Building Academic, Research, and Commercialization Programs in Micro and Nano Science and Engineering at the University of Utah

Ian R. Harvey[1,2,3], Mark S. Miller[1,2], Steve Blair[2], Tim Ameel[3], Bruce K. Gale[3,5], Terry Ring[4]
U of U Eng'g Dep'ts: [1]Materials Science, [2]Electrical & Computer, [3]Mechanical, [4]Chemical & Fuels, [5]BioEng
Utah Microsystems Science & Engineering Center (UMSEC)
University of Utah

Abstract—This paper presents a case-study of some University / Government / Industry interactions at the University of Utah that build research and academic programs and create opportunities for economic growth in the areas of micro and nano science and engineering.

I. Introduction

Several emerging microsystems technologies will probably follow the development path of IC microelectronics, providing many opportunities for technological, scientific, and commercial expansions. University based microsystems science and engineering programs will likely play leading roles in many of these developments.

Faculty from several Departments and Colleges at the University of Utah have been building up and coordinating the micro and nano systems science and engineering capabilities on campus, with the three principle goals (Figure 1) of:

- educating the next generation of scientists and engineers for this multidisciplinary field,
- enabling internationally competitive research, and
- facilitating commercialization of new technologies.

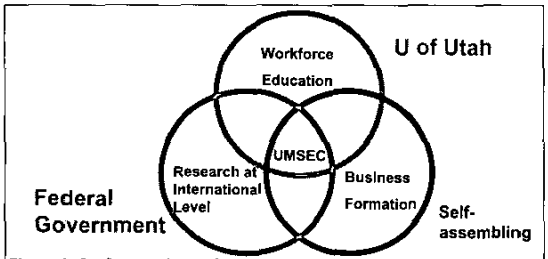

Figure 1. Confluence of three funding sources supporting diverse interests and a common infrastructure in the areas of micro and nano science and engineering. The Federal Government funds most of the research and the University most of the education. Commercialization activities are currently self assembling.

The U of U efforts are organized within a community of users of the College of Engineering Microfabrication Laboratories and affiliated characterization laboratories.

University labs enabling micro and nano research ("microfabs") are expensive to build and operate. The process technologies, which motivate the construction and operation of a microfab, are generally embedded in and kept alive by a healthy, collaborative local community. Other constraints include: (1) the lab must comprise a flexible set of capabilities, as opposed to a rigid manufacturing line, and (2) university microfabs cannot effectively compete with industrial fabs or even federal laboratories such as Sandia.

Seed funding through NSF IGERT Grant 9987616. Other partners include The State of Utah, Cyberkinetics, Micron Technology, Fairchild Semiconductor, M+W Zander, TM-Vacuum, and Charlie Crump, MBA.

II. Overview

Thie long-term vision is to establish a large, multi-user and multidisciplinary University micro and nano fabrication facility. This paper briefly reports on recent steps needed to support the long-term goal. Several mechanisms implemented to reach these goals are highlighted, including recent State and NSF grants, partnerships with area industry, and student support of the existing facilities.

III. Nano and Micro Science & Engineering at the U

Academic interest in the fields of micro and nano science and engineering at this University is manifest by the more-than-doubling over the last 3 years in the number of hands-on (lab-based) courses (7 from 3), new faculty teaching laboratory courses (6 from 2), and yearly student credit hours (SCH ~600 from 260), as measured just within the College of Engineering Microfabrication Labs.

Campus-wide nano-scale research activity was demonstrated by the tremendous response to a recent Nanoscience Miniconference [1], where over sixty U of U researchers from several science, engineering, and biomedical disciplines were represented in an informational exchange. The purpose of the grass-roots organized meeting was for researchers to become acquainted with the capabilities and research interests of their colleagues scattered around campus. From the collected surveys it was found that many individuals expressed the need to create a Surface Science center so that the materials and structures they were depositing could be adequately characterized. Many researchers encouraged expansion of micro and nano-fabrication techniques. Others expressed surprised excitement to learn of the existence of on-campus microfabrication capabilities in an open-use facility, thus supporting the basic motivational premise of the gathering. Insightful comments related to the need to couple advanced fabrication to characterization and make these both accessible and transparent to campus researchers and regional industry

users. Overriding sentiment related to the potential for interdisciplinary collaboration.

IV. Meeting the Infrastructure Needs

Renovations are in-progress for revamping the microsystems education program to meet increased student demand, and the broadening industrial reach of microfabrication technology. Curricula are being coordinated and refined. Faculty and staff are added with micromanufacturing expertise bringing such specialties as electronic, opto-electronic, bio-mechanical, and micro-thermofluidic expertise. Facilities are being expanded and updated for safety and consistency with state-of-the-art. Systems are being optimized around a new student culture of personal responsibility, trust, and interdependence. Quality, self-motivated students are the key to making this work, and our students assume roles from equipment "ownership" (coordinating training & maintenance), to self-policing, to advisory committees. Finally, surface analytical instrumentation is added and consolidated to increase the breadth of functional capability available to the research function and the educational process.

V. Government Seed Funding

A. NSF IGERT program

The catalyst for all the partnering activities at the University of Utah is the IGERT (Integrative Graduate Education and Research Traineeship) program of the NSF [2]. Established to promote creative improvement and multidisciplinary exposure in the educational preparation of graduate education, the research theme of the Utah award is micro-thermal fluidics. This NSF-funded research has enabled many long-term improvements that impact all micro and nano-scale research at the university:

- 16 Ph.D. and 10 M.S. students are involved in the program, representing 4 departmental majors.
- Three new technical courses have been created, covering the physics of dimensional scaling, to microfabrication techniques, to microsystems design and characterization.
- A fourth course gives students a formal exposure to training in creativity, teamwork and communication.
- Two new faculty/research engineers were directly funded through IGERT.
- IGERT meetings serve as a forum to bring together faculty from all over campus, fostering important multidisciplinary research and educational collaborations.
- New equipment was purchased by leveraging IGERT budgets as matched funding to other sources.
- Undergraduate students have been funded by the IGERT program to refurbish and characterize old equipment and fit up / characterize donated equipment. The record for recruiting these students into IGERT-sponsored graduate studies is 50%.
- New interdisciplinary research activity has been undertaken in microsystems areas, in many cases requiring multiple advisors from different Departments.

B. State/University support

Activity seeded through the IGERT program has spawned additional support for facilities expansion, equipment fit-up dollars, and safety upgrades—funded by the State.

VI. Industrial Partnering

Many regional businesses have expressed their satisfaction with the demonstrated improvements by:

- 1-year engineering employee-sharing arrangement.
- Donating new and used equipment.
- Donating expertise in planning safety / facility upgrades.
- Donating engineer time to teach specific course modules.
- Donating expertise in planning safety / facility upgrades.
- Financially sponsoring students in research projects.
- Providing revenue by using the facilities for their R&D.

VII. Commercialization Activity

Entrepreneurial R&D and commercialization activity is currently dependent upon individual researchers and companies supplying their own employees to train and work in the lab facilities. Growth in this area is dependent upon staffing at a level that enables companies to entirely subcontract work. A lab business plan has been developed to comprehend this activity in concert with research and teaching functions [3].

VIII. Vision— "Future Work"

From the academic standpoint, the vision is to leverage the IGERT graduate-based successes further, to the point where a multidisciplinary undergraduate degree or emphasis program can be created in Microsystems Engineering. Additionally, we recognize that strong and consistent science-educational preparation, beginning in the 7th grade, is critical to long-term advancement of knowledge and understanding within different fields of science and technology, due to the need for feeding more (and a greater diversity of) well-prepared students into the higher education system. Federal funding is available to catalyze these related activities [4,5].

The research vision is to expand nano and micro fabrication capabilities and to couple these with advanced surface and materials characterization techniques in a single open-use center. These together enable multidisciplinary collaboration on major Federal grant proposals. The ultimate goal is to create a purpose-built facility consolidating and expanding capabilities in a broadly-equipped and user-friendly research and teaching environment.

The vision for commercialization also leverages the infrastructure created for basic research. The critical distinguishing factor is the presence, necessary for development and prototyping activities, of a few broadly skilled staff to provide a "service center" approach to entrepreneurs and businesses.

Conclusion

The broad area of micro & nanotechnology is emerging as

one of the most important areas for scientific and engineering advancement in the 21st century. Partnering activities at the University of Utah have enabled significant expansion in these fields in an attempt to pace the student interest, research need, and market potential.

ACKNOWLEDGMENT

Appreciation is extended to users, students, and principal investigators who have placed value in collaborative relationships and community-based infrastructure, and who have demonstrated great support during periods of transition. Many thanks to all sponsors and partners.

REFERENCES

[1] University of Utah Miniconference on Nanoscience and Nanotechnology, SLC, 24 April, 2003

[2] NSF 02-145 Integrative Graduate Education and Research Traineeship (IGERT) program http://www.nsf.gov/pubs/2002/nsf02145/nsf02145.htm

[3] Crump, C. "Utah Microsystems Science and Engineering Center Business Plan 2003", presented to Mr. James Solomon, 4/21/03

[4] Department-Level Reform of Undergraduate Engineering Education; NSF 03-562 http://www.nsf.gov/pubs/2003/nsf03562/nsf03562.htm

[5] NSF Engineering Education program http://www.nsf.gov/pubs/progdesc/2001/eng/pdeng0101.html