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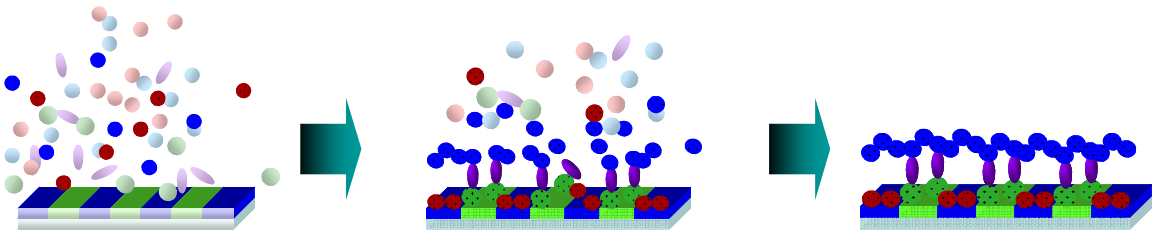
Directed Assembly of Functional Materials and Devices

March 19-20, 2008

Advanced Measurements Laboratory
215/C103
National Institute of Standards and Technology

Gaithersburg, Maryland



Revised 3/19/2008

Directed Assembly of Functional Materials and Devices

> *We do not yet know how to do it [directed assembly], and cannot even mimic those processes known to occur in biological systems.... the basic rules that govern these assemblies are not understood in useful detail, and self-assembling processes cannot, in general, be designed and carried out "to order."*
>
> *Prof. George Whitesides, Harvard University*
> *4th Foresight Institute Conference*

Introduction

Controlling the placement of nanoscale units into designed structures and patterns through directed assembly processes answers one of the grand challenges of nanotechnology. Innovative approaches using the directed assembly of nanoscale units are being developed to facilitate the nanofabrication of new materials and applications that can incorporate biological functionality, or devices such as flexible, large-area electronics devices. In general, these studies select one of many available driving forces such as van der Waals interactions, electrostatic potentials, hydrophobic/hydrophilic interactions, or specific recognition of biological molecules (antibodies, DNA), then tailor the NBB and one part of the template structure to selectively "guide" the NBB into the desired configuration.

Directed assembly methods provide an opportunity to overcome limitations of traditional semiconductor processing; specifically, the small materials set with which to work, restriction to two dimensional patterning, and exorbitant equipment costs. Although an abundance of nanoscale building blocks (NBBs) such as quantum dots, nanowires, and dendrimers have been developed, the lack of control over their assembly continues to limit the range of applications that can take advantage of their unique properties.

Directed assembly processes are currently developed through trial-and-error experimentation where the success of a given assembly process is evaluated at the end of the process, typically by electron microscopy, scanning probe techniques, or direct device testing. Researchers have focused primarily on the directed assembly of a single component such as a nanoparticle onto a templated surface prepared using traditional nanofabrication processes.

Moving directed assembly from research demonstrations to viable manufacturing processes is difficult because it requires control over the simultaneous transport, placement, and interactions of a potentially large set of NBBs with different size, shape, and chemical functionality. Further, intermediate stages of directed assembly span multiple length and time scales and involve multiple interactions among components. All but the simplest systems contain multiple assembly pathways, making it difficult to determine which component or process step is responsible for the failure of a particular manufacturing process design. New measurements and process control methods must be developed to enable the successful implementation of this groundbreaking technology.

Objectives

This workshop will bring together leading researchers and stakeholders from industry, government, and academia that are actively engaged in research and development of the directed assembly of nanoparticles into functional materials and devices. Through invited presentations and focused discussions, the workshop will explore and identify the most pressing measurement and technological needs to advance directed assembly as a viable manufacturing method for future nanotechnology applications. Specifically, the workshop will:

- Assess the technological challenges in the directed assembly of nanoparticles into next-generation materials, electronics, photonics, and sensing applications.
- Identify "Measurement Needs" that must be addressed to overcome significant technological challenges to innovation and growth of this technology.
- Document and publish the measurement and standards requirements needed to overcome the identified technological challenges for functional materials and devices assembled from nanoparticles.

Organizing Committee

Steven Hudson, Jeeseong Hwang, J. Alexander Liddle, Eric Lin, Vivek Prabhu, Scott Stanley

More Information, please contact

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Wednesday, March 19th, 2008 (Lecture Room C 103, Building 215)

8:00 AM	NIST Shuttle from Holiday Inn to NIST grounds Attendance check at visitor gate and transfer to Building 215 If arriving separately, please check Directions to NIST http://www.nist.gov/public_affairs/visitor/visitor.htm
8:15 – 8:55	Registration Open at Building 215 main lobby

Morning Session

Directed Assembly Vision and Possibilities

The goal of this session is to provide different points of view of the opportunities for the directed assembly of nanoparticles to advance new technology applications.

Chair: **Vivek Prabhu**, NIST

8:55 – 9:00	**Robert Celotta**, Director of the Center for Nanoscale Science and Technology, *NIST Welcome to the Workshop*
9:00 – 9:40	**Dan Herr**, Semiconductor Research Corporation - *Emerging Patterning Materials Challenges and Opportunities*
9:40 – 10:20	**Oleg Gang**, Brookhaven National Laboratory - *Biomimetic Approaches for Building Nanoscale Systems*
10:20 – 10:40	Break
10:40 – 11:20	**Evelyn Hu**, Siluria Technologies & U.C. Santa Barbara -*Biotemplating for Controlled Assembly of Novel Materials and Devices*
11:20 – 12:00	**Heiko Wolf**, IBM - *Preparation of functional particle arrays by a combination of directed assembly and adhesive transfer*
12:00 – 12:50	Box lunch provided
12:50 – 1:10	**Panel Discussion I**

Afternoon Session

Nanoparticles: Properties and interactions

The goal of this session is to identify the most important measurement methods and physical principles needed to characterize nanoparticles and their interactions that will enable the development of efficient directed assembly processes and broad cross-cutting applications.

Chair: **Jack Douglas**, NIST

1:20 – 2:00	**Michael Bevan**, Johns Hopkins University - *Colloidal Interactions, Dynamics, and Assembly on Energy Landscapes*
2:00 – 2:40	**Haw Yang**, U.C. Berkeley - Single-Particle Tracking Spectroscopy – *A New Tool for Studying Self-Assembly Dynamics*
2:40 – 3:20	**Abe Stroock**, Cornell - *The Roles of Shape, Roughness, and Stabilization Layers in Defining Selective Colloidal Interactions*
3:20 – 3:40	Break

3:40 – 4:20 **Sharon Glotzer**, U. Michigan – *Exploiting anisotropy for assembly: Physical principles, and what simulators need to know from experiment*

4:20 - 5:00 **Hiroshi Matsui**, City University of New York, Hunter College - *Biomimetic Assemblies of Peptide Nanowires and Nanoparticles and Their Controlled Mineralization at Room Temperature*

5:00 – 5:20 **Panel Discussion II**

Evening Dinner

5:40 – 7:00 Shuttle return to Holiday Inn for social hour (cash bar) / poster session
7:00 Dinner provided at Holiday Inn

Thursday, March 20th, 2008 (Lecture Room C 103, Building 215)

8:15 – 8:35 NIST Shuttle from Holiday Inn to NIST

Morning Session

Assembly: Strategies and methodologies

The goal of this session is to identify critical measurement challenges facing the development of directed assembly methods from small-scale feasibility studies to engineering solutions to full industrial scale production.

8:35 – 8:40 Welcome Back & Review of Worksheets

Chair: **Steve Hudson**, NIST

8:40 – 9:20 **Babak Parviz**, U. Washington – *Self-assembly for heterogeneous system integration*

9:20 – 10:00 **Chong Ahn**, U. Cincinnati - *Mass-Producible Nanoparticle Assemblies on Polymer Templates using Nanoinjection Molding*

10:00 – 10:20 Break

10:20 – 11:00 **CJ Kim**, UCLA – *Manipulation of Small Objects and Droplets*

11:00 – 11:40 **Tobias Kraus**, Leibniz Institute for New Materials - *Transport in templated particle assembly*

11:40 – 12:20 **Christopher Murray**, The University of Pennsylvania - *Directed self-assembly of multicomponent nanocrystal superlattices*

12:20 – 1:00 Box lunch provided

1:00 – 1:40 **Theresa Mayer**, Penn State University - *Electric-field directed assembly of nanowires for heterogeneous integration of on-chip electronic systems*

1:40 – 2:20 **Kate Stebe**, Johns Hopkins University - *Spontaneous ordering of particles at surfaces and interfaces*

2:20 – 2:40 **Panel Discussion III**

2:40 – 3:00 Closing Remarks
3:00 NIST Shuttle back to Holiday Inn