Cluster and Nanostructure Interfaces

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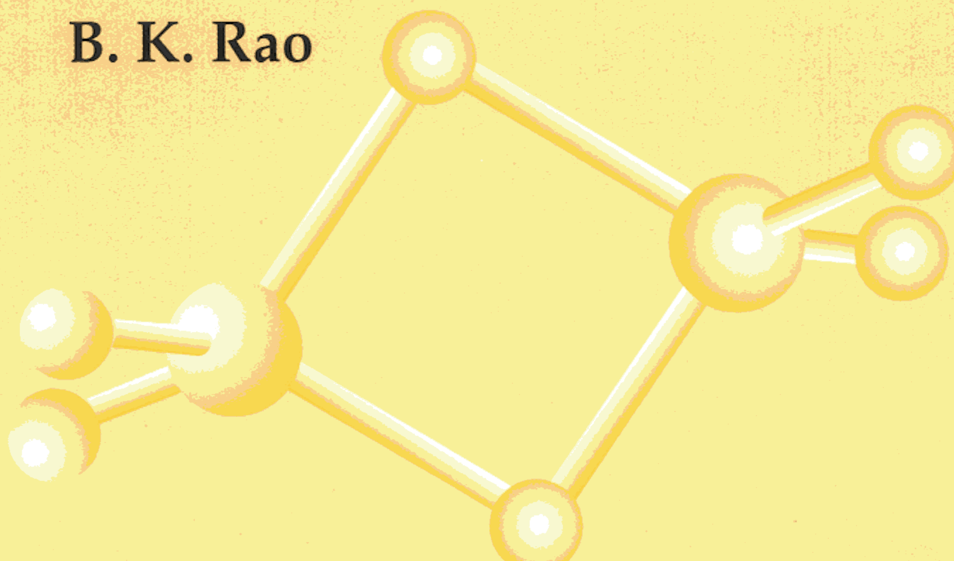

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CLUSTER AND NANOSTRUCTURE INTERFACES

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PREFACE

Extraordinary things can and do happen when materials are reduced in size to nanometer-scale. These include atomic clusters of specific size and composition containing up to a thousand atoms, nano-scale particles with a narrow size distribution, and multi-layers with atomic dimension. These materials are characterized by reduced size and symmetry, interatomic distances that vary with particle size, and low dimension. Consequently, they exhibit novel properties that are not found in bulk materials. As the length scales are reduced, the properties of bulk materials change monotonically until a critical length scale is reached. Below this length scale, the properties vary non-monotonically and are influenced more strongly by quantum phenomena. The critical length scale does depend on the properties being considered. For example, while the inter-atomic distances approach the bulk value with as few as a dozen atoms in a cluster, the evolution of their electronic, magnetic, and optical properties may not reach the asymptotic value until they contain hundreds or even thousands of atoms. This flexibility endows researchers with an unprecedented ability to design clusters and nanostructures with specific properties that are very different from their bulk.

The ability to create new materials with tailored properties by assembling clusters and nanostructures is providing hope that technology can soon benefit from the advancements made in our understanding of the science of nanostructures. This has fueled a great deal of interest in multi-disciplinary research of nanostructured materials involving physics, chemistry, biology, materials science, and engineering. While advancements in experimental techniques are enabling the synthesis of novel nanostructured materials, first principles theories aided by powerful computers are used as predictive tools to guide new experiments. This synergism between theory and experiment is redefining the way research is done in this emerging field.

As nanostructured materials are created by consolidating nano-particles or clusters, the interface between the particles and that between the particles and their support plays an important role on the properties of the virgin building blocks. Unlike conventional interfaces common in macroscopic systems, the interfaces in nanostructured materials have a unique character as almost all the atoms in a nanoparticle are surface atoms, and the resulting interface involves interaction between "all" the atoms in individual particles across the interface.

The International Symposium on Cluster and Nanostructure Interfaces held in Richmond, Virginia from October 25-28, 1999, focussed on the role of interface on the properties of cluster-assembled and nanostructured materials. This book contains the proceedings of this symposium.

Nearly 200 scientists from 18 countries participated in this symposium. A total of 183 papers (43 invited and 140 contributed) were presented at the symposium. The topics included synthesis, nucleation, growth, characterization, atomic and electronic structure, dynamics, ultrafast spectroscopy, stability, electrical, magnetic, optical, thermodynamic, and catalytic properties of:

Clusters:	Free and supported
Cluster Materials:	Self-assembled, ligated, and embedded
Nano-structures:	Quantum dots, wells, and corrals; nano-tubes and wires; colloidal and biological material
Nano-technology:	Electronic, magnetic, and optical devices

The keynote address of the symposium was delivered by Professor Ahmed Zewail, the 1999 Nobel Prize winner in chemistry, who spoke about femtodynamics with atomic resolution spanning elementary processes of molecules, clusters, and nanostructures. There were fourteen plenary sessions dealing with theory and experiments on materials characterized by multiple time and length scales. While chemical reactions were probed at the femtosecond time scale, computer simulation of self assemblies and phase changes were reported that require orders of magnitude longer time. An array of synthetic routes including lithographically induced self-assembly and controlled chemical routes to nanotube architectures were presented. Transport properties across nanocontacts and carbon nanotubes were discussed. The existence of magnetic isomers, quantum effects in single molecule nanomagnets and self organized magnetic clusters on surfaces revealed the novel magnetic behavior at various dimensions. Nonlinear optical materials involving semiconductor nanocrystals were discussed. Results on organic/inorganic composites at multiple length scales, novel network structure of organo-metallic clusters and clusters supported on metallic substrates or passivated by organic ligands highlighted the importance of the interface. The technological issues ranging from cryogenic applications of nanostructures to molecular nanoelectronics, nano-computers, and DNA nanotechnology were covered. The symposium ended with a panel discussion on Perspectives in Science and Technology.

This symposium would not have been possible without the tireless efforts of the members of the Local Organizing Committee, the advice of the International Advisory Board, and the financial support of Virginia Commonwealth University, Philip Morris, USA, The National Science Foundation, and the Army Research Office. Our special thanks go to the graduate and undergraduate students and post-doctoral fellows of Virginia Commonwealth University for volunteering their services during the symposium, to the conferees for the high quality of their participation, and last but not the least to Ms. Barbara Martin for her assistance throughout the two year period in which this symposium was in the making.

Richmond, Virginia
February, 2000

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