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Kusuhiro Mukai

Translation supervised by Taishi Matsushita

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Preface to the Japanese Edition

In our daily life, knowingly or unknowingly, we often see phenomena where the presence of an interface plays a dominant role, i.e., interfacial phenomena. For example, (1) a needle with an oil coating floats on water, (2) a piece of wood with camphor applied to one end begins to move on the water surface by itself (a so-called "camphor boat"), and (3) tears of wine (see Section 2.3.3 for details). Phenomenon 1 is mainly caused by the surface tension of water and the low wettability between the needle and water. Phenomena 2 and 3 are induced by the *Marangoni effect* (see Sections 2.3.3 and 2.5.2 ii and 4.2). Not only are such interfacial phenomena considered entertaining but they have also been proven by recent studies; they are closely related to important technological subjects in the processing of high-temperature materials.

Such phenomena, dominated by the existence of the interface, show up in a so-called "*interface-evolved world*," where the existence of the interface cannot be ignored (see Section 1.2). The world that is treated in nanotechnology, which has been attracting attention recently, can also be included in the "interface-evolved world."

Meanwhile, not limited to interfacial phenomena, it is probably a standard approach to thoroughly observe an event and scientifically describe it to deeply understand it and comprehend its nature. Moreover, such a scientific approach can be a steady step in controlling various phenomena, solve problems, or achieve technological developments and improvements related to various technological subjects.

In the above-mentioned "scientific description of interfacial phenomena," the term "science" represents the title of this book, "interfacial physical chemistry" (see Section 1.1). Therefore, when we deal with the interfacial phenomena or various phenomena in the "interface-evolved world," it is especially important to acquire an ability beforehand to deeply understand the interfacial physical chemistry and apply it.

In Chapter 2 of this book, the fundamentals of interfacial physical chemistry are described to guide the readers and help them obtain a deeper understanding. To the best of my knowledge, the fundamentals of interfacial physical chemistry, such as surface tension, are still not completely understood by many researchers and engineers in the materials science and engineering field. Thus, it can reasonably be said that the understanding of surface tension is unclear worldwide. For this reason, surface tension is described in detail in Chapter 2. For a sufficient application of the fundamentals, I consider it necessary to understand the important equations through the derivation process. Therefore, derivation processes are also described in this chapter to some extent.

Chapter 3 briefly introduces the interfacial properties of high-temperature melts, which is the subject of high-temperature materials processing. This chapter is compiled so as to help the readers thoroughly understand Chapter 2 and apply the knowledge to Chapter 4.

In Chapter 4, examples of the application to materials processing at high temperature are described, focusing on the recent research results obtained by the author and his co-workers. Due to space limitations, many important studies by other researchers were unfortunately excluded. There are some research results and descriptions provided by the author and co-workers introduced in this book whose validity is the subject of future judgments. However, I have mentioned them as problem presentations and appreciate your understanding and patience.

Finally, I would like to thank the following individuals: Assoc. Prof. Toshiyuki Kozuka (Faculty of Engineering, Kumamoto University); Prof. Yutaka Shiraishi (Institute of Mineral Dressing and Metallurgy, Tohoku University); Dr. Masafumi Zeze (Yawata R & D Lab., Nippon Steel Corp.); Assoc. Prof. Tomio Takasu (Faculty of Engineering, Kyushu Institute of Technology); Prof. Taketoshi Hibiya (Faculty of Systems Design, Tokyo Metropolitan University); and Dr. Taishi Matsushita (Department of Materials Science and Engineering, Royal Institute of Technology (KTH), Sweden) for their contribution to examining the contents of the manuscript, collecting references, and so on, and to Ms. Yukari Izumi; Ms. Yoko Oosue; Dr. Olga Verezub; Ms. Hiroko Tanaka; Ms. Yoko Tonooka; Mr. Takahiro Furuzono; and Yukiko (my wife) for typing the manuscript, drawing figures, and so forth. For publication, Mr. Akikazu Maesono and Ms. Hisako Mihori (AGNE Gijutsu Center Inc.) have put in extraordinary efforts. I would like to express my sincere gratitude to them.

Kusuhiro Mukai
November 2006

Preface to the English Edition

This book was first published in 2007 by AGNE Gijutsu Center with the following title: *Kouon-yuutai No Kaimen-butsurikagaku*. This book is its English translation.

For the last 10 years, I presented the research results described in this book at every opportunity, and it attracted many researchers. For example, the theory and experimental results from microgravity experiments on the movement of fine particles caused by the surface tension gradient attracted researchers involved in the nozzle clogging problem in the continuous casting process. The work on the mechanism of the local corrosion of refractories has a good reputation, and the *in situ* observation of the penetration behavior of molten slag and molten metal into porous refractories has also received much recognition.

Professor Kusuhiro Mukai—the author of this book and my supervisor when I was a Ph.D. student—asked me to write and publish a revised enlarged edition of the above-mentioned Japanese book in English. However, in May 2018, while we were preparing the English edition, Professor Mukai passed away, and I felt that it was not appropriate to revise the book without his supervision. Then, encouraged by the graduate students of Prof. Mukai's lab, we collaborated to publish this English edition as a lasting tribute to his work.

This book is basically translated from the Japanese edition, but some notes have been added by the translation supervisor. The † symbol means that related video clips are provided at https://www.crcpress.com/9780367210328.

Throughout the preparation, I have received the cooperation from the Japanese edition publisher, AGNE Gijutsu Center. Moreover, last but not least, I wish to acknowledge the contributions to the publication of this English edition by Prof. Mukai's former students who graduated from the laboratory during his more than 30-year career at the Kyushu Institute of Technology.

Taishi Matsushita
Editor and Translation Supervisor
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Authors

Kusuhiro Mukai was a Professor Emeritus at the Kyushu Institute of Technology, Japan and Northeastern University, China. He received his Ph.D. from Nagoya University (1968) and became an Associate Professor at the Kyushu Institute of Technology (1969). He was a guest professor at University of Toronto, Canada (1985) and Imperial College London, UK (2005). He was a Professor at the Kyushu Institute of Technology from 1986 to 2004. His research area is high-temperature physical chemistry.

Taishi Matsushita is an Associate Professor at the School of Engineering, Jönköping University, Sweden, since 2012. He received his Ph.D. from Kyushu Institute of Technology (2003) and became a Senior Researcher at the Royal Institute of Technology (KTH), Sweden in the same year. He was given the title Docent (corresponding to Associate Professor) from KTH in 2008. His research area is high-temperature physical chemistry.