

Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems



### Nano-CEMMS: Overview December 2007

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an NSF-sponsored center for nanoscale science and engineering



### Nano-CEMMS Synopsis



Nano-CEMMS: Nanoscale Chemical-Electrical Mechanical Manufacturing Systems 34 Graduate Students, 15 REU students, 31 Faculty, 7 Post Docs, 7 Professional Staff 4 Institutions, 10 Industrial Affiliates,

US\$ 2.5M from NSF, 310K from institutions, 1.5M dollars leveraged from industry







**Vision**: <u>Manufacturing</u> at the nanoscale:

- Is routine and practical,
- Resides on <u>well-developed scientific knowledge</u>
- Supported by a diverse, educated workforce

### **Core Premise of Center Research:**

- Nanofluidic and ionic transport
- practical and efficient 'liquid-based' nanomanufacturing
- miniaturization and heterogeneous integration





Emerging Paradigm in New Product Development

 Heterogeneous Integration of functions into products rather than 'assembling' them





## Motivating Examples



Scientific tools, such as Lab-on-a-Chip devices are increasingly dependent on miniaturization and integrated functionality













### These and other applications demand manufacturing pathways that enable

# Miniaturization

### and

### Heterogeneous Integration

with classes of materials and in geometries that are incompatible with with established micro/nanofabrication technologies

# **Research Program: Goals**



- **Goal 4:** *Demonstrate* the new manufacturing platform's capabilities in nanoscale heterogeneous integration through test beds and applications in:
  - (i) Energy, lighting and displays
  - (ii) Combinatorial chemistry and chemical sensing
- **Goal 3:** Integrate knowledge and technology into new nanomanufacturing processes. Integrate processes into a platform for nano-manufacturing
- **Goal 2:** Develop and extend the basic technology infrastructure to enable fluidics-based manufacturing at the nanoscale
- **Goal 1:** Explore and characterize nanoscale fluidic and ionic transport



## **Research Organization**



### **Thrust 4: Test beds and Applications**

- Displays, Lighting and Energy Combinatorial Chemistry
- Smaller Opportunistic Efforts in Bio-sensing & Self-Healing Materials

#### Thrust 3: Manufacturing Processes and Systems

- Process Integration & Staging
- Tooling and Instrumentation
- Characterization & Automation
- Process Planning and Optimization

#### Thrust 2: Sensing, Positioning & Fabrication

- Chemical Species Sensing
- Optical and Electronic Monitoring
- Multi-scale Positioning Strategies
  - VLSI Microfluidic Fabrication

#### **Thrust 1: Micro Nano Fluidics**

- Computational Models 
  Nanoscale Confined Transport 
  Surface Chemistry
- Particulate Two-phase Flows Colloidal Transport and Assembly Scaling Laws







### **Enabling Technologies**









Nanoscale Positioning









VLSI Microfluidics 11





### **Research Outcome**

- By the numbers.....
  - Publications
    - 140 Journal papers,
    - 85 Conference papers,
    - 113 with multiple NSEC authors
  - Patents
    - 14 Invention disclosures,
    - 12 Patent applications,
    - 1 Patent allowed,
    - 1 License
  - Graduate Students
    - 15 PhD graduates
    - 15 MS graduates

Tuesday, May 15, 2007

Sheets of Stretchable Silicon Researchers have shown that ultrathi in two dimensions--opening up the pc and smart surgical gloves. By Kate Greene

Microflows and

INTERDISCIPLINARY APPLIED MATHEMATICS





Published: 13:27 EST, February 21, 2007

New stamping process creates metallic interconnects, nanostructures



# Education and Human Resources

- Graduate Students
  - Leadership, Foreign research experience and 3 new courses in Nanomanufacturing
- REU program
  - Summer REU totals 60 students
- Teacher Workshops
  - 500 Teachers, 16 Teaching Modules, ISBE funding for program, Targeted Student Enrichment (NanoChallenge)
- Diversity
  - Center helped recruit 6 graduate students and 2 professors
- Informal Education
  - Stretchable Silicon Exhibit in Silicon Valley
- Self-Funding
  - Received approximately \$425,000 for outreach activities





Professor Alleyne speaks at a Nano-CEMMS Graduate Student Meeting







#### Profile of Past Participants (2004-2007):

## 24% Underrepresented Minorities 33% Female

#### **REU Home Institutions**

- Participants
- Applicants

<u>Academic Majors</u> :	Average GPAs:
26% ME 16% ECE 14% ChemE	2004: 3.3
12% Chem 12% Bio-related	2005: 3.4
10% MatSE 10% Other	2006: 3.67
	2007-372



### E&HRD Activities: Modules & Displays





**3-dimensional printing** 



museum display



## **Industry Program**



### Activities

- Annual Industrial Advisory Board
- 'Smalltalk' published quarterly



- Organized on-campus visits for companies
- Nano-CEMMS visits to companies
- Industrial Affiliates Program
- Publications & website for industry outreach
- IP mining conducted by Illinois OTM



## Industry Programs



- <u>Leverage</u>: More than \$1.5 million leveraged externally
- <u>Applications</u>: Ongoing collaborative industrial research projects
  - Ford is working on flexible solid-state lighting,
  - Semprius is working with the center to automate transfer printing,
  - Sandia is working on a combinatorial chemistry application.
- <u>Outreach</u>: Nano-CEMMS' Annual IAB averages 20 industries
- <u>Collaboration:</u> Nano-CEMMS has 10 industrial affiliates
- Interaction: Over 30 companies have visited the Center
- <u>IP:</u> Mining exercises have resulted in 12 patent applications





Nano-CEMMS has integrated the vision, expertise and results of a diverse set of researchers and professionals to produce a unique research, education and outreach environment.

- Fundamental knowledge being generated and transformed into manufacturing capability
- An invaluable human resource being created
- Strong and productive industrial engagement