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Editorial

Modeling of Nanodevices and Nanostructures

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Since its first development in more than half a century ago, the silicon-based transistors have been experiencing rapid growth following the trend known as Moore's Law. The transistor scaling into nanometer regime has reached decananometer dimension since the last decade, which brings about the unprecedented complexities in the fabrication process, especially in the effort to keep pace with the technology projection. In addition, the conventional device structure that has been around for decades is extremely hard to be scaled further due to many limitations. These obstacles generate broad interests on novel device architectures as well as involvement of new materials other than silicon. The industry is already preparing for the postsilicon era, with the enormous researches in emerging materials such as III–V compounds, SiGe, and carbon as can be observed from the International Technology Roadmap for Semiconductor (ITRS).

In parallel with the fabrication, semiconductor industries rely heavily on simulation to ramp up the prototyping time as well as to reduce the cost in development cycle. Hence, a proper, accurate model for device of interest is crucial to help in producing the necessary evaluation and projection of the final device performance. In the wake of these interests on novel devices, structures and materials alike, a number of modeling approaches have been investigated and formulated, either explicitly, analytically, or computationally intensive. The modeling work now takes greater influence which is crucial for simulating the behavior of those new nanostructures as well as predicting the performance for the future nanodevices. The inclusion of more sophisticated transport phenomena into the model with adopted quantum effect also adds to the importance, as it is closely associated with the proper explanation of low dimensional structures.

In this special issue, several selected examples of current research efforts related to the modeling approach of nanostructures and nanodevices are presented. The modeling puts into perspective broad interest of the material involved. The paper by W. Y. Jung and S. C. Han elaborated the elastic theory of the nanoscale plate using Eringen's nonlocal differential constitutive relations and higher-order shear deformation theory (HSDT). The solutions of transient dynamic analysis of nanoscale plates are solved using the presented model, which is crucial for better understanding of the motion for such structural arrangement. The role of electric-field coupling on a two-dimensional electron gas (2DEG) GaN based planar nanodevice is modeled by K. Y. Xu et al. Two models are developed and simulated using the approach of 2D ensemble Monte Carlo (EMC) method combined with self-consistent 2D and 3D Poisson equation solution. It is revealed that the different coupling path of electric field contributes to the deviation of the wave shape with the variation of device parameters. The effect of graphene nanoribbon geometry on diode performance is explored by M. Rahmani et al. The model formulated bilayer graphene nanoribbon for Schottky-barrier diode using different stacking arrangements, that is, between a semiconductor (AB stacking) and metal (AA stacking) layers. The simulated model showed a strong dependency of the I–V characteristic on geometry and temperature. The result also showed that it has better performance compared to the silicon-based device for several metrics. H. R. Obayes et al. offer the theoretical study of buckyballs preparation from corannulene, coronene, and circulene using density functional theory (DFT). Determination of the HOMO energy levels provides necessary information about the stability of the most symmetric buckyball with the most efficient gap energy, which showed good prospect towards solar cell applications.

Another example of microstructure modeling is the twisted clad containing DB medium, presented by M. A. Baqir and P. K. Choudhury. The propagation patterns of flux densities of the guiding structure are explored analytically for the varying pitch angles condition. B. Sun and E. C. Aifantis illustrate how to extend the second author's gradient theory of elasticity to shells. Three formulations are presented based on the implicit gradient elasticity constitutive relation.

As examples of microstructure-based device application, two papers elaborated the use of graphene microstructure for sensor modeling. Gas and chemical sensor, biosensor, and medical sensors are general sensor applications which are useful to human being and for industrial application. One of the best candidates as a detecting material is nanomaterials. When nanomaterials are appropriately engineered, they present a variety of outstanding and adjustable chemical and physical properties which can be used as a sensing element. E. Akbari et al. presented the modeling of bilayer graphene for NO_2 sensor using physical-based approach, while H. Karimi et al. used particle swarm optimization technique in optimizing the DNA sensor model. Both papers offer the understanding of graphene device in complex situation and when dealing with different substances.

We believe that this special issue could provide new insight on different approaches of nanodevices and nanostructure modeling. Whilst this special issue could not cover every aspect, it attempts to offer pointers on recent progress in these areas.

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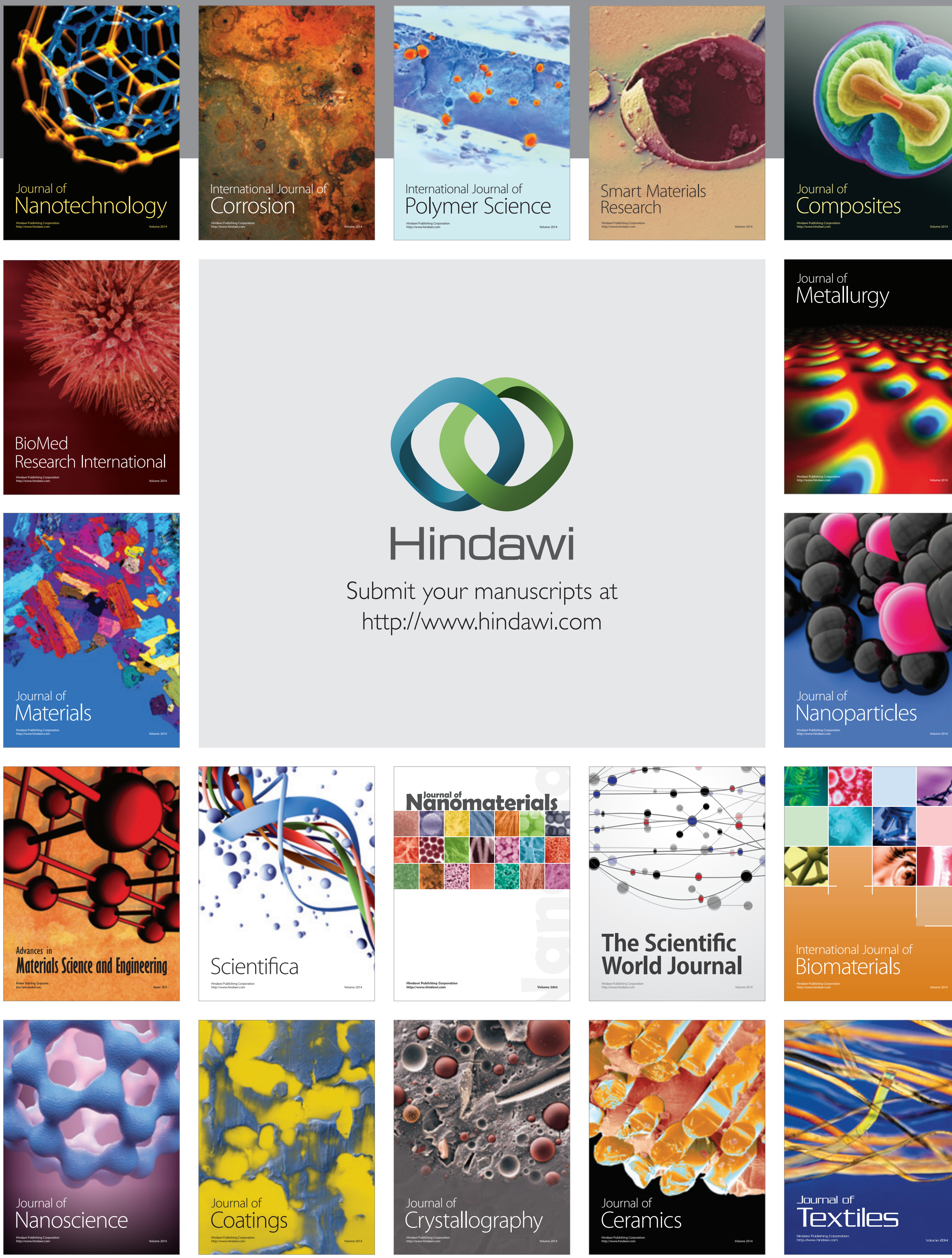
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