The NSF Nano-scale Science and Engineering Center (NSEC) for Scalable and Integrated Nanomanufacturing (SINAM)

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The Center for Scalable and Integrated Nanomanufacturing (SINAM) was established in 2002 through the National Science Foundation's (NSF) Nano-scale Science and Engineering Centers (NSEC) program. With the vision of a new nanotechnology manufacturing paradigm combining fundamental scientific research with industrial outlook, SINAM has developed its leadership in nanomanufacturing through the collective effort of its exceptional interdisciplinary team of academic and industrial researchers from seven institutions during our Phase I operation. In our Phase II operation, the multi-institutional team effort of SINAM including the University of California at Berkeley (UCB), the University of California at Los Angeles (UCLA), Stanford University, the University of North Carolina Charlotte (UNCC), Northwestern University, Massachusetts Institute of Technology (MIT) and Hewlett-Packard Laboratories, brings together a wealth of expertise in manufacturing, process systems and modeling, material synthesis, the physical sciences and applications development. In an environment dedicated to multi-disciplinary and collaborative science, in addition to education programs for the next generation of leaders, SINAM creates opportunities for industrial quantum-leaps in nanotechnology.

The major challenges that the current nano-technology revolution is facing are to manufacture nano-devices below 20 nm and to heterogeneously integrate multiple functionalities. In tackling these challenges, SINAM envisages a new manufacturing paradigm which integrates new technologies including Plasmonic Imaging Lithography, Nano Imprint Lithography, as well as hybrid top-down and bottom-up approaches with the ultimate goal of delivering manufacturing tools for the critical resolution range of 1-50 nm. Driven by a strong system focus, SINAM research emphasizes manufacturability, scalability, reliability and environmental impact. An innovative synchronous systems engineering approach is under development to enhance the scalability and productivity of the manufacturing process at the nano-scale.

There is currently no shortage of nano-scientific discoveries from research laboratories; the problems that researchers are currently facing involve mastering the control of nano-dimensions in large scale production facilities. Industrial level production of nano-technology still poses critical challenges due to the lack of a high throughput and efficient nanomanufacturing techniques. The Center for Scalable and Integrated NanoManufacturing (SINAM) tackles these two key fundamental challenges in expediting a nano-technology revolution: firstly, the ability to perform lithography below 20 nm; and secondly, the ability to fabricate complex 3D nano-structures. SINAM works to realize such a manufacturing paradigm by combining fundamental science and technology in nanomanufacturing to transform laboratory science into industrial applications for new energy, healthcare and traditional technology industries. SINAM continues to push towards this nanomanufacturing revolution. In doing so, SINAM has made significant advances in fundamental knowledge, technology, education, and industrial outreach. SINAM serves as a unique bridge, transforming fundamental nano-scale science into a manufacturing revolution through the synergetic research, education and outreach programs.

Nanomanufacturing is expected to have a ground breaking impact in a new era of industrial production. The new and exciting technologies that SINAM is discovering today will open the door to untapped length and time scales for both pure and applied scientific breakthroughs of tomorrow impacting the entire spectrum of the physical sciences. Applications such as computing, telecommunications, photonics, biotechnology and medicine are set to be radically overhauled. SINAM's research program is structured by the three Integrated Research Groups (IRGs). IRG I focuses on prototyping plasmonic nanolithography with an aim towards the critical resolution and required throughput and yield for real world applications. The demands of such a new nanomanufacturing tool will be defined by the industrial needs and also the product development of the IRG II and III. IRG II focuses on the building of a nano-plasmonic-based healthcare platform. And IRG III aims at significantly reducing the barriers of solar energy utilization via developing low-cost nanofabrication process for solar photovoltaic and solar fuel.

SINAM has established a close relationship with industry through direct collaboration, synergistic activities, and external advisory board. Besides the long term collaboration with HP, the Center has successfully established research collaborations with a number of diverse companies from various industrial sectors, such as automobile, information technology and microelectronic industries. SINAM's industrial sponsor portfolio has been greatly increased in the past funding year; a long list of them includes Hitachi, Western-digital, Information Storage Industry Consortium (INSIC), Xerox, Intel, IBM, NanoComp Technologies, Mitsubishi Chemical Research and Innovation Center, Motorola, Honda Research Institute, GCEP, Reliance, GM Samsung, and the NanoCarbon Research Institute. This dramatic increase of the supporting level from industry is a great recognition and measure for SINAM's success in the past years. It will continue to facilitate SINAM's operation in the new phase, which is aiming at application and product driven development. In return, SINAM is making an important impact on the economy and industry. During its development, SINAM's research has generated or assisted 10 spin-off companies and they are actively operation in fields of nanoscale scienence and engineering.

As the technology in manufacturing shifts to new nanoscale technologies, SINAM's educational mission is to fill these emerging vacancies in nanomanufacturing workforce by promoting the research integrated educational outreach programs covering groups from 7th graders to graduate students. SINAM serves as a unique bridge, transforming fundamental nano-scale science into a manufacturing revolution through the synergetic research, education and outreach programs. A quarter of the current science and engineering workforce will retire by the end of this decade; SINAM's educational mission is to address this serious workforce crisis. As a nation, in order to fill these vacancies, we must attract underrepresented demographic groups to the engineering workforce. As the technology in manufacturing shifts to new nano-scale technologies, SINAM sees a great opportunity to address this national issue with an educational program integrated with SINAM's research: hands-on demonstrations of nanomanufacturing to 7th-12th grade classrooms; a summer academy for undergraduate and high school students; a range of graduate and undergraduate courses taught in SINAM institutions working towards founding a nanomanufacturing curriculum; and a Graduate Young Investigator program.

A nanomanufacturing paradigm will greatly impact human society as did the industrial and technological revolutions. SINAM has assumed a substantial responsibility for teaching, training,

and learning through on-going research programs and new curriculum development in nanomanufacturing. Postdoctoral researchers, graduate, undergraduate, and high school students are actively involved in SINAM's research and outreach activities. By approaching younger underrepresented communities, SINAM not only helps to address the needs of a high technology workforce, it also helps to educate a wider population about nanotechnology. The broader impact of nanomanufacturing goes far beyond today's imagination and will have an effect upon a boundless mixture of social spheres, for example: health care, energy, entertainment, education as well as transportation, aerospace and public policy. A nanomanufacturing paradigm will greatly impact human society as did the industrial and technological revolutions.

For further information about this project link to **www.SINAM.org** or email **xzhang@me.berkeley.edu**