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Collaborative Landscape for Academia-Industry Relationship in US

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Pre-requisite for Successful Collaborative Research

- Open research environment with cross/multi disciplinary interactions
- Shared research infrastructure where both academia and industry can easily meet
- Culture which promotes innovative ventures
- High density of skilled/trained technical professionals

Needs for Common Playgrounds for Tightly Coupled Collaboration on Campus

- NNIN as an infrastructure
- Mobility of resources in between
- Incentives for technology productization
- Cross fertilization for cross disciplinary cooperation and interactions

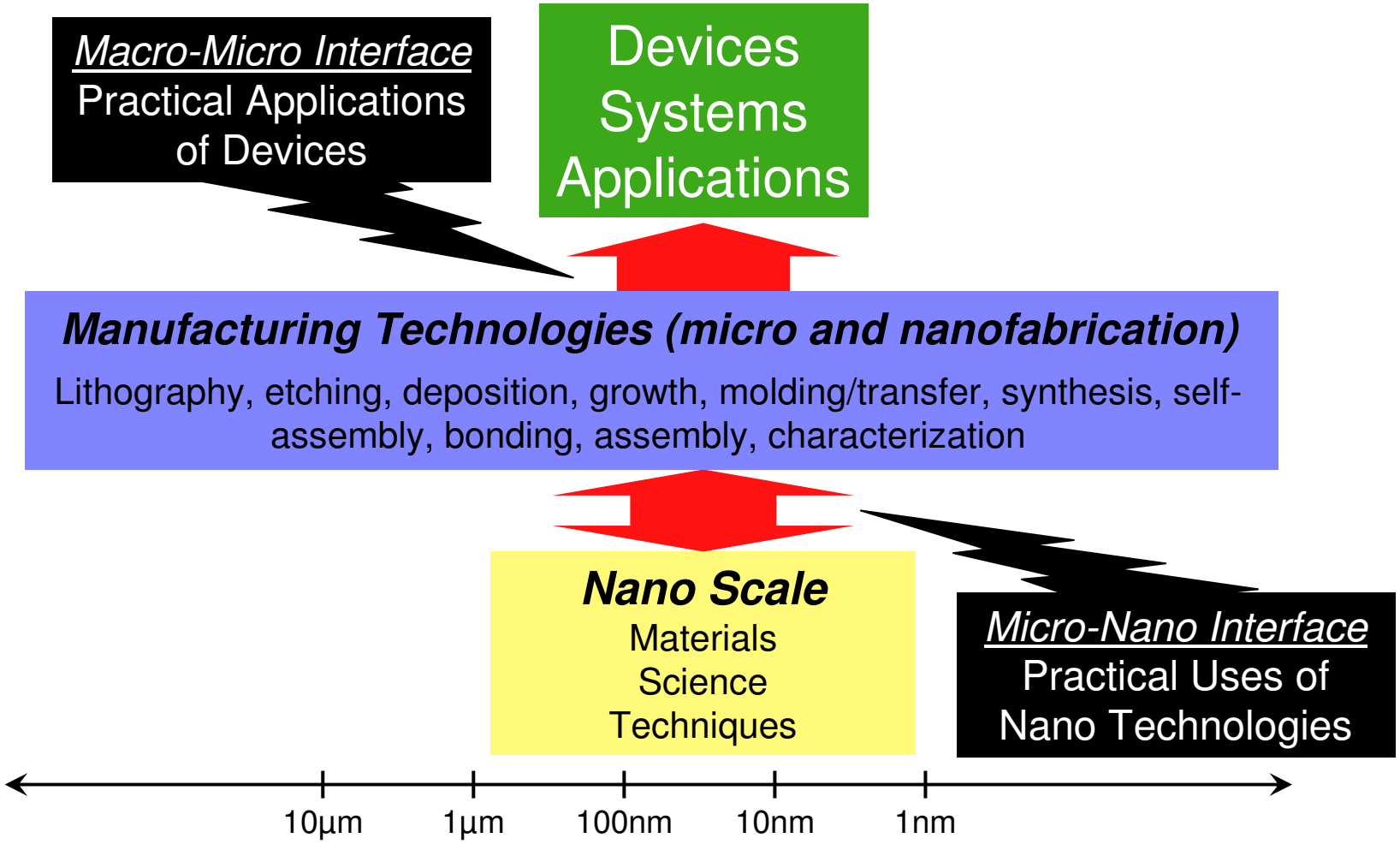
What is NNIN?

- Funded by NSF (35%) and by User Fees (65% Academic and industrial)
- NNIN (National Nanotechnology Infrastructure Network) is a significant (2.5x) expansion of NNUN (National Nanofabrication Users Network) which was established 9 years ago
- NNIN is to increase the network capability and capacity to cover entire regions of US, and also cover broader disciplines not only nanoscale science and technology but also societal implication, human resource development, ethics etc.
- Coverage for micro/nanoelectronics, photonics, MEMS/NEMS, biology, chemistry, physics, material science
- Capability used by academia and industry
- Cornell and Stanford lead the NNIN with both academia and industry participation

Vision and Mission

Enable rapid advancements in science, engineering and technology down to the nano-scale by efficient access to nanotechnology infrastructure

Putting Nano-Technologies to Use



Infrastructures

- Stanford Nanofabrication Facility (SNF): serve as the shared fabrication infrastructure to support nanoelectronics, nano-MEMS, nano-bio, photonics etc, and open to external users, which creates “cross disciplinary” interactions among the SNF users. Funded by NSF through NNIN project
- Stanford Nanocharacterization Laboratory: Shared characterization facility with the state of art tools
- Nanowire/nanotube facility: Shared facility for nanowires and nanotubes research

The Stanford Nanofabrication Facility

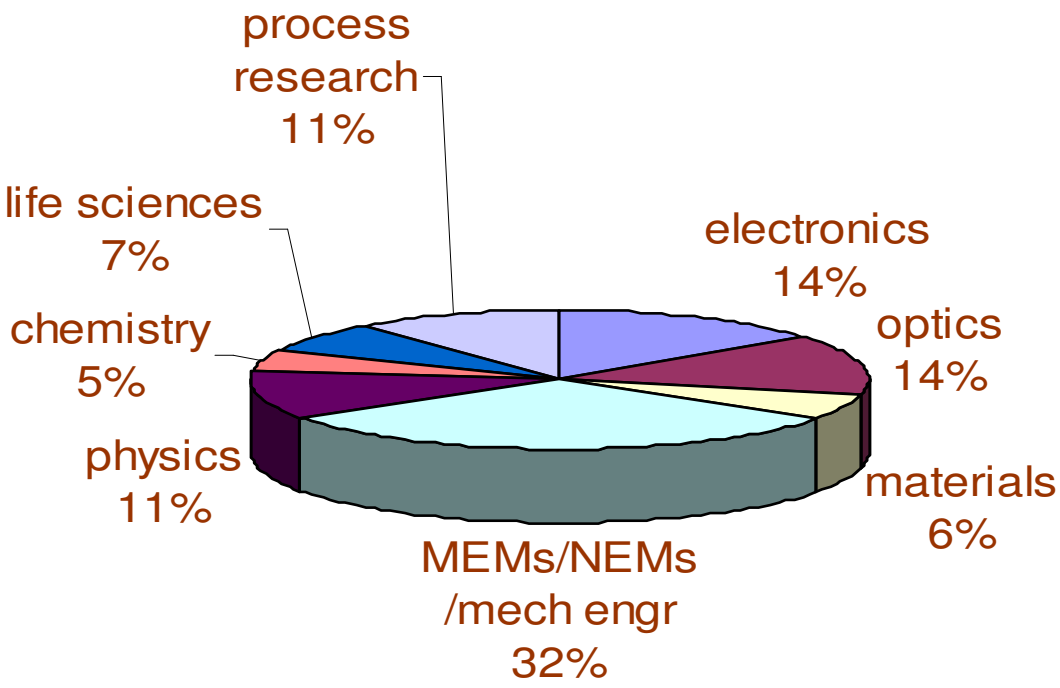
- SNF is part of the infrastructure of Stanford's Center for Integrated Systems, but does not receive direct funding from CIS.
- there is 10.5k ft^2 (1k m^2) of class 100 cleanroom space with separate floors for fan deck and support equipment.
- primarily 4" wafer processing although some 6" equipment is available.
- over 200 active labmembers in any given month. 130 Stanford academic users, 20 non-Stanford academic users, and 50 industrial users.
- industrial users are primarily from small, local startups, but also several large companies (Intel, HP, IBM, Applied Materials, Hitachi, and others).

NNIN

snf

Areas of Research at SNF

Highly productive research environment:170 publications (local users) and 60 publications (external users) per year



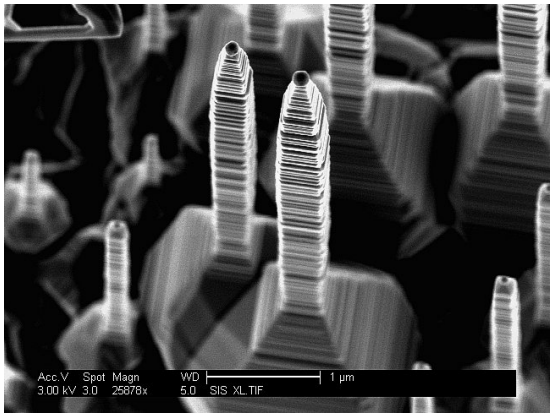
NNIN

snf

Stanford Nanocharacterization Laboratory (SNL)

contacts – Ann Marshall, Richard Chin, Professor Robert Sinclair

- associated with SNF through NNIN grant
- high resolution scanning electron microscopes (SEM)
- focussed ion beam (FIB)
- high resolution transmission electron microscope (TEM)
- high resolution Auger electron spectroscopy (AES)
- x-ray photoelectron spectroscopy (XPS)
- secondary ion mass spectroscopy (SIMS)
- specimen preparation equipment
- x-ray diffraction laboratory



nanowires – Professor Yoshio Nishi and H. Jagannathan, Stanford

SSI S-Probe monochromatized XPS spectrometer

NNIN

Engineering at Stanford

- Approximately 1/4 of all Stanford graduate students
  - Graduates over 200 Ph.D.s/year
  - About 220 professors
    - 65 are members of the National Academy of Engineering
    - 42 Presidential/NSF Young Investigators or CAREER
- Microelectronics and related:
  - A focus of the largest single department in the university: Electrical Engineering (70 PhDs/year)
  - Efforts across multiple depts: Computer Science, MechEng, ChemEng, MatSci&Eng, natural sciences

Knowledge Transfer Patterns

Contract Research

- Focus on research results (specific deliverables)
- Transfer by traditional patterns
  - Reports, research papers
  - Hiring graduates
- Transfer by licensing

Pattern is one-way transfer, mostly at project end

Research Centers

- Focus on industry-relevant research in progress
- Transfer by real-time relationships, e.g.:
  - Industry mentors for Ph.D. students
  - Visiting scientists
  - Strategy discussions

Pattern is real-time, two-way knowledge exchange

"*Research Centers" at Stanford*

- Different focus than contract research
  - Earlier stage, new approaches: often specific deliverables still unknown
  - A partnership: Real-time, two-way knowledge exchange
- Part of the university, but separate from the academic departments
- Typically have interdisciplinary focus
- Serve as interface between (business-driven) industry and (academically-driven) academic departments
  - Departments handle all academic matters
  - Centers provide an important type of funding
    - Relatively unrestricted: enables a professor to try new things, establish new research agendas

Some Research Centers and Other Membership-Based Groups

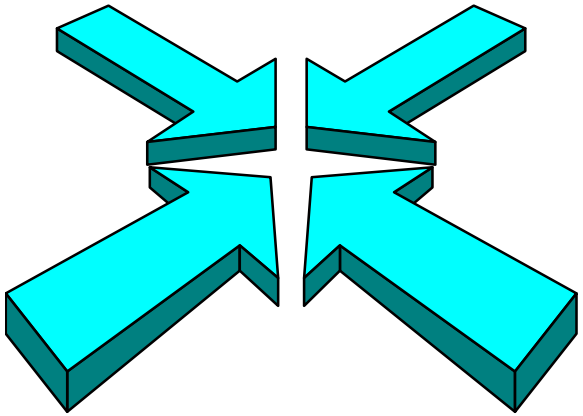
- Center for Integrated Systems (CIS)
- Computer Forum (supports only Computer Science Dept.)
- Stanford Photonics Research Center (SPRC)
- Initiative for Nanoscale Materials & Processes (INMP)
- Nonvolatile Memory Initiative (NMTRI)
- Rethinking Analog Design (RAD)
- Center for Interfacial Engineering for MEMS (CIEMS)

“Integrated Systems”

- In the beginning 1985-1990: integration challenges at all levels of structure (devices, circuits, and systems)
- Evolved to include interactions in design and technology across hardware and software -- 1990s
- Now, even broader: the cross-fertilization of semiconductors, nano- and micro-electronics and other technologies, optoelectronics, computer and network systems, and related fields
  - Especially the integration of new, alternative technologies with more established (roadmap) technologies

Management

- Dean of Engineering: James Plummer
- CIS Director of Research: Yoshio Nishi



- CIS Executive Director: Richard Dasher
- Industry <u>Advisory</u> Committee and Faculty <u>Executive</u> Committee

Fellow-Mentor-Advisor Program (FMA)

- Pioneered by Prof. John Linvill (EE) and Yoshio Nishi (HP) in 1987
- CIS helps match an outstanding Ph.D. student (the “Fellow”) with a partner company expert (the “Mentor”) for research under the guidance of a CIS-affiliated professor (the “Advisor”)
- CIS transfers funds from the partner’s yearly fee to the professor’s research account
- The Mentor becomes an integral part of the Fellow’s doctoral education
- The FMA provides a channel for ongoing, in-depth contact between the partner company and the Advisor’s research group

Custom Research Allocation

- CIS helps match partner company with research area of a professor of particular company interest
- Can be implemented in several ways:
  - As an FMA (Ph.D. student with company Mentor)
  - As a Visiting Scientist (company expert) assigned to be in residence in professor's group for up to one year
    - CIS assists with visa application process, other logistics
  - Other arrangement by case-by-case approval
- Flexible: according to company's specific interests
- CIS transfers funds from partner's yearly fee to professor's research account

CIS Seed Research Pool

- Pool of funds from all Full Partner company member fees, plus unallocated FMA and Custom Research funds from previous year budget
- Allocated by CIS Director of Research based on faculty proposals
- Awarded in small grants (typically $40 - 75K for one year), with possible second year renewal
- Typical uses:
  - Exploratory efforts to start new research area / theme
  - Start-up grants for new incoming professors
  - Areas of obvious interest to more than one CIS partner company

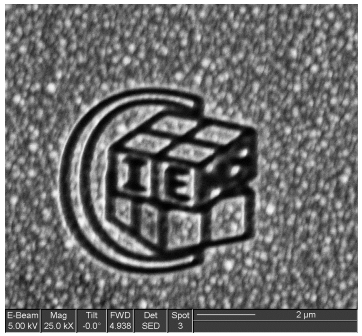
CIS spin-out initiatives

- Initiative for Nanoscale Materials and Processes (from 2003)
  http://inmp.stanford.edu/
- Nonvolatile Memory Technology Research Initiative (from 2005)
- Center for Interfacial Engineering for MEMS (from Sept. 2006)*
- Rethinking Analog Design (from late 2006)

Center for Interfacial Engineering for MEMS

- Academic institution(s)
  - Stanford University, Lead
    - Roger Howe, PI
    - Tom Kenny (on leave at DARPA)
    - Olav Solgaard
    - J Provine, Research Associate
  - University of California, Berkeley
    - Roya Maboudian
    - Carlo Carraro
    - Tsu-Jae King Liu
  - Iowa State University
    - Krishna Rajan
  - [illegible]h [illegible]ubcontract)

- Industry
  - Agilent
  - Boeing
  - Bosch
  - Hewlett-Packard
  - Intel
  - Seiko Epson
  - Qualcomm
  - Institutional match: Stanford



Trends reflected in research interests

- Greater diversity of technology approaches with special emphasis on systems-level as well as novel devices & materials
- Greater diversity of applications: not just computing systems anymore
- University remains a good place for exploratory research:
  - CIS areas of strength: "If this is successful, it will be big. But, we're still not sure this can work / be practical."

CIS vis-à-vis new initiatives

- CIS continues to look broadly across industry interest areas
  - Areas of emphasis evolve with member companies' interests
- CIS has always provided a window to the broader scope of research at Stanford
  - U.S. government grants, other Stanford research centers
  - Initiative topic areas continue to receive CIS funding, especially through custom research allocations

Benefits of Membership - 1

- Collaboration with world-class research, including the "customization" of 60% of the membership fee (a) to an FMA Ph.D. student project and (b) to a second Stanford project of particular interest
- Real-time knowledge exchange with Stanford faculty and gifted PhD students in microelectronics and related areas
- Regular presentations, briefing and information exchange about CIS-related research and other information of interest
  - CIS roundtable meetings, seminars, newsletters, the CIS members-only website, etc.
- The opportunity to send a visiting scientist from the partner company to be in residence at Stanford through CIS

Benefits of Membership - 2

- Participation in the CIS Advisory Committee (AdCom)
  - Executive representatives from all CIS partner companies meet twice/year to discuss CIS strategy and precompetitive issues of concern to all parties
- Periodic visits by Stanford students, faculty and researchers for reports and informal discussions of research in progress
- Assistance by CIS in accessing students for recruiting
- Preferential access to information about commercializable Stanford technologies, preferential licensing privileges in regard to Stanford-owned IP that derives in part or whole from CIS support

Stanford model for academia-industry collaborative research

- Research Centers:
  Multi-disciplinary, inter-departmental research mechanism
- Infrastructures:
  Provide strong shared capability for experimental research which is open to external users, both academia and industry, naturally fostering stimulating environment for novel ideas and inventions
- Low barriers between faculty members and departments which help grow students with broader perspectives
- World class faculty members and students, which works as a magnet to further attract top notch talents, and funding