Research on human evolution reports that our ancestors learned how to *cook using fire*; it became a developmental turning point, enlarging their brains. Secondary benefits of fire included light, warmth, and protection from predators. In other words, civilization likely was born out of those initial uses of fire, after which it fulfilled a big role in human life. Securing fuel for its citizenry has been at the core of politics for centuries. Currently, humankind’s main fuel is petroleum. Changes in oil prices have a dramatic impact on the world’s economy. Unfortunately, the generation of heat by the combustion of wood (biomass) and fossil fuels inevitably generates greenhouse gases such as carbon dioxide (CO$_2$), a gas which has been designated as being partly responsible for global warming. However, energy released from the combustion process cannot be sustained for very long, therefore further development of sustainable energy is necessary.

Chemical syntheses and materials sintering must be tempered to avoid the unnecessary production of CO$_2$. Today’s chemical industry has changed from processes that use fire to processes that use steam or Joule heating—which can be easily controlled. However, more than 100 years have passed since they were initially used, and further innovation is desired. When sintering ceramics in an electric furnace, the refractory material in the furnace is first heated with an electric heater, and then the sample is heated by heat transfer. Consequently, the temperature of the sample is lower than the temperature in the furnace. Approximately 20–30% of the available energy is used in the heating process. Chemical engineering and heat transfer engineering has been used to optimize the relationship between substrate and heating—these two disciplines have witnessed remarkable development. Nonetheless, more advanced heating methods are required today.

Microwave radiation has been used for more than 30 years as a heat source for materials synthesis and sintering. Accordingly, the microwave energy must be absorbed directly by the materials. Energy savings represent one of the advantages of using microwave radiation. With microwave heating, over 60% of the available power can be used to heat the sample. Pioneering microwave scientists initially focused their efforts on developing the domestic microwave oven—a device which can be obtained at low cost, unlike other chemical heating sources. It was only
natural for such ovens to find their way into the research laboratory. The convenience of microwaves meant scientist felt that new processes might be developed for rapid heating and cooling, as well as to produce high-quality materials. Several excellent review articles and books that describe the vast results of microwave chemistry and materials processing have been published in recent years. The presence of a microwave heating device in a laboratory is no longer unusual. At present, researchers use microwaves as a tool to perform chemical reactions and materials sintering. Regrettably, this situation has increased the number of researchers who have little understanding of the principles of microwaves as an energy source and little knowledge of microwave equipment. Such a situation will likely slow down innovative research using microwave heating in chemical and materials processing, unless of course the fundamentals and possible applications of microwaves are clearly understood.

This tutorial book represents the backbone of the fundamentals and applications of microwaves in chemistry and materials processing. It aims to develop new research ideas into microwave chemistry and materials processing. In addition, when researchers are confronted with problematic issues in performing microwave-assisted chemistry and materials processing, they may find in this book the means to avoid such issues. The contents embodied in this book are based on the authors’ experiences and learnings. Thus, it has the characteristics of a textbook aimed not only at students, but also professionals and engineers. Every attempt has been made to avoid the use of complicated equations to describe the principles of microwaves; instead, they have been explained as much as possible through the use of illustrations and examples.

In Chap. 1 the readers will learn about microwave heating; in Chap. 2 they will find a discussion about heat, and in Chap. 3 will learn the basics of electromagnetic waves. Chapters 4 and 5 clarify the unique characteristics of microwave heating and its underlying theory. Chapter 6 introduces the various functions of each component found in microwave equipment, while Chaps. 7 and 9 present various caveats, features, and uses of microwave chemistry. Chaps. 8 and 10 describe points connected to microwave materials processing. Appendix A presents a summary of various data concerning the use of microwave radiation. A unique find by the reader will be the Coffee Break paragraphs added at the end of each chapter that are intended to refresh the reader’s memory before moving to the next chapter.

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