Appendix 1: Cornell University/Center for Nanoscale Systems Profile

I. Description

Institution: Cornell University
PI: Robert Buhrman
Co-PIs: none
Title: Center for Nanoscale Systems in Information Technologies
Proposal: 0117770
Program Officer: Bruce Kramer
Education Outreach Director: Dr. Monica Plisch, mjp11@cornell.edu

II. Research Agenda

Research Focus: Information technologies

The Center for Nanoscale Systems (CNS) has assembled interdisciplinary teams to execute an aggressive and wide-ranging nanoscale science and engineering research program. The CNS research mission is to substantially increase the impact of nanotechnology by advancing the understanding and control of the electronic, photonic and magnetic properties of materials at the nanoscale, and by exploiting these material systems and associated nanoscale phenomena in the development and demonstration of high-performance devices and systems. The Center's primary research objective is the innovation and development of effective nanoscale systems that have the potential of being revolutionary solutions for the ever-more demanding requirements of future computational, sensing, information storage and communication systems. CNS also seeks to invent and develop effective NSE research tools and techniques to support and further advance these information technology efforts.

In parallel with pursuing its research agenda, CNS seeks to attract, educate, and mentor substantial numbers of a diverse population of students, at all levels, in both introductory and advanced topics in nanoscale science and engineering, including ethical and societal issues, and career development. CNS also operates a very significant education outreach program for high school physical science teachers.

III. Education Activities within the University

1. Research Experience for Undergraduates

Description of activities
Undergraduate students spend 10 weeks at Cornell doing research under the supervision of CNS faculty. In addition, a series of short courses and faculty lectures are designed to give students a broader understanding of NSE and introduce skills relevant to research.

Program staff and expertise
P.I.: Prof. George Malliaras, Materials Science and Engineering

Goals and objectives
Our goal is to provide 12 undergraduates with the opportunity to:

- Experience independent research at a leading center for NSE research
- Develop practical skills for research activities
- Gain in-depth perspective on opportunities in NSE
- Become part of the NSE community

Target audience (educational levels, number of students at each level, etc.)
This program funds up to 12 undergraduate students each summer. We give priority to qualified students from underrepresented minorities, women and students from primarily undergraduate institutions.

Current activities
See goals and objectives above

Nano S&E content focus
NSE research in a broad array of fields related to information technologies

2. Nanotechnology Curriculum

Description of activities
AEP 102 *Introduction to Nanoscience and Nanoengineering* is a lecture and lab course designed as a hands-on, engaging introduction to NSE.
AEP 661 *Nanocharacterization* is a serious introduction to the tools used to image and probe materials at the nanoscale.

Program staff and expertise
AEP 102

- Lecturer: Prof. Robert Buhrman, Applied & Engineering Physics
- Lab Instructor: Monica Plisch, Ph.D. Physics

AEP 661

- Lecturer: Prof. David Muller, Applied & Engineering Physics

Goals and objectives
AEP 102 - To increase students awareness and interest in NSE.
AEP 661 - To provide instruction in nanocharacterization techniques for grad students and advanced undergraduates.

Target audience (educational levels, number of students at each level, etc.)
AEP 102 is a course designed for freshmen engineering students and has room for up to 80 students per year. It has been nearly full for the past two years offered.
AEP 661 is a course designed for senior undergraduate and beginning graduate students.

Current activities
To date, 10 lab modules have been developed for introducing college freshmen to NSE. In addition, more than 200 students have taken the course to date and have increased awareness of NSE concepts, and many report a strong interest in pursuing further studies in this field.

Nano S&E content focus
See description of activities above

3. CAPES mentoring program

Description of activities
The Career Advancement Program for Engineers and Scientists (CAPES) is an innovative mentoring program with the goal of better motivating and preparing graduate students and postdoctoral scholars to excel in their chosen career by improving their competitiveness when they enter the workforce.

Program staff and expertise
Chair: Prof. Melissa Hines, Chemistry and Chemical Biology

Goals and objectives
To help students develop important real-world skills such as public speaking, proposal writing and scientific "salesmanship."
To give students a realistic and unbiased view of academic and non-academic career opportunities.
To help prepare female and minority students for high level careers in engineering and science.

Target audience (educational levels, number of students at each level, etc.)
The target audience is graduate students and postdoctoral scholars. Typically, more than 100 students attend each of the 4 seminars offered each semester.

Current activities
Slides and video from each seminar are available at www.cns.cornell.edu as an on-line resource. Also, see goals and objectives above.

Nano S&E content focus
See description of activities above.

IV. Education Activities Outside the University

1. CNS Institute for Physics Teachers

Description of activities
See current activities below.

Program staff and expertise
Director: Monica Plisch, Ph.D. Physics
Coordinator: Linda Clougherty, B.S. Accounting

Goals and objectives
To update high school teachers on recent advances in physics including NSE.
To provide teachers with take-home laboratory exercises designed to meet the time and budgetary constraints of a typical high school, as well as fitting state-mandated curriculum.
To develop a continuing relationship between CNS and participating high school teachers.

Target audience (grade levels, number of students at each level, school districts, etc.)
Our target audience has been high school physics teachers, primarily in New York State. Satellites allow us to reach teachers in other locations, including minority-serving school districts in Los Angeles and Cleveland. To date, more than 500 teachers have come to at least one CNS workshop.

Current activities
More than 10 teacher workshops are held each year across New York State and at satellite locations including Los Angeles and Cleveland.
A three-week summer institute at Cornell University with a lecture and lab format provides teachers with intensive training.
To date approximately 20 new lab activities have been developed for teaching high school physics.
An equipment lending library provides kits for teachers to implement CNS activities.

Nano S&E content focus
Lectures at teacher workshops frequently have a NSE theme related to information technologies, which is the expertise of the faculty in our center. Hands-on activities focus on helping teachers meet learning standards, which sometimes can be related to NSE content.

Nano S & E content consultants
CNS researchers work closely with teachers to develop new materials.

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
Each year, we bring together teachers and researchers to develop new hands-on activities with the goal of updating physics classrooms and engaging students with stimulating learning experiences. Teacher training workshops are used to disseminate new activities. Activities are described on our website www.cns.cornell.edu.

Describe a recent successful education outreach activity See above.

VI. Education Outreach Evaluation

Summarize outreach evaluation plan
All workshops, courses and classroom materials are evaluated by participants, including classroom teachers and/or students. Written and oral evaluations are used to solicit quantitative and qualitative information. This feedback is used to improve programming and materials. In addition, a three-page annual survey is sent to alumni of the summer institute to determine classroom impact.

Summarize outreach evaluation results
Teacher feedback from summer institute 2004

- Highly enthusiastic response; typical teacher comments included:
  "CIPT has provided a source of new and interesting labs."
  "I feel re-energized about physics."
  Liked best: "To see the current research."
- All teachers planned to use most labs at end of courses

- Many teachers want more
  9 teachers returned in 2004
  17 teachers returned in 2005

Follow-up survey (end of school year)

- 67% return rate for June 2005 annual survey
- Overall effect of participation? (1 = no effect, 5 = enormous effect)
  2003 participants: 3.9
  2004 participants: 4.6

Average lab implementation rate: 40%

VII. Lessons Learned

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

1. Activities that meet learning standards are much more likely to be used by teachers than those that do not address the curriculum in any way.
2. It is essential to bring together researchers and teachers when developing new classroom materials and activities.
3. Teacher training is important for teachers to adopt new curricular materials.

Describe what you might do differently in the future
In the future, we plan to focus on the middle school curriculum to reach a wider population, especially underserved minority students and teachers. High school physics is infrequently taught in under-resourced schools.