

## APPENDIX 13: UNIVERSITY OF ILLINOIS/CENTER FOR NANOSCALE CHEMICAL-ELECTRICAL-MECHANICAL MANUFACTURING SYSTEMS PROFILE

### I. Description

**Institution:** University of Illinois, Department of Mechanical and Industrial Engineering

**PI:** Dr. Placid M. Ferreira

**Co-Pis:** Dr. Ilesanmi Adesida, Dr. John Rogers, Dr. Paul Kenis

**Title:** NSEC: Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS)

Proposal: 032816

**Program Officer:** Dr. Kevin Lyons

**Education Outreach Director:** Lizanne Destefano, destefan@uiuc.edu and Ms. Martha R. Atwater, atwater@uiuc.edu

### II. Research Agenda

**Research Focus:** The Center's goal is to develop a reliable, robust and cost-effective nanomanufacturing system to make nanostructures from multiple materials.

**NSEC Description:** Scholars from mechanical, industrial, chemical, biomolecular, electrical, computer and materials science engineering collaborate with colleagues in applied physics, chemistry, and molecular and cell biology to create a viable manufacturing technology and science base for nanomanufacturing. The Center's research goals are addressed through a coordinated set of 28 research projects organized into four research thrust areas: Micro-Nano Toolbit, Nanoscale Sensing, Manufacturing Systems and Applications, with Computational Modeling as a cross-cutting activity. The research, commenced in January 2004, spans four campuses: University of Illinois at Urbana-Champaign (UIUC), North Carolina Agriculture and Technical State University (NCAT), the California Institute of Technology (Caltech) and Stanford University.

### III. Education Activities within the University

#### Description of activities

The Nano-CEMMS education team concentrates in the following areas:

- ◆ **Courses** in nanoscience, nanotechnology, and nanomanufacturing for undergraduate and first year graduate school courses
- ◆ **Research Ethics Training** for all participants of the Center
- ◆ **Graduate Student Group** that serves to enrich the student experience and to promote collaboration
- ◆ **REU Program** where undergraduates from various institutions gain laboratory experience under the direction of faculty sponsors and graduate student mentors
- ◆ **Teacher Workshops** that are designed to introduce middle and high school science, math, and industrial arts teachers to nanomanufacturing research and to facilitate knowledge transfer to their students.

- ◆ **Designated Diversity Recruitment Programs** that deliver nanotechnology-related content to underrepresented middle and high school students and recruit undergraduate students for graduate school
- ◆ **Summer Camp Programs** that target audiences of middle and high school students who are interested in engineering, math and science.
- ◆ **Evaluation** is conducted by College of Education evaluators who submit constant feedback to Center programs.

### Program staff and expertise

Faculty and students involved with Nano-CEMMS spend 15% of their time participating in the Center's educational outreach activities. The Nano-CEMMS Executive Committee sets priorities for the HRD team. To maximize efficiency and output, the team is augmented by professors, teachers (high school and middle school), students (graduate, undergraduate, high school) and part-time professionals just as needed to provide particular expertise or to execute particular tasks.

Martha Atwater	Education Coordinator	50%
Prof. Devdas Pai and Prof. Cindy Waters (NCA&T)	Education Facilitators	
Joseph Muskin (UIUC)	Education Facilitator	25% during the school year, 100% during summer
Kaamilyah Abdullah-Span (UIUC)	Diversity Programs Coordinator	50%
Patrick Grenda (UIUC) Deborah Bartz (NCA&T)	Education Evaluators	50%

### Goals and objectives

Nano-CEMMS targets its internal HRD activities to:

- ◆ Contribute to the diversity of the Center participants and the scientific community
- ◆ Promote the professional advancement of B.S., M.S., and Ph.D. students
- ◆ Educate and transfer knowledge specific to Nano-CEMMS research to visiting secondary and community college students and to the Center's undergraduate and graduate students.

**Target audience**

Nano-CEMMS provides a wide range of activities specifically targeting undergraduate students, graduate students, middle and high school students, and teachers who come to university programs. The following chart shows the numbers of people reached from 9/1/2004 until 9/1/2005.

Graduate students	61
Undergraduate students	16
Middle and high school teachers	54
Middle and high school students	1096

**Current activities**

Throughout the year, the Center provides programs for schools and community organizations. We are also working in the following areas:

- ◆ **Learning Modules** – The summer teacher workshops yielded kernels for several new learning modules that use common materials to transfer laboratory research concepts into lessons for school students. The education team is currently finalizing and piloting the learning modules.
- ◆ **Learning Kits** – With a grant from Motorola, Inc., the education team is building learning kits for the various Nano-CEMMS learning modules. The kits will include all the materials necessary to teach a module to 30 students as well as assessment and evaluation instruments and return postage. Nano-CEMMS will advertise the kits through various mailing lists and professional organizations, and teachers will order kits through the Center website.

**Nano S&E content focus**

Nanomanufacturing

**IV. Education Activities Outside the University****Description of activities**

- ◆ **School and Community Presentations** inform students and the general public about upcoming changes in manufacturing and the societal implications of this change
- ◆ The **Central Illinois Community College Initiative** includes faculty and students within the university, community colleges, high schools plus state and local government agencies and industries. This consortium is planning a training program to prepare a nanomanufacturing workforce for Central Illinois.
- ◆ The **Museum Initiative** trains and supports educators at the Children's Discovery Museum in Normal, Illinois, who deliver the Nano-CEMMS education modules in their Learning Labs program for school students.

**Program staff and expertise**

Same as above

### Goals and objectives

Educate and transfer knowledge specific to Nano-CEMMS research to external secondary and community college students, teachers, and community members.

### Target audience

Nano-CEMMS conducts external recruitment activities for undergraduate students, training for teachers who will deliver Nano-CEMMS education modules, and programs for schools and community groups. The following chart shows the numbers of people reached in external programs from 9/1/2004 through 9/1/2005.

Undergraduate students (external recruitment)	89
Middle and high school teachers	19
Middle and high school students	482

### Current activities

- ◆ Preparing for external programs
- ◆ Developing materials specifically targeted for recruitment within the diversity program
- ◆ Seeking new partnerships with outreach efforts at partner institutions

### Nano S&E content focus

Nanomanufacturing

### Nano S & E content consultants

Nano-CEMMS faculty and graduate students provide content expertise.

## V. Education Outreach Materials

Materials developed for outreach activities for the K-12 and/or informal audiences

The Center's ability to present effective educational experiences to a variety of audiences with minimal staff is directly related to the development of learning modules with clearly identified learning objectives, targeted audience types, and timeframes. The modules can be "snapped together" in various configurations depending on the particular interests and age ranges of the audience, as well as the time allotted for the presentation.

The Nano-CEMMS learning modules include a wide variety of cognitive, affective, and psychomotor learning experiences, and all have clearly stated learning objectives that are geared to Illinois and national learning standards. Module development is ongoing by education staff and by teachers and secondary students who are engaged in workshops and special projects. The modules are used extensively in camp and school programs and are modified based on piloting and evaluation. Each learning module contains a teacher's activity guide, a PowerPoint presentation, student handouts, evaluation instruments and lab materials.

### Recent successful education outreach activity

Two teacher workshops held in July illustrate how the Center teams of faculty, graduate students, undergraduates, secondary teachers and high school students collaborate to create curriculum.

- ◆ A high school science teacher who had attended a 2004 workshop spent the month of June visiting various Nano-CEMMS labs to determine developing technologies that would make effective learning modules for high school science classes and working with faculty and students to prepare for the teacher workshops.
- ◆ During teacher workshops in July, middle and high school teachers spent one week learning about the Nano-CEMMS technologies from the principle investigators and from graduate students and undergrads who conducted research demos and hands-on labs.
- ◆ The teachers and a high school student spent the second week replicating the experiences using inexpensive materials and developing safe procedures that are practical for a middle or high school classroom. As a result, the teachers created:
  - ◆ a 3D printing technique using a data projector and PowerPoint slides
  - ◆ a device using PDMS and Puffy Paint that shows laminar flow of dyed alcohol in small channels
  - ◆ a lab to make colloidal gold and silver and to demonstrate that the two colloids can be separated using commercially available filters

The Center's education team will work during the fall semester to finalize these labs for classroom use.

## VI. Education Outreach Evaluation

### Outreach evaluation plan

The evaluation effort is a collaboration between Nano-CEMMS and the College of Education faculty and staff at UIUC and NCA&T. Evaluation is imbedded in all of the Center's human resource and education activities and is keyed to the goals set for each program component. The approach is designed to provide both formative and summative feedback regarding program improvement and progress toward goals. Quantitative and qualitative data are gathered using direct observation, interviews and surveys.

### Summarize outreach evaluation results

Goals for each program were reached.

- ◆ **Graduate Students** - Participants took ownership of the Graduate Student Group, identified needs and interests they shared, and took steps to meet them. Participants identified connections across research areas and gained an understanding of their individual roles within the Center's research plan.
- ◆ **Undergraduate students** - All participants gained hands-on experience in nanoscience/technology, and progress was made in reaching underrepresented groups.
- ◆ **Teachers** - Participants expanded their knowledge of nanoscience, created modules that were incorporated in their classrooms, and continued their involvement with the center during the year by participating in curriculum development and piloting.
- ◆ **Middle and High School Students** - Participants were exposed to a range of information regarding nanotechnology. Participants were exposed to positive modeling regarding diversity in science.

## VII. Lessons Learned

### Three lessons learned

- ◆ **Use existing infrastructures** – Nano-CEMMS has formed collaborative relationships with many well-established camp programs at UIUC and NCA&T. All have the infrastructures to handle the housing and entertainment facets of camp life, allowing Nano-CEMMS to utilize resources efficiently to create learning modules for the various camps.
- ◆ **Modularize learning materials** – The Center’s modular approach to curriculum development allows the team to respond quickly to requests for presentations.
- ◆ **Hire staff just as needed** – Nano-CEMMS has a small part-time staff of secondary teachers and undergraduates who work as needed to fulfill its education goals. The staff is augmented when necessary by faculty and graduate students who also provide content expertise. This staffing plan maximizes efficiency and controls costs.

### What the Center is doing differently in the future

- ◆ **Workshops** - Recruiting teachers who serve a higher percentage of underrepresented students
- ◆ **Curriculum** - Focusing future development efforts on materials directly related to nanomanufacturing
- ◆ **Internships** - Working with industry to provide more internships for students
- ◆ **Collaboration** - Identifying opportunities to work with outreach efforts at the Center’s other partner institutions