Special Issue on Unique Physical Behavior at the Nano to Atomic Scales

Preface

This special issue was launched in response to growing academic and industrial interest in size effects manifesting in materials, structures, and spaces. In 1965, Gordon Moore, who would later become co-founder of Intel, proposed that the number of elements incorporated into semiconductor integrated circuits would double every 18 to 24 months. This famous Moore's Law has led to the miniaturization of semiconductors and cost reductions, leading to improved performance and the widespread adoption of electronic devices for over half a century. Technological limitations have been repeatedly pointed out, but new technologies have always overcome them. The level of the manufacturing process using the minimum feature size of semiconductor devices, according to "design rules," have continued to shrink year by year, moving into the 10, 7, 5, and 3 nm generations. The impressive scale of a 3 nm process unit can be easily understood by considering it to be only about 30 atoms in size. In addition to pursuing miniaturization, new transistor structures and materials are being developed, and technological innovations such as stacked chips and chiplets are advancing with an eye toward the "post-Moore era."

Thanks to these semiconductor processing technologies, we are now in an era where ultrafine structures ranging from submicron to nanoscale can be created with high precision. This means that materials, structures, and spaces can be realized with high accuracy at nano to atomic scales. In these size ranges, actual "size effects"—phenomena that the concept of a continuum cannot explain—may emerge.

This special issue contains nine original and excellent research papers covering a wide range of topics, from the development of new functional materials to material characterization at the atomic and nanoscale, device applications, and system-level demonstrations, related to "size effects." These papers represent valuable research results from Japan's leading university researchers and reflect the current momentum and future direction of this dynamic field.

I would like to express my sincere gratitude to all the authors who submitted high-quality papers and to the reviewers who contributed to the improvement of this volume. I would also like to thank the *Sensors and Materials* editorial team, especially Ms. Tomoko Tanabe, for her support and efficient coordination throughout the publication process. I hope that this special issue will not only provide a timely summary of the latest research findings but also serve as an impetus for further research and development into size-effect phenomena.

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