

APPENDIX 5: NORTHEASTERN UNIVERSITY/CENTER FOR HIGH-RATE NANOMANUFACTURING PROFILE

I. Description

Institutions: Northeastern University, University of Massachusetts Lowell, and University of New Hampshire

PI: Ahmed A. Busnaina

Co-PIs : Joey L. Mead, Carol M. F. Barry, Nicol McGruer, and Glen P. Miller

Title: Nanoscale Science and Engineering Center for High-rate Nanomanufacturing

Proposal: 0425826

Program Officer: Delcie Durham

Education Outreach Director: Carol Barry, Carol_Barry@uml.edu

II. Research Agenda

Research Focus: High-rate, high-volume, template-directed self-assembly of nanoelements, including nanotubes and polymers, along with concurrent assessment of environmental, economic, and societal impact of the developed technology.

NSEC Description: Nanomanufacturing

III. Primary Education Activities within the Universities

Description of activities

- ◆ **Undergraduate course modules.** CHN is currently adding content to existing courses, particularly in required freshman, sophomore, and junior courses, at the three institutions.
- ◆ **Courses for non-science and non-engineering majors.** Courses will be developed from an existing Nanoscale Undergraduate Education (NUE) project at UML
 - ◇ **Goal (1,2):** a) Expose undergraduates in the core institutions to nanotechnology and interest some of them in nanomanufacturing careers. b) Disseminate modules to other universities.
 - ◇ **Program staff (1,2):** No staff. With the exception of UNH teaching post-doctoral researcher, course materials are being developed by NEU, UML, and UNH faculty with small stipends to cover faculty time, supplies, etc.
 - ◇ **Target audience:** (1) Overall, 5000+ NEU, UML, and UNH science and engineering undergraduates. (2) More non-technical majors in any year of their education.
 - ◇ **Current activities:** (1) During 2005-2006, CHN will sponsor the development and implementation “nanomaterials” for engineering materials, general and organic chemistry, ethics, and other courses. Funding for the 2006-2007 academic year will emphasize expansion of the portfolio of modules and dissemination of the tested modules. (2) Developed for face-to-face and on-line delivery, the current course, “Introduction to NanoEngineering,” was offered for the first time in spring 2005 and will be offered again in spring 2006.

- ◇ nanomanufacturing and its societal implications.
- ◆ **Graduate courses.** CHN is developing and delivering cross-university seminar courses
 - ◇ **Goal:** Prepare full and part-time³ graduate students in the core institutions for nanomanufacturing careers.
 - ◇ **Program staff:** Course materials are being developed by NEU, UML, and UNH faculty. Distance learning support from Universities, with some extra funds from CHN.
 - ◇ **Target audience:** Currently, full and part-time graduate students plus seniors (as elective) at NEU, UML, and UNH. Eventually, distance delivery to others.
 - ◇ **Current activities:** (1) During spring 2005, CHN delivered a, “Introduction to High-rate, Template-based Nanomanufacturing,” with an attendance of 80 students. (2) A full hybrid course, “Nanomanufacturing I,” will be delivered via web and video conferencing during fall 2005. (3) Additional jointly-developed graduate courses are planned for spring 2006 and beyond. (4) In addition, faculty member at participating institutions have developed courses for delivery at their home institutions. (5) The Institutional Advisory Board (engineering deans, etc.) are currently working on an articulation agreement for these single-institution courses.
 - ◇ **Nano S&E content focus:** Nanomanufacturing processes and their societal implications.
- ◆ **Research experiences for undergraduates.** A 10-week long research program with a professional development component.
 - ◇ **Goal:** Involve undergraduates in nanomanufacturing research and interest some of them in nanomanufacturing careers.
 - ◇ **Program staff:** NEU and UNH added REUs to existing programs for some professional development. UML partially tied to NEU program.
 - ◇ **Target audience:** Undergraduates at other institutions, particularly HBCUs.
 - ◇ **Current activities:** (1) Sixteen undergraduates participated during summer 2005, but most were from CHN’s core Universities. (2) During 2006, an additional nine undergraduates (funded from an REU supplement) will be added to the 16 students funded through CHN. (3) We also plan to expand the professional development component.
 - ◇ **Nano S&E content focus:** CHN nanomanufacturing research plus professional development. Students participated in ethical reflection workshop for all researchers in June 2005.
- ◆ **Safety training for CHN researchers.** A half-day workshop on safety issues associated with nanomanufacturing.
 - ◇ **Goal:** Make all CHN researchers aware of worker health and environmental issues associated with nanomanufacturing processes. This workshop is an addition to current safety training at each University.
 - ◇ **Program staff:** Michael Ellenbecker, director of UML’s Toxics Use Reduction Institute and CHN researcher.
 - ◇ **Target audience:** All CHN researchers (faculty, post-docs and students).
 - ◇ **Current activities:** Safety training began in spring 2005 and CHN will have three workshops during September, 2005.

³ NEU and UML have large numbers of part-time graduate students.

- ◇ **Nano S&E content focus:** Good practices for safe nanomanufacturing.
- ◆ **Societal impact workshops for CHN researchers.** Workshops on the societal impact of nanomanufacturing.
 - ◇ **Goal:** Make all CHN researchers aware societal issues associated with nanomanufacturing processes and research in general.
 - ◇ **Program staff:** Various. Donna Qualters and Perrin Cohen, NEU, led the June 2005 workshop.
 - ◇ **Target audience:** All CHN researchers.
 - ◇ **Current activities:** (1) A half-day workshop on an ethical reflection model for assessing research issues was attended by 60 CHN undergraduate, graduate, and post-doctoral researchers in June 2005. (2) A workshop on regulatory issues is planned for fall 2005.
 - ◇ **Nano S&E content focus:** Societal impact of nanomanufacturing.

IV. Primary Education Activities Outside the Universities

Description of activities:

- ◆ **Research experiences for teachers.** A 6-week long research program with professional and curriculum development (NEU and UML only).
 - ◇ **Goal:** a) Allow teachers to participate in nanomanufacturing research. b) Have teachers develop modules to introduce nanotechnology to their students.
 - ◇ **Program staff:** Researchers from NEU and UML with professional development handled by CESAME program at NEU (under direction of Claire Duggan).
 - ◇ **Target audience:** High school and middle school teachers teaching math and/or science in Massachusetts schools.
 - ◇ **Current activities:** Four teachers participated during summer 2005.
 - ◇ **Nano S&E content focus:** CHN nanomanufacturing research plus professional and curriculum development.
 - ◇ **Nano S & E content consultants:** See staff.
- ◆ **Summer teacher institute.** A week long professional development plus curriculum development program (UNH only).
 - ◇ **Goal:** a) Expose teachers to nanomanufacturing research. b) Have teachers develop modules to introduce nanotechnology to their students.
 - ◇ **Program staff:** Researchers from UNH plus UNH's K-12 staff person, Susan Greenberg
 - ◇ **Target audience:** Teachers from New Hampshire schools.
 - ◇ **Current activities:** Successful initial workshop during summer 2005.
 - ◇ **Nano S&E content focus:** CHN nanomanufacturing research plus curriculum development.
 - ◇ **Nano S & E content consultants:** See staff.
- ◆ **Workshops for industry.** Workshops on technical and societal issues associated with nanomanufacturing.

- ◇ **Goal:** Provide industry practitioners with targeted information on nanomanufacturing.
 - ◇ **Program staff:** Various. Michael Ellenbecker, UML, will lead October workshop.
 - ◇ **Target audience:** Industry practitioners and other interested parties.
 - ◇ **Current activities:** (1) Third New England International Nanomanufacturing Workshop provided two days of technical information on nanomanufacturing as well as a half-day session on the safety aspects of nanoparticles. (2) A half-day workshop on nanoparticle safety will be held in October, 2005.
 - ◇ **Nano S&E content focus:** Good practices for safe nanomanufacturing.
 - ◇ **Nano S & E content consultants:** None. NEU and UML have considerable experience with industry workshops.
- ◆ Nanomanufacturing at MOS. Exhibits, interactive presentations, etc. will be
- ◇ **Goal:** (1) Expose general public to the differences between nanotechnology and nanomanufacturing. (2) Expose general public to benefits and issues associated with nanomanufacturing.
 - ◇ **Program staff:** Carol Lynn Alpert, Museum of Science (Boston) and two half time MOS staff
 - ◇ **Target audience:** General public.
 - ◇ **Current activities:** This program is just getting started⁴.
 - ◇ **Nano S & E content consultants:** See staff.

V. Education Outreach Materials

Describe and provide examples of materials, outlines, demonstrations, etc. developed for outreach activities for the K-12 and/or informal audiences

CHN is just starting with education outreach, and thus, curricula are under development by teachers who participated in this summer's RET and Summer Institute programs.

Describe a recent successful education outreach activity

RET and Summer Institute programs were very successful, with K-12 teachers enjoying their time at the Universities. For example, after successfully injection molding nanoscale features at UML, the three UML teacher-researchers attempted to use tooling made by two NEU teacher-researchers. Although this was initially unsuccessful, the teachers intend to try again so that parts will be available for the curriculum module developed by the NEU-based teachers.

VI. Education Outreach Evaluation

Summarize outreach evaluation plan. (1) Eric Heller from U Mass Amherst's Donahue Institute is the lead evaluator for all but the MOS program. Evaluation of current course work and summer institute has been through questionnaires. REU students were evaluated through focus groups and a separate questionnaire. (2) Evaluation of the RET program at NEU and UML is tied to the overall CESAME RET program. (3) Carol Lynn Alpert is currently selecting an evaluator for the MOS program.

⁴ MOS program was delayed because it is partially funded by the Commonwealth of Massachusetts.

Summarize outreach evaluation results. Results are currently available only for spring 2005 graduate course. This course met the goals of familiarizing CHN researchers with all aspects of the Center's research and developing in those researchers an awareness of the non-technical impacts of their decisions. The CHN researchers did not like the round robin traveling required to deliver the course alternately at NEU, UML, and UNH, but did like the interacting with colleagues from the other institutions.

VII. Lessons Learned

List 2-3 lessons learned to share with others embarking on a nano education outreach effort. (1)

Linking with existing programs was worthwhile because you accessed prior knowledge from the program coordinators. (2) Freshmen courses are difficult to penetrate because of the current content. (3) Coordinating courses between three Universities is a challenge.

Describe what you might do differently in the future. Need experienced K-12 coordinator at each institution. Susan Greenberg's connections in New Hampshire have been valuable, but we are currently seeking additional funds for such a coordinator at UML.

