Preface

This book is based on the presentations from the "International Workshop on Molecular Architectonics" in Shiretoko, Japan from August 3 to 6, 2015. This workshop was planned to discuss recent progress related to "single molecule electronics", especially to identify future trends in related areas.

After the pioneering proposal of single molecule electronics in the 1970s, numerous efforts have been made to measure the electric properties of single molecules. Progress in this field can be divided into three stages. In the first stage, before around 2000, monolayer films were mainly used for measurements. The establishment of the break-junction technique made quantitative analysis of various molecules possible, which in turn opened up the second stage in this area. Since then, significant progress has been made in the field of single molecule electronics. Vast knowledge and technical know-how concerning carrier, spin, and heat transport in metal-molecule-metal junctions have been accumulated. Now research has reached the third stage, where challenging efforts should be made to achieve better functionalities by overcoming inherent disadvantages of using molecules, such as thermal instability and fluctuations.

Accurate design of molecules and electrode surfaces will lay the foundation for creating fundamental functionalities such as switching by external stimulus, memory, amplification, logic gates, pulse generation, and small signal detection. Instead of random integration of single molecules that possess these functions, a system for proactively utilizing the fluctuations and noises in the signals is orchestrated for realizing signal processing by cooperative actions of numerous molecules. Such systems are often observed in biological information processing.

The phrase "Molecular Architectonics" refers to the manifestation of electronic, optical, magnetic, and information-processing functions that are orchestrated by molecular assemblies. We can think of this process in terms of building a physical structure. The researchers will participate as "molecular architects" in the design and fabrication processes, to elaborately design a procedure for the determination of the position of "pillars" (molecules) on the "foundation" (surface), for creating molecular organisms.

The implementation of this fundamental strategy is initiated by the creation of design and concept as architecture. The most important topics involved are the careful examination of and improvements in system designs, i.e., designs of molecules that will form the "pillars and beams," designs of the surface that will form the "foundation," and designs for connecting one molecule with another. Furthermore, new methodologies and guidelines for structural design or function manifestation through cooperative efforts will be developed by proactively incorporating thermal instability and structural fluctuation into the signal process to ensure that the resultant structure is harmonious. The outcome of such efforts will lead to further progress in this field with the final aim being the development of a new generation of single molecule electronics.

The organizers of the workshop are grateful that globally recognized speakers agreed to contribute to this book. The book covers versatile aspects of the topic and is composed of four chapters: "Systems for molecular architectonics", "Surface science for molecular architectonics", "Measurements for molecular architectonics", and "Design and synthesis of molecules for molecular architectonics". We hope this book will help the readers to enjoy the scientific frontier bridging material science and informatics science.

Group photograph of "International Workshop on Molecular Architectonics" at Shiretoko, Japan, on August 3–6, 2015

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