

NANOMANUFACTURING CENTER OF EXCELLENCE, UNIVERSITY OF MASSACHUSETTS AT LOWELL

CENTER HISTORY AND TECHNOLOGY FOCUS

The Nanomanufacturing Center of Excellence (NCOE) emerged from the University of Massachusetts at Lowell (UML)'s history in applied industry research, its expertise in plastics engineering, and the University's leadership's goal to expand the University's contribution to the emerging nanotechnology field. UML was working with industry on nanoscale composites, polymers, and manufacturing processes with existing technologies and had received NSF funding for some of these activities. NSF matched UML researchers with others at Northeastern and the University of New Hampshire, and this collaborative received a \$12.4 million five-year NSF grant in 2004 to create a Center for Nanoscale Manufacturing, prior to UML seeking funding from MTC's John Adams Innovation Institute. Concurrently, the chancellor and a local state representative worked to secure state funding to expand UML's nanotechnology research. JAII's authorizing legislation mandated that it fund three Centers of Excellence under its Research Center Matching Grant Fund in medical devices, biotechnology, and nanotechnology. It also mandated that one of these centers be in northeastern Massachusetts. UML's proposal for a nanomanufacturing center fit this mandate¹. The Innovation Institute approved a \$93,000 planning grant for the center in September 2004, which was incorporated into a \$5 million NCOE grant approved in November 2004.

Grantee: University of Massachusetts at Lowell
Project: Nanomanufacturing Center of Excellence

JAII Grant Amount: \$5,000,000 matching grant
Contract start date: 6/1/05

Purpose: The Center is dedicated to the development of high-rate, high-yield processing technologies for materials that incorporate nanoscale structures *and* to the application of such technologies within a broad spectrum of industries in Massachusetts and elsewhere.

The NCOE is not a federally-funded research center and JAII funds were not committed to leverage a federal research award. Rather, the Center uses state funds to complement activities under its related NSF center and to leverage additional federal funding through contract research projects and other grants. NCOE research focuses on the broad application of nanomanufacturing processes to established industries, including electronics, textiles, and consumer goods. It originally emphasized four areas: multi-layer extrusion, electrospinning, nano-composite fabrication, and injection molding, but its research focus has expanded with the COE's growth over the past five years.

UMass Lowell describes that JAII did not play a major role in the conception and design of the NCOE; it largely accepted the concept developed by UML. JAII did provide funds

¹ Center staff did not know how this legislative mandate occurred, but they did observe that they understood many factors were involved in securing state funding for the center and the mandate might have resulted from lobbying by the chancellor and state legislators.

for a consultant to help prepare a business plan for the Center and it has been very helpful with industry outreach activities.

CENTER PROFILE

The NCOE is a multi-disciplinary center that draws on faculty and students from several schools and departments and reports to the deans of Engineering and Science. There are 44 faculty associated with the Center from engineering, science, health and environmental policy, the social sciences, and arts and humanities. Professors Julie Chen, Carol Barry, and Joey Mead served as center co-chairs in the first four years. Barry and Mead are now co-chairs following Dr. Chen's appointment as vice provost for research. Staff include a business development director and administrative staff. Financial administration is handled centrally at the university and consultants are used to identify funding opportunities and business partners. NCOE and the NSF Center for High-Rate Nanomanufacturing (CHN) are entwined with overlapping activities, faculty, staff, and funding. Thus, it is difficult to separate the activities, outputs, and outcomes uniquely associated with NCOE.

NCOE undertakes multiple activities to support nanomanufacturing. The primary activity is applied research projects around nanoprocessing in different geometries and with different processes. Most research is done either under contract for firms or through federally-funded projects (including some done in collaboration with private firms). NCOE also provides seed grants for exploratory or higher risk projects proposed by faculty.

NCOE has an active public education and outreach program conducted via a grant to the Museum of Science (MOS) to increase public awareness and to educate K-12 teachers on nanotechnology and its impacts. Another area is curriculum development for graduate and undergraduate studies and for professional education. For example, the Center created a four-course nanotechnology certificate program for engineers in the field. Finally, NCOE conducts outreach and works with industry to inform them about developments in the field and to identify promising areas for future research. These efforts include organizing an annual Nanotechnology Summit for industry, organizing an industry advisory committee, center faculty participation in industry and research conferences, and holding "ideation" workshops to explore how new developments can be used to address customer and business needs of specific firms.

Although financial reports do not provide a complete and up-to-date picture of NCOE revenues and expenditures, NCOE is spending below budget and leveraging funds on a larger scale than projected. The original proposal had a five-year budget of \$18 million with \$2.7 million in year one growing to \$4 million in year five. JAI's \$5 million grant was to be matched with \$13 million (\$5.5 million in federal grants, \$3.2 million from industry, \$650,000 from donations and foundation grants, and \$3.7 million from UML²).

² The UML match included \$2 million in cash and \$1.7 in indirect costs.

Quarterly reports to JAI detail the Center's budget and expenditures of JAI funds but not its exact amount and use of matching funds. The fourth year (most recent) operating budget is \$1.3 million with \$590,000 for staff (including student research assistants), \$250,000 for seed project grants and the Museum of Science (MOS) education programs, \$238,000 for materials, supplies, and miscellaneous expenses, and \$216,000 in indirect costs. However, NCOE has spent JAI funds at a slower rate than projected, expending only \$2.735 million through the first quarter of year five. Consequently, UML plans to seek an extension of JAI funding for several additional years. A delay in developing critical lab facilities contributed to these delays.

A midterm report listed \$15 million in total NCOE revenue for its first 2.5 years, with 66 percent from federal agencies, 17 percent from industry, and 17 percent from JAI. However, the report did not document how this \$15 million was spent.³ Recent reports reinforce that NCOE is exceeding its projected match and relying heavily on federal research funding. The latest quarterly report (Year 5, Q1) lists \$1.389 million in matching funds, 91 percent from federal agencies, compared to \$177,399 in JAI funding expended for the quarter. Over its first four years, NCOE has used the JAI grant to pay Center staff, provide grants to seed research projects, and to fund graduate student research positions, the MOS public education efforts, and industry outreach. Leveraged funds appear to be largely used to fund specific research projects by faculty and students and for some curriculum development and educational activities.

NCOE has grown considerably over its four years with increasing numbers of faculty and students involved. This has allowed the center to expand its research beyond the initial focus on nanomanufacturing processes in different geometries. For example, the center has an active program around the health and environmental risks associated with nanomanufacturing and ensuring safe manufacturing practices. Another change is that NCOE did not implement its original plan for a collaborative membership-based research center in which industry members define shared research needs. Instead, the Center works with individual firms on specific research projects related to the company's research and development needs. NCOE also has found it difficult to work with small firms since its limited resources only allow it to fund small short-term projects. The Center has focused more on working with larger firms that can provide more funding (e.g., sufficient to support a graduate student research assistant) and partnering with businesses to pursue large federal research grants for multi-year projects. NCOE has not abandoned projects with small firms, but has used business development staff to oversee and coordinate these projects so that it does not burden Center faculty.

Business/Industry Participation

With UML's history of applied industry research and a technology focus that offers applications to many industries, the NCOE has extensive industry participation and uses

³ In response to inquiries, Center staff indicated the current UML financial systems make it difficult to provide a full expenditure report for the Center and to document expenditures on a programmatic (vs. individual account or grant) basis.

varied approaches to cultivate and sustain its collaborations with industry. The core of its industry collaboration is applied research projects with individual firms on a problem that the firm wants to address. In the last fiscal year, NCOE was engaged in 21 such project with companies in industries that include consumer products (Ocean Spray), electronics (Osram/Sylvania), aerospace (Boeing), solar energy (Konarka), and many others. Many of these projects involve research around new materials, materials improvements, and manufacturing processes. NCOE formed its first industry research consortium in 2009 on nanohealth that addresses monitoring worker exposure to nanoparticles.

NCOE has an external Business Advisory Board that meets annually. This board began as a way to provide advice on how the Center's research and other activities can address industry needs, but has evolved into a more integrated and engaged body. For example, this past year, several board members adopted a specific technology and provided a mentoring role to junior faculty around development of the technology. Board members also have worked on team building for faculty and on university intellectual property issues. Another forum for Center-industry interaction is the conferences and workshops that showcase the work of the Center and engage industry participants in discussing applications of the Center's work. These include an annual Nanomanufacturing Summit, which had 100 representatives from 50 firms in 2009, the New England International Nanomanufacturing Workshop (75 attendees in 2009), and fall and spring research symposiums. NCOE has held consultations with individual companies to explore changes in the firm's customer needs and markets and how NCOE can help the firm address them. The Center also coordinates firm access to university research equipment; about 50 firms use this equipment for short-term needs, such as characterizing a compound. Finally, the Center regularly conducts outreach to firms through faculty visits to companies and by contacting small firms about their interest in partnering around SBIR and STTR opportunities.

Center Outputs and Outcomes

With assistance from MTC's John Adams Innovation Institute, UML has built a substantial applied research center in nanomanufacturing that has attracted new faculty and graduate student talent to the state, improved and expanded education and research in this field, and conducted extensive collaborative research with industry. Although quantitative data are limited, NCOE has clearly been an important source of new knowledge and has worked on many product and process innovations with industry — several of which are in use. There may be economic impacts from these innovations via increased sales, profits, and employment (and retained employment) at collaborating businesses, but NCOE has not monitored or collected information on such impacts. NCOE has not been a vehicle for the creation of new firms or commercial ventures thus far. A partial summary of the Center's outputs for FY2009 are presented in Table 1.

Table 1: Summary of Center Outputs	
Output Measure	Fiscal Year 4 Data ⁴
Research projects completed	No data provided
Major new discoveries	<ul style="list-style-type: none"> ▪ Preparation of nanoscale patterned polymeric structures ▪ New method to evaluate nanoparticle toxicity
Research papers published	132 in conference proceedings, magazine and journal articles, and book chapters
Invention disclosures and patents	<ul style="list-style-type: none"> ▪ 13 invention disclosures/provisional patents ▪ 1 patent award ▪ 3 UMass Commercial Venture and Intellectual Property Awards (out of 7 system-wide)
Other activities/events	<ul style="list-style-type: none"> ▪ International Workshop – 75 attendees ▪ Nanomanufacturing Summit – 90 attendees from 50 companies ▪ NSF Summer Institute – 90 attendees ▪ Seminar Series — 13 seminars 20-40 attendees each
Private research and development funding	<ul style="list-style-type: none"> ▪ 21 cooperative industry research projects; 12 with industry funding (2 or which are in-kind) ▪ “There are many ongoing projects and collaborations with companies focused on product improvements as well as new product developments” ▪ One example of “follow-on” industry investment for an extrusion process developed with the Center

JAI funding and the creation of NCOE was a catalyst for a major UML investment in faculty related to nanotechnology that attracted new talent to Massachusetts and affected the overall university research culture. UML established 10 new faculty slots as part of creating NCOE and Center staff report that 15 to 20 new faculty hires have occurred as part of the Center with all but two of them coming from out of state. NCOE also attracted 10 postdoctoral researchers from out of state (two were promoted to research professors), and the Center has helped attract more and better quality graduate students nationally and from outside the U.S. NCOE’s co-directors estimate that 50 to 60 graduate students are supported by the Center and that 50 percent stay in Massachusetts after graduation. Through this expanded research capacity and its connections to many UML departments, NCOE believes it helped change the research culture of UML. The University now views itself as a research university with the potential to contribute new

⁴ This data was provided by the Center in February 2010 in response to an information request on Center outputs and outcomes by Mt. Auburn Associates and only addresses the Center’s most recent fiscal year, not cumulative outputs.

knowledge on a larger scale than solving narrow industry problems and with more interest in interdepartmental research and more demanding projects.

NCOE is undertaking a substantial volume of research activity with tangible research results of value to industry. Although exact figures on research spending were not available, information from quarterly reports to JAI indicates minimum research funding beyond the JAI grant of \$18.4 million. With JAI-funded seed research grants (approximately \$140,000 per year), total research funding is at least \$19 million. Research outputs for FY2009 included 132 papers, 13 invention disclosures or patent applications, and one approved patent. An earlier midterm report listed 23 licensable discoveries associated with the Center's research. Moreover, Center staff indicated that two-thirds of the inventions and disclosures at UML come from nanotechnology research. Although NCOE has not tracked commercial use of its research, Center staff pointed out several cases in which new discoveries are in commercial use:

- Several licenses are being negotiated for its nano, multi-layered extrusion process.
- Boston Scientific is using its work on biodegradable coatings for stents.
- NYPRO is using knowledge developed by the Center in its processes.
- Triton Systems wants to license new technology on nanomaterials for its work on government contracts.

NCOE has prompted some changes to the research and innovation process at UML. Faculty are now more likely to look at issues broadly and involve faculty from other disciplines in framing the problem and conducting research. There is also more attention to creating a process for idea generation and to creating and communicating research projects that can secure large federal grants and industry support

JAI's Center of Excellence grant made a vital contribution to NCOE's development and outcomes. The initial \$5 million state commitment led to UML adding 10 faculty positions in nanotechnology-related disciplines and creating a much larger research enterprise in this field. The flexibility of JAI funds has allowed NCOE to undertake activities that are difficult to fund with NSF or contract research dollars such as the meetings, summits, and workshops that build the Center's visibility, reputation, and relationships. The support for Center staff facilitates more interaction with businesses and administrative capacity to work with small firms on smaller research projects. Finally, JAI funds are used to seed work on new and riskier ideas that are too early stage to get external funding.

CONCLUSIONS

Now in its fifth year, NCOE has emerged as a large center of applied nanotechnology research that works closely with businesses in diverse industries on a broad range of applications and issues, including a specialization in addressing the health and environmental impacts of nanotechnology manufacturing. NCOE has substantial direct

research and education results, with significant research funded by or conducted with business partners and has secured over \$6 million in outside funding for every dollar of JAIJ funding. Its success in leveraging funds and careful use of JAIJ funding has allowed the Center to spend JAIJ funds well below budget and extend the grant for one to two more years. NCOE has generated economic development outcomes for Massachusetts in two realms: (1) attracting new scientific and engineering talent to the state; and (2) developing new knowledge and technology with commercial value and in commercial use. A third outcome is its role in strengthening UML's position, reputation, and aspirations as a research university.