEMFC's state of health adequately.

On a multidisciplinary basis, through the contributions by internationally recognized researchers in the field, this book provides a complete and comprehensive critical review on crucial scientific topics related to PEMFC materials' degradation and ensures a strong balance between the experimental and theoretical analyses and fabrication techniques with several practical applications for both the research and the industry communities.

The editor is convinced that the readers will benefit from the scope of this book, which is devoted to the discussion on our present understanding of several individual processes in the cell components, the interplaying between individual scales over the spatiotemporal hierarchies with their possible competitive or synergetic behavior, and the contribution of each mechanism to the global cell response under dynamic conditions. These aspects are extremely important for the design of new materials and operation controllers for the PEMFC durability enhancement under automotive operation conditions.

The editor would like to thank the authors for their dedication and hard work and the publishers for their supportive role in the realization of this book.

Alejandro A. Franco
April 2013