AVS 50th Anniversary Plenary Session
Room 310 - Session AP-MoA

Where Next for Nanotechnology?

Moderator: R.J. Colton, Naval Research Laboratory

2:00pm **AP-MoA1 Nanotechnology: A Policy Perspective*, S. Hays,*** National Science and Technology Council **INVITED**

Nanotechnology research and development is a top priority of the current Administration. Scientific and technological breakthroughs in the ability to measure, manipulate and understand matter on the atomic and molecular scale are enabling the development of novel structures, systems, and devices. Realizing the full potential of the discoveries requires multidisciplinary efforts among researchers as well as truly interdisciplinary work by those who can bridge the "languages" and cultures of biology, physics, chemistry and engineering. The National Nanotechnology Initiative is a coordinated multi-agency federal research program that supports not only fundamental and applied research but also development of necessary tools and infrastructure, education and workforce development, and the study of societal issues. The future of nanotechnology rests in particular on advances in instrumentation and materials processing capabilities, two areas that are central to the interests of the AVS and the expertise of its members.

2:40pm **AP-MoA3 Nanotechnology: Future Challenges and Opportunities*, E. Hu,*** University of California, Santa Barbara **INVITED**

The launching of the National Nanotechnology Initiative nearly 4 years ago has captured the scientific and popular imagination and has catalyzed tremendous scientific discovery at an international level. Working with building blocks at the nanometer scale (molecules, nanoclusters, quantum dots, etc.), nanoscale science and engineering promises to alter not only what complex systems we can make, but also how we can make or manufacture systems. Substantial advancements have been made in (1) designing new instrumentation to image and characterize structures at the nanoscale, in (2) computational power and architectures that will allow modeling and simulation of nanostructure properties and performance, in (3) integrating diverse nanoscale building blocks (e.g. biological and electronic materials), and in (4) assembling modest-level nanosystems. The next 'giant steps' in the realization of multifunctional, manufacturable, higher-complexity nanosystems will require substantial improvements in all the areas mentioned above. Complex assembly of new materials will require designing in redundancy and repair into the processes. As more biological/molecular-electronic composite systems are utilized, we will need much a better understanding of information transfer and coherence across biological-electronic material interfaces. The richness of the work done thus far in creating a new Nanotechnology reveals a multitude of outstanding challenges and at the same time opens many avenues for further exploration and applications.

3:20pm **AP-MoA5 Self-Assembly Processing for Nanomanufacturing*, M. Tirrell,*** University of California, Santa Barbara **INVITED**

Self-assembly is a route to processing of chemical products that relies on information content built into the process precursors. The bonding mechanisms of self-assembled products are weaker than the electronic bonds of molecules; the complexity built into self-assembled products is at the level of supermolecular structure. Self-assembly processes may be spontaneous or directed by the influence of templates or fields. Self-assembly occurs frequently in biology but translating that bioinspiration to controllable chemical processing presents many interesting problems. A challenge for chemical engineers is to develop the practical routes to technologically important self-assembly processes. Applications will be to biomaterials, porous materials, molecular electronics and many other areas. Hurdles that must be overcome include the precision synthesis of precursors, mastering the kinetics and dynamics of such processes, scale-up, and the characterization and control of self-assembly products and processes. Prospects for success and current efforts in these areas will be discussed.

4:00pm **AP-MoA7 Nanotechnology: Constructing a Computer from Molecular Components*, J.M. Tour,*** Rice University **INVITED**

Research efforts directed toward constructing a molecular computer will be described in the context of recent developments in nanotechnology. Routes will be outlined from the synthesis of the basic building blocks such as wires and alligator clips, to the assembly of the processing functional blocks. Specific achievements include: (1) isolation of single molecules in alkane thiolate self-assembled monolayers and addressing them with an STM probe, (2) single molecule conductance measurements using a mechanically controllable break junction, (3) 30 nm bundles, approximately 1000 molecules, of precisely tailored molecular structures showing negative differential resistance with peak-to-valley responses far exceeding those for solid state devices, (4) dynamic random access memories (DRAMs) constructed from 1000 molecule units that possess 15 minute information hold times at room temperature, (5) demonstration of single-molecule switching events and (6) initial assemblies and programming of molecular CPUs in a Nanocell configuration that show room temperature electronic memory for days.

4:40pm **AP-MoA9 Massively Parallel Assembly*, J.N. Randall,*** *G.D. Skidmore, M. Ellis, A. Geisberger, K. Tsui, M. Nolan, R. Saini, C. Baur, K. Bray, M. Chiew, R. Folaron, R. Gupta, J. Hochberg, J.F. Liu, R. Stallcup, P.G. Yu,* Zyvex Corp. **INVITED**

Assembly is generally considered a low-tech, tedious, and expensive undertaking that must be dealt with to manufacture useful systems. Monolithic integration and system-on-a-chip efforts minimize the required assembly, but even the IC industry is economically driven to separate memory and logic chips that are assembled into systems. Where assembly has been automated, the results are expensive primarily because the assembly is serial. This talk will update the ongoing efforts to take assembly manufacturing through the same transition made when Kilby and Noyce revolutionized electronics by going parallel and providing a path for downscaling. We are developing technology for the parallel assembly of Microsystems supported by a NIST-ATP award.@footnote 1@ This technology involves both Micro-Electro Mechanical Systems (MEMS) and high precision robotic stages. By using novel MEMS components that we refer to as "Silicon Snap Connectors" and MEMS grippers, we can do automated, parallel, pick-and-place assembly that achieves higher precision assembly than the precision of the robot that did the pick and place. This is made possible through a self-centering mechanism in the connectors and the sub-micron CD control of the MEMS components. Videos of various microscale automated assembly construction projects will be shown. While the assembly being demonstrated so far is being done with MEMS components and is only modestly parallel, the general strategy for parallel assembly is not restricted to MEMS parts and, as the parts are downscaled, the level of parallelism can grow exponentially. The paper will close with some recent developments towards both massively parallel and nanoscale assembly. @FootnoteText@ @footnote 1@ NIST ATP Award #70NANB1H3021

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