



Creating an Innovation Ecosystem

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Innovation

- ◉ There are numerous innovative definitions of Innovation
- ◉ There are multiple elements in the Innovation Process
- ◉ For purposes of THIS presentation:
Focus on **NSF-funded research** that has led to direct, **quantifiable economic benefit** (a product, process, practice, service, social change)



Science of Science and Innovation Policy (SciSIP)

- **UC Davis**

How the DOE can accelerate the rate of progress in energy innovation

- **UNC Greensboro**

Assessing the Innovative performance of University Research Parks

- **U Georgia**

Impact of programmatic university resource investments on innovation

- **U Kansas**

Contributions of foreign students to knowledge creation and diffusion

- **Arizona State U**

Innovation as characterized by public values contribution



Innovation Through Translational Research





Translational Research

- Is interdisciplinary by nature
- Involves a team
- Relies on partnerships
- Results in clear benefit to society



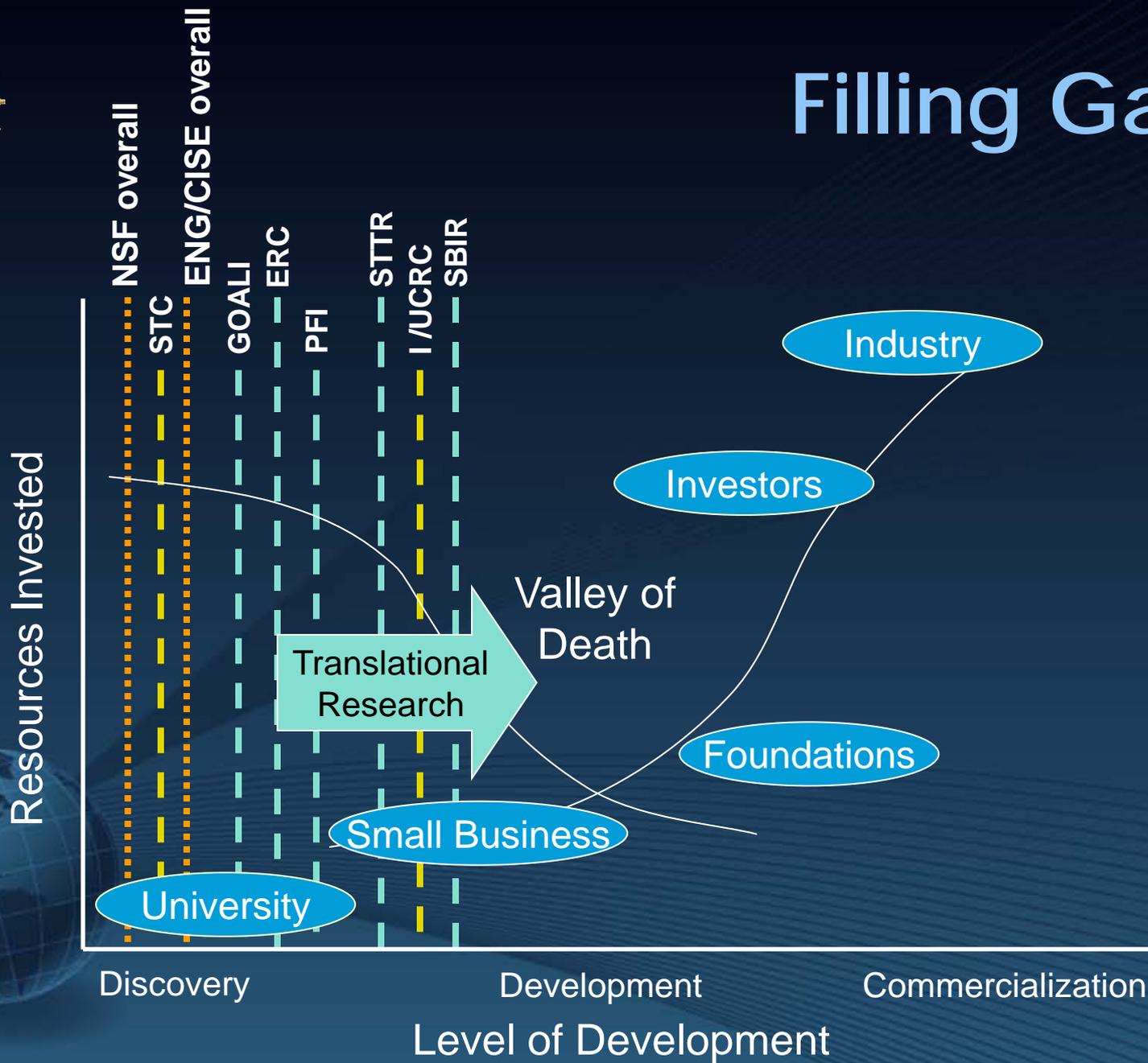


NSF Programs for Translational Research

- Science and Technology Centers (STC)
- Engineering Research Centers (ERC)
- Materials Research Science and Engineering Centers (MRSEC)
- Grant Opportunities for Academic Liaison with Industry (GOALI)
- Industry/University Cooperative Research Centers (I/UCRC)
- Partnerships for Innovation (PFI)
- Small Business Technology Transfer (STTR)
- Small Business Innovation Research (SBIR)
- Nanoscale Science and Engineering Center (NSEC)
- Nanoscale Interdisciplinary Research Teams (NIRT)
- Emerging Frontiers of Research and Innovation (EFRI)
- Other ENG programs



Filling Gaps





Some concrete examples

- ◎ SBIR
- ◎ ERC
- ◎ I/UCRC
- ◎ STC
- ◎ GOALI
- ◎ Single PI Awards
- ◎ CISE



Disclaimer

- NSF doesn't claim SOLE responsibility for these successes, but
- NSF played a clear and definable role in the intellectual evolution of all these innovations.





SBIR Support of Symantec

- ◉ In 1981, Gary Hendrix founds Symantec
- ◉ In 1982, NSF SBIR awards \$30,000 for developing a framework for managing dissimilar data
- ◉ In 1984, Symantec was acquired by C&E Software
- ◉ Now, a leading anti-virus and PC-utilities software company valued at \$12B



symantec. Confidence in a connected world.



SBIR Support of Qualcomm

- ◉ In 1985, Andrew Viterbi and 6 colleagues formed "QUALity COMMunications"
- ◉ In 1987–1988 SBIR provided \$265,000 for single chip implementation of Viterbi decoder
 - › Led to high-speed data transmission via wireless and satellite
- ◉ Now the \$78B company holds more than 10,100 U.S. patents, licensed to more than 165 companies



QUALCOMM®



Other SBIR Success Stories

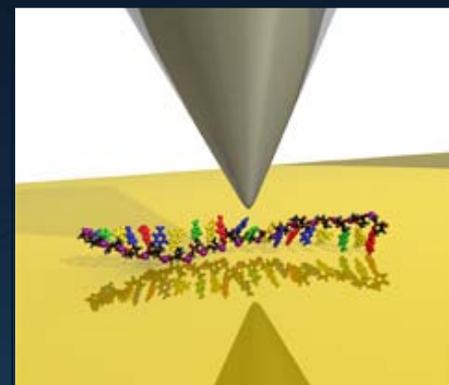


Integrated electric and magnetic field sensor for subsurface mapping in field use.

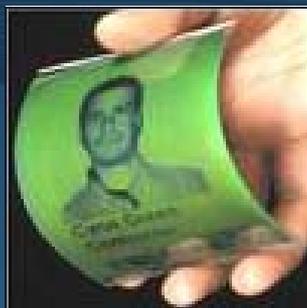
Credit: QUASAR Federal Systems, Inc.



Dr. Henry Liu invented the 100 percent fly ash brick.
Credit: Freight Pipeline Co.



NNIN atomic force microscope for nanoscale characterization and fabrication. *Credit: John Lund and Babak Parviz, Univ. of Washington*



A flexible film photo display optically addressed with a high resolution image.
Credit: Kent Displays Inc. and Kent State Univ.



Engineering Research Centers





Nickel Aluminum Underlayer Enables High-capacity Memory Storage

- Carnegie Mellon University Data Storage Systems ERC 1990–2001
 - > Laptops
 - > MP3 players
 - > Consumer electronics





Engineered Yeast Produce the Anti-Malarial Drug Artemisinin

- Synthetic Biology ERC, Univ. of California, Berkeley, director Jay Keasling
- Artemisinin is 90% effective against the malarial parasite, but it is naturally produced in small quantities and expensive to extract.



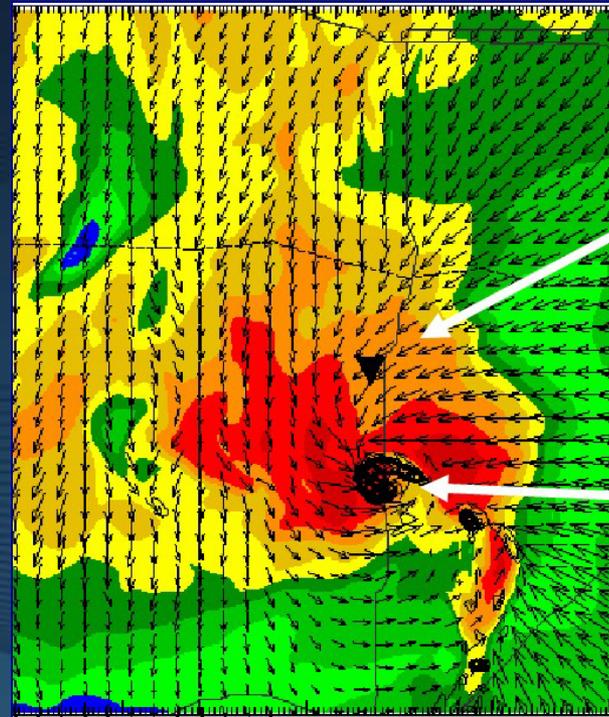
Sanofi-aventis is scaling up the engineered yeast cells, with **drug production expected in 2010.**

The leaves of *Artemisia annua*, the sweet wormwood tree, are the source of artemisinin. *Lawrence Berkeley National Laboratory*



Radar Network Detects Low-Altitude Weather Phenomena

- ERC for Collaborative Adaptive Sensing of the Atmosphere, Univ. of Massachusetts, Amherst
- Improves on Doppler radar and NEXRAD



Actual location of the tornado touchdown

Two hour lead time computer model forecast of low-level rotation, indicative of a tornado





Surgical Assistant Workstations for Tele-operated Surgical Robots

- ERC for Computer Integrated Surgical Systems and Technology
 - › Awarded to Johns Hopkins Univ. in 1998
 - › ERC supplement for translational research in 2006
 - › Industry match
- Partnered with Intuitive Surgical, Inc.
- Goal: augment the capabilities of Intuitive Surgical's da Vinci clinical tool to enable programming more complex, specialized tasks based on ERC research and software



Laparoscopic ultrasound use case.



Medical image viewer use case.
Credit: Johns Hopkins Univ.



Industry/University Cooperative Research Centers





Berkeley Sensor and Actuator Center

- ◉ I/UCRC at University of California, Berkeley and Davis, created many spin-off ventures
- ◉ **Dust Networks:** wireless sensor networks for intelligent buildings
- ◉ **Harmonic Devices:** early stage fabless MEMS, especially piezo MEMS for cellular
- ◉ **Iris AO:** MEMS mirror arrays for adaptive optics
- ◉ **Silicon Clocks:** SiGe MEMS-on-CMOS components for wireless radios
- ◉ **SiTime:** MEMS-based time-base generators and cell phone components
- ◉ **Therafuse:** optical flow sensors for industrial, commercial, and medical applications

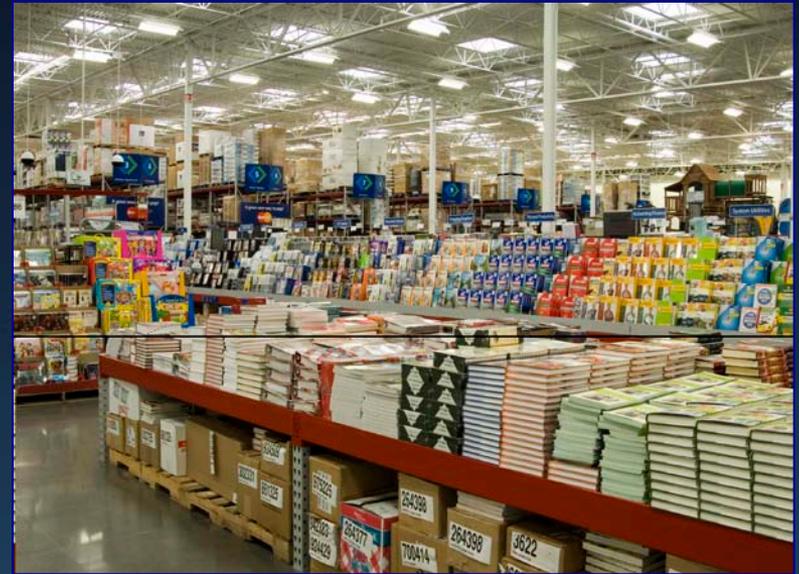
Packaging of MEMS timing components.
Credit: SiTime Corp.





I/UCRC for Engineering Logistics and Distribution (CELDi)

- Collaboration between Univ. of Arkansas and Sam's Club
- Created an Excel-based simulator to replicate the functionality of the Sam's Club inventory and logistics software
- Resulted in more than 4% reduction in inventory costs in categories where applied
- Expected savings of approximately \$10M in annual cost-of-inventory.



Sam's Club

Sam's Club: When complete, cost savings from inventory reductions could be as much as **\$70M annually.**



I/UCRC for Intelligent Maintenance Systems

- Collaboration between Toyota and the Univ. of Cincinnati on a compressor maintenance problem.
- Determined that another degree of motion needed to be studied with regard to the bearing.
- Developed a sensor and controller to eliminate the problem.

Won the Toyota Cost Reduction Prize for **saving each Toyota plant \$80,000 a year.**





Science and Technology Centers





Magnetic Resonance Imaging

- ◎ STC for Magnetic Resonance Technology for Basic Biological Research at UIUC established in 1991
- ◎ PI Paul Lauterbur discovered the possibility of creating a two-dimensional image by producing variations in a magnetic field

Lauterbur was awarded a **Nobel Prize** in 2003 for discoveries leading to magnetic resonance imaging.





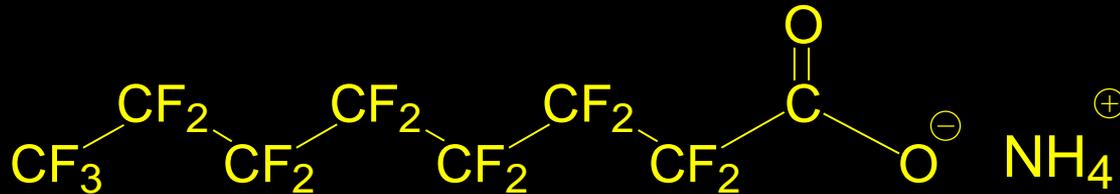
Environmentally Responsible Solvents and Processes

© STC At UNC- Chapel Hill



DuPont's Fayetteville Works Teflon-in-CO₂ Manufacturing Plant

“DuPont Introduces Fluoropolymers Made with Supercritical CO₂ Technology”
March 22, 2002 (www.dupont.com)



“C-8” / PFOA

- Needed for the manufacture of fluoropolymers in water
- Persistent organic pollutant

Fluoropolymer manufactured without:

- Water
- CFCs
- PFOA

Resulting in a cleaner process

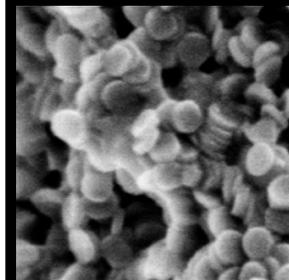
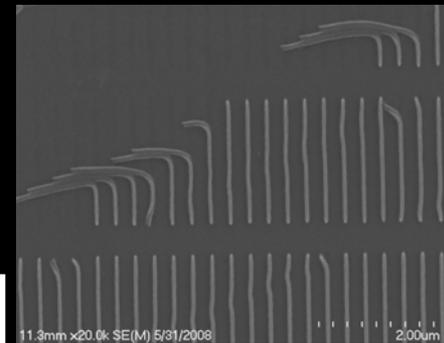
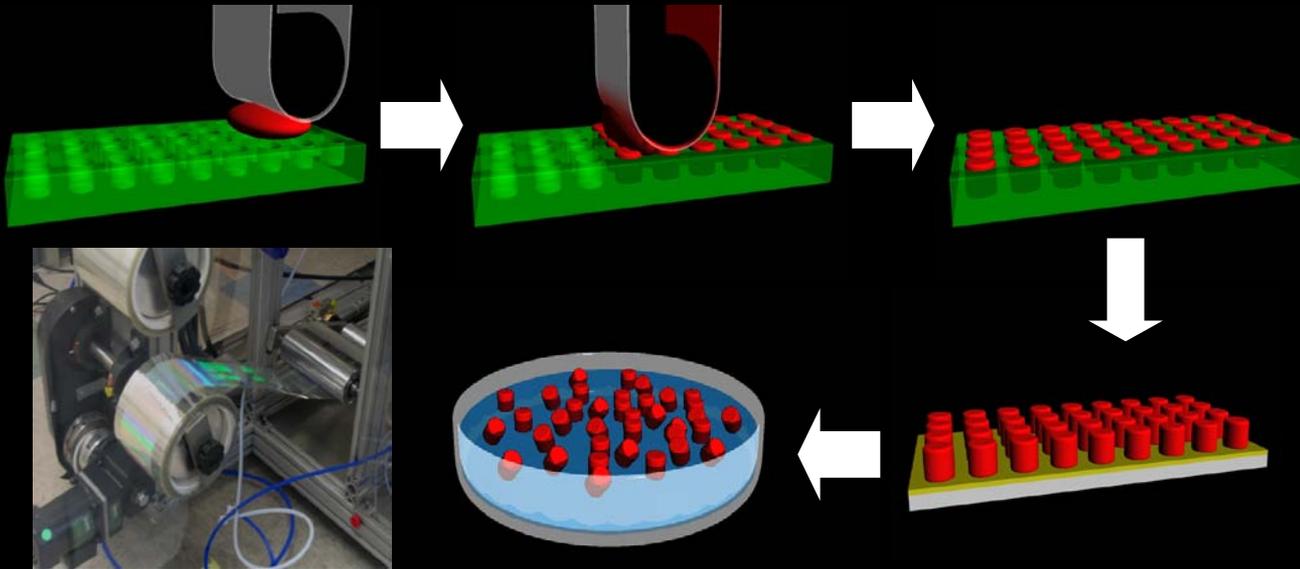


Science

“Synthesis of Fluoropolymers in Supercritical Carbon Dioxide” DeSimone et. al.
Science 1992, 257, 945-947

PRINT® (Particle Replication in Non-wetting Templates) Platform

PRINT affords a systems engineering approach important for customizing therapeutics and vaccines



Semiconductor Clean Room



Impact on North Carolina

- Projected \$275 million Investment by DuPont
 - \$40 million investment in phase I complete
 - Generates >1 million pounds of Teflon/year
 - Royalty stream to university
 - Outstanding DuPont customer feedback!
- Estimated creation of 500 construction jobs
- Estimated creation of 100 permanent technical jobs
- \$55 million tax credit from State for DuPont
- DuPont continuation of expansion underway

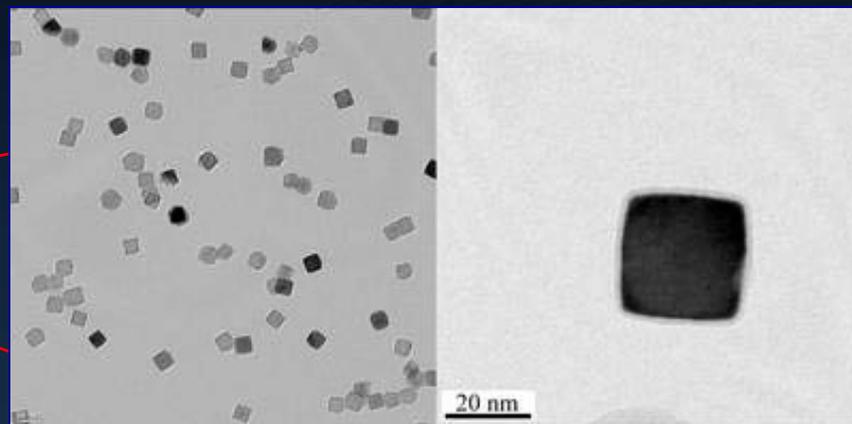
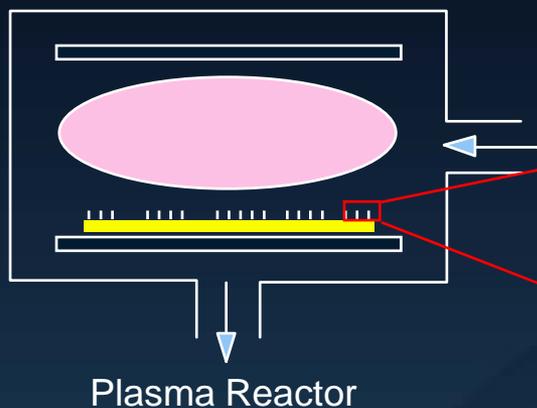


Grant Opportunities for Academic Liaison with Industry GOALI





GOAL: Nanocrystal Formation and Morphology in Nonthermal Plasmas



- Uwe Kortshagen (Unvi. of Minnesota-Twin Cities) and Michael Zachariah (Univ. of Maryland College Park) have demonstrated the ability of plasmas to produce crystalline nanoparticles with specific geometries and beneficial properties.
- Innovalight, Inc., licensed the approach to synthesize silicon nanocrystals for the use in low-cost, efficient solar cells based on silicon nanoparticle films.



Individual Awards





Membranes for Purification of Gases and Water

- Benny Freeman, UT Austin
- NSF (0515425) partially supported research used for the Polaris™ line of membranes, now sold by Membrane Technology and Research, Inc.
- Results from an NSF Graduate Fellowship and a CBET grant (0554109, 0637040) were the basis for Advanced Hydro, Inc., a start-up focusing on water purification membranes with improved fouling resistance.



Polaris™ membranes remove CO₂ from Syngas.
Credit: MTR



Nanopatterning and Detection Technologies

- Chad Mirkin, Northwestern Univ.
- NSEC for Integrated Nanopatterning and Detection Technologies (0647560)
- Mirkin holds more than 350 patents
- NanoInk (founded in 2001) offers Dip Pen Nanolithography (DPN) tools for fabricating MEMS and other nanoscale devices.
- Nanosphere (founded in 2000) offers nanotechnology-based molecular diagnostic testing.



Dip Pen Nanolithography for nanofabrication. *Credit: NanoInk*

Nanosphere is now valued at **\$164.5M.**



Computer and Information Science and Engineering



Four Stories of Innovation from the Computing Community

- 1980s: The Internet
 - DARPA → CSNET → NSFNet → The Internet
- 1993: The Browser
- 1998: Google
- 2008: Vanishing Data

The Browser



Mosaic (NCSA)
1993



Netscape
1994



Microsoft
Internet Explorer
1995 and counting



Mozilla Firefox
2003



Apple Safari
2003



Google Chrome
2008

Journal Publications

Please see <http://www-diglib.stanford.edu> for a list of publications. "Please see <http://www-diglib.stanford.edu> for a list of publications.",
Please see <http://www-diglib.stanford.edu> for a list of publications.

The Google search engine was developed as part of the project.
It is now a company (www.google.com)

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Bibliog

URL(s):

<http://www-diglib.stanford.edu>

Description:

Other Specific Products

Product Type:

Data or databases

Product Description:

The Google search engine was developed as part of the project.
It is now a company (www.google.com)

Sharing Information:

The engine is publicly available



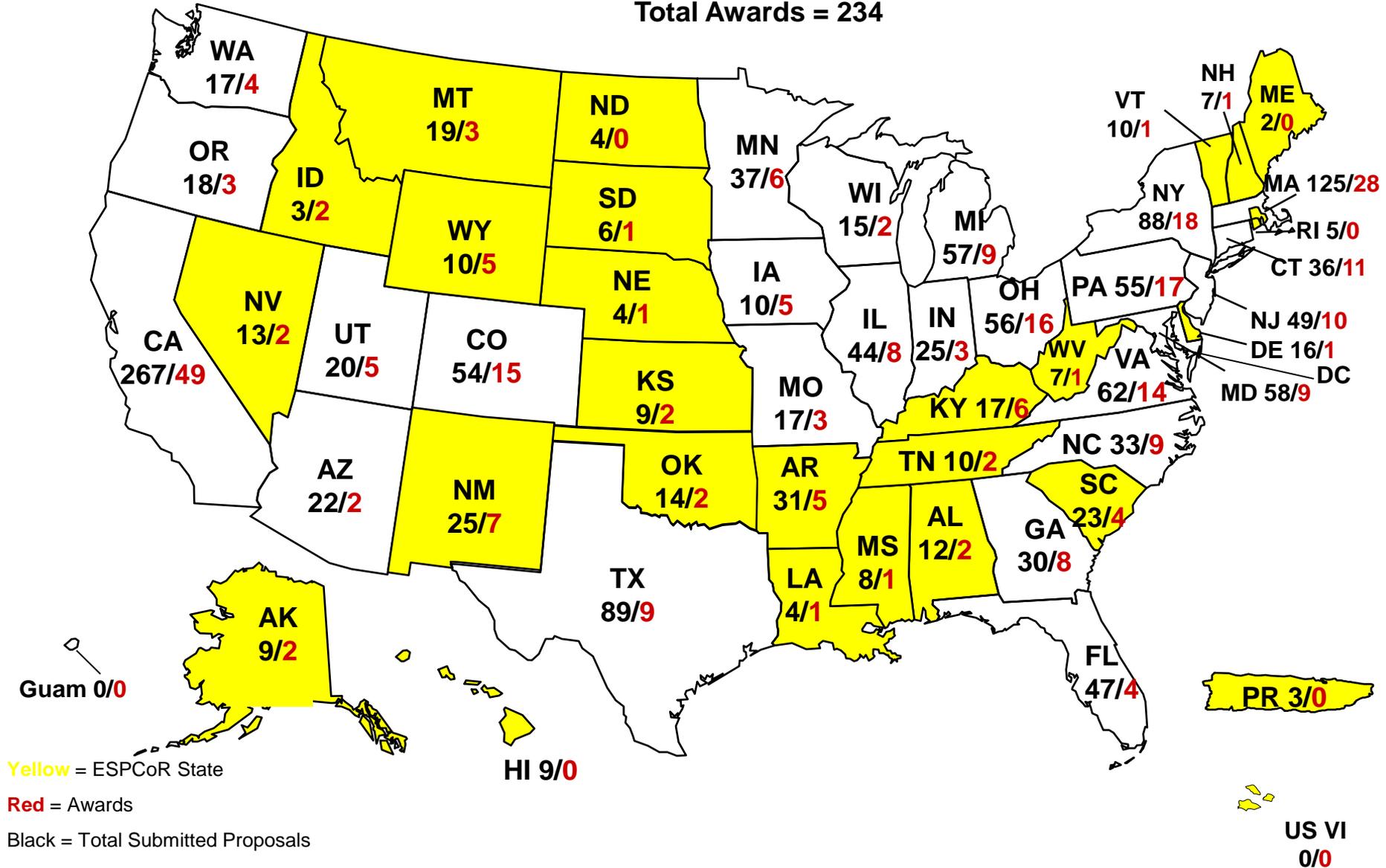
NSF Centers as a Hub for Regional Innovation Clusters



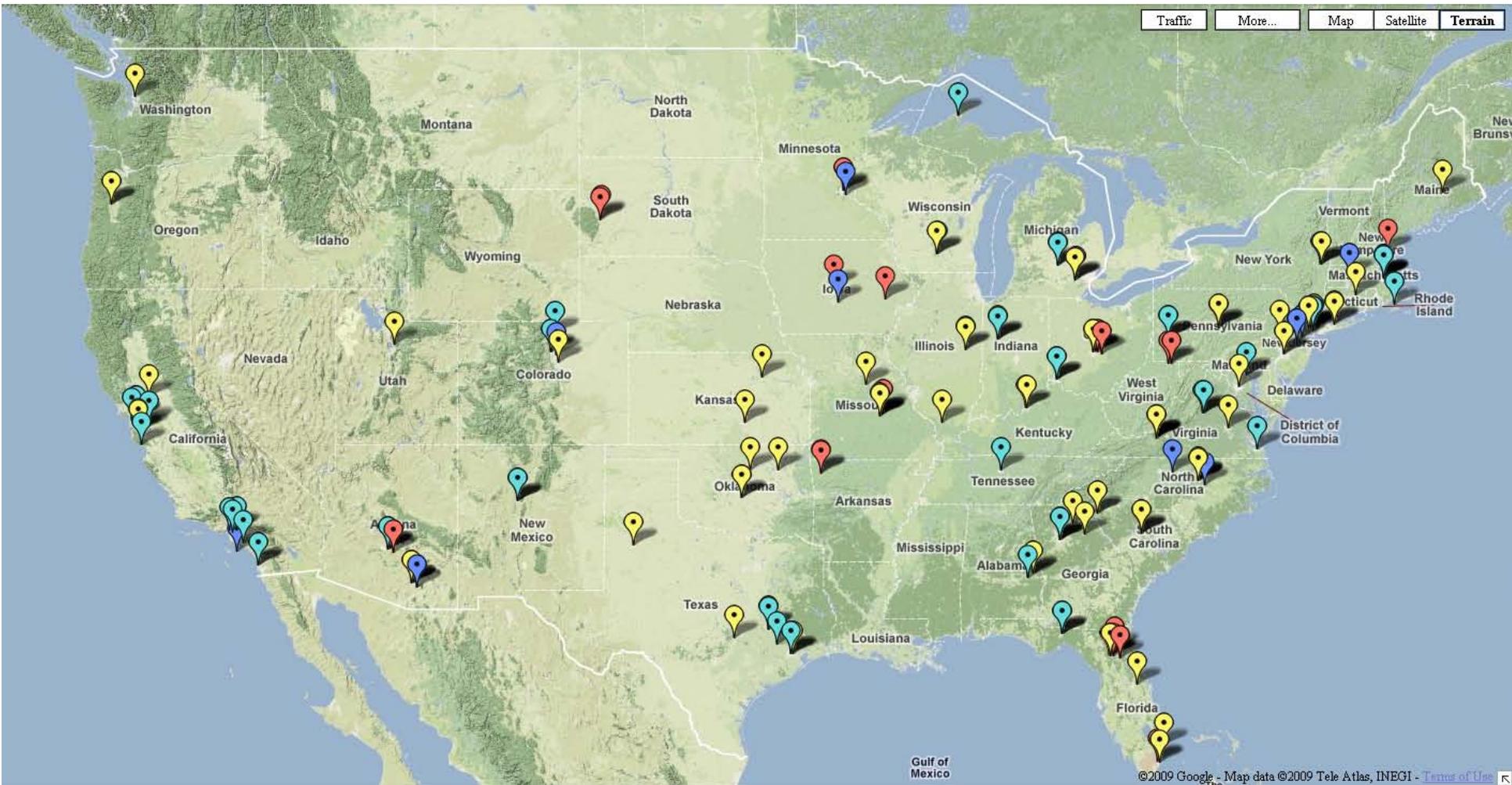
2008 Phase I SBIR Proposals

Total Submitted = 1285

Total Awards = 234



Current ERC and I/UCRC Sites



- ERC Lead
- I/UCRC Lead
- ERC Partner
- I/UCRC Partner

Engineering Research Centers and Industry/University Cooperative Research Centers Platform for Innovation and Regional Economic Development

Advanced Electronics Sector

- Center for Advanced Vehicle Electronics (CAVE)
Auburn University
- Center for Telecommunications -Connection One: Communication Circuits & Systems Research
Arizona State University, University of Arizona, Rensselaer Polytech, University of Hawaii, Ohio State University
- Center for Electromagnetic Compatibility (CEMC)
University of Missouri - Rolla, University of Houston, Clemson University.
- Cooling Technologies Research Center (CTRC)
Purdue University
- ERC for Extreme Ultraviolet Science & Technology
Colorado State University, Fort Collins, CO (lead institution) in partnership with the University of Colorado at Boulder and the University of California at Berkeley

Engineering Research Centers and Industry/University Cooperative Research Centers Platform for Innovation and Regional Economic Development

Advanced Manufacturing and Fabrication Sector

- Center for Structured Organic Particulate Systems (C-SOPS)
Rutgers University, New Brunswick, NJ (lead institution) in partnership with Purdue University, New Jersey Institute of Technology, and the University of Puerto Rico at Mayaguez
- Center for Intelligent Maintenance Systems (IMS)
University of Cincinnati, University of Michigan at Ann Arbor, Missouri University of Science & Technology
- Center for Lasers and Plasmas for Advanced Manufacturing (LAM)
University of Virginia, University of Michigan, Southern Methodist University, University of Illinois
- Center for Precision Forming (CPF)
Ohio State University, Virginia Commonwealth University
- Smart Vehicle Concepts Center (SVC)
Ohio State University, Texas A&M University
- Center for Particulate and Surfactant Systems (CPaSS)
University of Florida, Columbia University
- ERC for Compact and Efficient Fluid Power
University of Minnesota, Minneapolis, MN (lead institution) in partnership with Georgia Institute of Technology, Purdue University, the University of Illinois at Urbana-Champaign, and Vanderbilt University
- Berkeley Sensor & Actuator Center (BSAC)
University of California at Berkeley, University of California at Davis
- Center for Friction Stir Processing (CFSP)
South Dakota School of Mines and Technology, University of South Carolina, Brigham Young University, Missouri University of Science and Technology, Wichita State University
- Membrane Applied Science and Technology Center (MAST)
University of Colorado at Boulder

Engineering Research Centers and Industry/University Cooperative Research Centers Platform for Innovation and Regional Economic Development

Advanced Materials Sector

- Center for Dielectric Studies (CDS)
Pennsylvania State University
- Ceramic and Composite Materials Center (CCMC)
Rutgers University, University of New Mexico, The
Pennsylvania State University
- Wood-Based Composites - WBC
Virginia Tech, Oregon State University

Engineering Research Centers and Industry/University Cooperative Research Centers Platform for Innovation and Regional Economic Development

Biotechnology, Healthcare, and Service Sector

- ERC for Revolutionizing Metallic Biomaterials
North Carolina A&T State University (HBCU) in partnership with the University of Cincinnati, the University of Pittsburgh
Center for Advanced Polymer and Composite Engineering (CAPCE)
Ohio State University, Florida State University, University of Wisconsin
- Synthetic Biology ERC (SynBERC)
University of California at Berkeley, CA (lead institution) in partnership with Harvard University, the Massachusetts Institute of Technology, Prairie View A&M University, and the University of California at San Francisco
- Quality of Life Technology ERC (QoLT-ERC)
Carnegie Mellon University, Pittsburgh, PA (lead institution) in partnership with the University of Pittsburgh
- ERC for Biomimetic MicroElectronic Systems
University of Southern California - Keck School of Medicine and Viterbi School of Engineering, Los Angeles, CA, in partnership with California Institute of Technology and the University of California, Santa Cruz
- Biomolecular Interaction Technologies Center (BITC)
University of New Hampshire, University of Louisville
- Center for Advanced Forestry Systems (CAFS)
North Carolina State University, Oregon State University, Purdue University, University of Florida, University of Georgia, University of Maine, University of Washington, Virginia Tech
- Center for Bioenergy Research and Development (CBeRD)
South Dakota School of Mines, Kansas State University, Kansas University, University of Hawaii, North Carolina State University, State University of New York - Stony Brook
- Center for Safety, Search, & Rescue Robots (SSR-RC)
University of Minnesota, University of Pennsylvania, University of Denver
- Minimally Invasive Medical Technologies Center (MIMTeC)
University of Minnesota, University of Cincinnati
- Center for Child Injury Prevention Studies (CChIPS)
Children's Hospital of Philadelphia

Engineering Research Centers and Industry/University Cooperative Research Centers Platform for Innovation and Regional Economic Development

Energy, Sustainability, and Infrastructure Sector

- ERC for Collaborative Adaptive Sensing of the Atmosphere
University of Massachusetts, Amherst, MA (lead institution) in partnership with Colorado State University, University of Oklahoma, and University of Puerto Rico at Mayaguez
- Arizona Water Quality Center (WQC)
University of Arizona at Tucson, Arizona State University at Tempe
- Center for Fuel Cells (CFC)
University of South Carolina, University of Connecticut
- Center for Grid-Connected Advanced Power Electronic Systems (GRAPES)
University of Arkansas, University of South Carolina
- Center for Integrative Materials Joining Science for Energy Applications
Ohio State University, Colorado School of Mines, University of Wisconsin, Lehigh University.
- Center for Multiphase Transport Phenomena
Michigan State University, The University of Tulsa
- Queen's University Environmental Science and Technology Research Centre (QUESTOR)
The Queen's University of Belfast, Northern Ireland
- Silicon Solar Consortium (SiSoC) Research Center
North Carolina State University, Georgia Tech
- Center for Repair of Buildings and Bridges with Composites (RB2C)
University of Missouri at Rolla, North Carolina State University

Engineering Research Centers and Industry/University Cooperative Research Centers Platform for Innovation and Regional Economic Development

Information, Communication, and Computing Sector

- Advanced Space Technologies Research and Engineering Center (ASTREC)
University of Florida and North Carolina State University
- Center for Autonomic Computing (CAC)
University of Florida, University of Arizona, Rutgers University
- Center for Identification Technology Research (CITeR)
West Virginia University, University of Arizona
- Center for Information Protection (CIP)
Iowa State University, State Univ. of New York at Stony Brook
- Center for Advanced Knowledge Enablement
Florida International University, Florida Atlantic University
- Center for Experimental Research in Computer Systems (CERCS)
Georgia Institute of Technology, Ohio State University
- Center for Hybrid Multicore Productivity Research (CHMPR)
University of Maryland - Baltimore County, Georgia Tech, University of California - San Diego
- High-Performance Reconfigurable Computing (CHREC)
University of Florida, The George Washington University, Virginia Tech University, Brigham Young University
- Wireless Internet Center for Advanced Technology (WICAT)
Polytechnic University, University of Virginia, Auburn University, Virginia Polytechnic Institute and State University.
- ERC for Integrated Access Networks
University of Arizona in partnership with the California Institute of Technology, Norfolk State University (HBCU), Stanford University, Tuskegee University (HBCU), the Universities of California, in Berkeley, San Diego, and Los Angeles, and the University of Southern California



Characteristics of the Innovation Ecosystem

- University research is key, often driven by industrial needs.
- Faculty are involved along the innovation continuum, working with industry at all stages.
- A focus on translational research smoothes the handoff of technology from universities to industry—resulting in rapid, efficient innovation.



NSF Resources for the Innovation Ecosystem

- ◉ Grow the existing portfolio and strengthen the translational phase
- ◉ Extend the reach of industry-driven research initiatives
- ◉ Educate to innovate
- ◉ Better understand the social dimensions of innovation (SciSIP)





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Industry-Inspired Fundamental Research (IFR)

- ◉ Awarded by Industrial Innovations and Partnerships (IIP) Division
- ◉ Awarded to Industrial Research Institute
- ◉ Establish Research Advisory Committee from Industry.
- ◉ Identify Research areas that could have a transformative economic impact on an industry or sector.



NSF Resources for the Innovation Ecosystem

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- ◉ Extend the reach of industry-driven research initiatives
- ◉ **Educate to innovate**
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Industry Postdoctoral Fellows

- ◉ Awarded by Engineering Education and Centers (EEC) Division
- ◉ Awarded to The American Society for Engineering Education (ASEE) as a part of the Innovation Fellows initiative
- ◉ 40 postdoctoral fellows with innovation-focused industry members
- ◉ Industry matched funds