ADVANCED TECHNOLOGY PROGRAM

Competing for the Future:
A Historical Review of NIST ATP Investments in Semiconductor and Micro/Nano-Electronics

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Competing for the Future: A Historical Review of NIST ATP Investments in Semiconductor and Micro/Nano-Electronics

The **semiconductor** and **micro/nano-electronics** industry plays a vital role in the continued growth of the US economy and national security. Since 1991, the Advanced Technology Program (ATP) of the National Institute of Standards and Technology (NIST), Technology Administration, U.S. Department of Commerce, has funded path-breaking new technologies of importance to this industry and the infrastructure upon which it depends. This report provides a historical review of ATP's investments in technologies of importance to this industry.

Characteristics of the Semiconductor and Micro/Nano-Electronics Industry

Semiconductor devices and their components are the basic building blocks for a wide range of consumer and industrial electronics end equipment, such as cell phones, computers, avionics or controls. In 2008, the global sales of semiconductor devices and components are projected to be $309 billion.[1] When incorporated into electronics end-equipment, semiconductor building blocks support a number of end-use markets, such as communications, consumer electronics, transportation, or healthcare, as examples. In 2008, the global value of the electronics end-equipment market, that is built upon semiconductor devices and components, is projected to be approximately $1.7 trillion.[1]

Microelectronics typically encompasses products based on silicon and silicon compounds. Silicon-based integrated circuits (ICs) have feature sizes in the micrometer and nanometer[2] range. Advancement in the semiconductor industry involves a progressive reduction in dimensions of ICs and packaged chips. As the key dimensions of ICs fell below the 100 nanometer range, microelectronics became nano-electronics. In 2000, the semiconductor industry entered the nano-electronics era with the introduction of sub-100 nanometer ICs.

The semiconductor industry can be divided into two categories: front-end and back-end. The front-end industry is commonly referred to as the chip industry. Front-end manufacturing refers to the fabrication of semiconductor ICs on chips, which are then assembled and packaged in the back-end manufacturing processes. It is the packaged semiconductor chips of the micro/nano-electronics industry that find their way into products such as PCs, cell phones, appliances, TVs, medical devices, and automobiles.

According to the 2006 annual report of the Semiconductor Industry Association (SIA), "the U.S. chip industry pumps billions of dollars into the national economy, supports related industries across the country, provides more than $100 million annually to support research by U.S. universities, invests $15 billion in R&D for commercialization of products, employs 226,000 persons in the United States, and contributes significantly to U.S. exports." [3] The SIA also reports:

> *"The revenues of U.S.-based chip companies account for nearly half of global semiconductor sales and more than three-quarters of U.S.-owned chip manufacturing capacity is located in the United States. The U.S. chip industry enables related industries across the country, such as telecommunications, software, and consumer electronics. The technology industry is the largest merchandise exporter, representing*

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[1] SEMI presentation by Lara Chamness, February 22, 2006, '2005: A year in review for the semiconductor equipment and materials market and trends moving forward' http://content.semi.org/cms/groups/public/documents/newsresources/p037643.pdf.

[2] A nanometer is one-billionth of a meter (10^{-9} m). The width of an average human hair is approximately 100,000 times larger than one nanometer.

[3] Semiconductor Industry Association 2006 annual report http://www.sia-online.org.

> *23 percent of total exports. Semiconductors are the number one U.S. high tech export, nearly 75 percent of U.S. chip industry revenue is the result of export sales."*[4]

As important as the chip industry is within the U.S., recent trends show striking changes in the U.S. profile. Whereas in 1999 the U.S. market share of leading-edge chip production capacity was approximately 36 percent of global output, in 2005 the U.S. share has dropped to about 14 percent. In contrast, semiconductor manufacturing in Asia has grown appreciably during this period.

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[4] Semiconductor Industry Association, Choose to Compete: Semiconductors and America's innovation leadership
http://www.choosetocompete.org/us_chip_industry.html .

Scope of This Report

This report provides a historical summary of co-funded awards made by the NIST ATP in technologies of importance to semiconductor and micro/nano-electronics. The ATP awards within the scope of this report include those endeavors that directly involve innovations in semiconductor and micro/nano-electronics technologies that contribute to the manufacturing of future generations of IC products based upon silicon and silicon compounds. Awards in both front-end and back-end electronics manufacturing technologies are included.

R&D projects leading to products based on III-V and II-VI compound semiconductors are not included in this report. They are addressed in a separate ATP report entitled "*Competing for the Future: A Historical Review of NIST ATP Investments in Photonics and Optical Technologies*".[5] ATP awards involving micro-electro-mechanical systems (MEMS) R&D are also excluded.

The report includes tables showing ATP award distribution among states (*Appendix A*), university participation in ATP awards (*Appendix B*), and ATP award distribution in nine technology categories (*Appendix C*).

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[5] Competing for the Future: A Historical Review of NIST ATP Investments in Photonics and Optical Technologies http://www.atp.nist.gov/iteo/elec_photon.htm.

NIST & ATP Goals

For more than a century, NIST has helped to lay the foundation for the innovation, economic growth, and quality of life that Americans have come to expect. NIST technology, measurements, and standards help U.S. industry invent and manufacture superior products reliably, provide critical services, ensure a fair marketplace for consumers and businesses, and promote acceptance of U.S. products in foreign markets.

The ATP, one of the three external programs within NIST, has the mission of helping U.S. companies bridge the gap between the research lab and the market place by encouraging them to pursue the development of high-risk, enabling technologies that otherwise would not be developed or that would be developed too slowly to take advantage of market opportunities. Through partnerships with the private sector, ATP's early stage investments accelerate the development of innovative technologies, deemed too technically risky or too far from commercial viability to be considered by private sector funding sources. ATP-funded projects promise significant commercial payoffs and widespread economic benefits for the nation in the longer term.

Through a competitive, peer review process, ATP issues awards based on two rigorous technical and economic criteria:

- Scientific and technological merit - innovation, high technical risk and feasibility; and quality of R&D plan; and
- Potential for broad-based economic benefit—national economic benefits; need for ATP funding; and pathway to economic benefits.

In the 44 competitions that have been held by ATP between 1990 and 2004, and the nearly 7,000 proposals received, 768 awards in all technologies have been selected for ATP funding. These awards have involved 1,511 participants, an equal number of subcontractors, more than 170 university and 30 national laboratory participants. This amounts to 218 joint ventures and 550 single company awards and $4,371 million of funded high-risk R&D—of which the ATP share is $2,269 million and the industry share is $2,102 million. **Over 66% of all ATP awards have been made to projects led by small businesses.**

NIST ATP Awards in Semiconductor and Micro/Nano-Electronics Technologies

Broadly speaking, ATP's funding in semiconductor and micro/nano-electronics helps the semiconductor and electronics industry, and the materials and equipment infrastructure upon which they depend, develop innovative, enabling, and path-breaking technologies for future generations of products and for strengthening the manufacturing infrastructure within U.S.

Since 1991, ATP has funded **63 awards** across 20 states in semiconductor and micro/nano-electronics technologies. These awards represent **approximately $454 million of total industry-based R&D**, of which approximately $224 million has come from ATP and approximately $230 million of cost share from industry. The proposals ATP receives, and the projects that are funded, are the ideas and objectives of industry. They are a reflection of what high-risk R&D is needed for continued economic competitiveness, but for which a market failure exists in the ideas being funded due to the magnitude of the technical risk.

Table 1 summarizes ATP's funding of projects for semiconductor and micro/ nano-electronics technologies. Table 1 also shows the distribution of ATP awards among small, medium, and large companies. A small-size company has less than 500 employees and a large-size company is a Fortune 500 company. A medium-size company falls between these two limits.

It is interesting to note that 22 of the 63 awards funded are joint-ventures (JVs) that involve two or more U.S. companies. A total of 215 entities have participated in these 63 ATP awards, indicating on average over three entities participate in any one award. *Appendix A* shows all companies, universities, or other entities that are current participants in ATP awards in semiconductor and micro/nano-electronics technologies.

Historically it is found that universities, as joint venture partners or subcontractors, have participated in a number of ATP awards in semiconductor and micro/nano-electronics technologies. A total of 32 instances of university participation, or approximately one for every two awards, in ATP awards in semiconductor and micro/nano-electronics technologies is observed. This larger than average level of participation, relative to all ATP awards, is a reflection of the essential role universities play in developing innovations for the semiconductor and micro/nano-electronics industry. *Appendix B* shows all universities that are current participants in ATP awards in semiconductor and micro/nano-electronics technologies.

Table 1
NIST ATP Semiconductor and Micro/Nano-Electronics Awards and Funding

Total R&D Funded	**$454.9 million**		**Total Participants**	**215 Entities**
ATP	$224.7 million		Small Companies	75
Industry Cost-Share	$230.2 million		Medium Companies	37
			Large Companies	59
Total Awards	**63 projects**		Not for Profit Organization	6
Single Applicant	41 projects		Universities	32
Joint Venture	22 projects		Federal Laboratories	6

Table 2 below indicates the funding distribution among states, based on the location of the lead company for the award. The funding distribution shown does not reflect the actual funds that each state has received as projects distribute funds to several subordinate JV partners and subcontractors that may be located in other states.

Table 2
Semiconductor and Micro/Nano-Electronics Awards and Funding Among States

State	AWARDS			FUNDING*	
	Total	Joint Venture	Single Company	ATP Share $M	Company Share $M
CALIFORNIA	18	6	12	$73.38	$83.31
COLORADO	1	0	1	$1.99	$1.00
CONNECTICUT	1	0	1	$1.71	$2.06
FLORIDA	2	0	2	$3.86	$1.24
ILLINOIS	2	2	0	$11.87	$12.48
KANSAS	1	0	1	$2.00	$0.31
MARYLAND	1	0	1	$1.97	$1.41
MASSACHUSETTS	5	1	4	$9.93	$7.63
MICHIGAN	5	4	1	$38.70	$40.59
MINNESOTA	4	0	4	$6.25	$5.58
MISSISSIPPI	1	0	1	$1.78	$0.76
MISSOURI	1	0	1	$2.00	$1.50
NEW JERSEY	3	2	1	$10.59	$12.19
NEW MEXICO	1	0	1	$1.83	$.090
NEW YORK	5	2	3	$8.81	$9.04
NORTH CAROLINA	1	0	1	$1.96	$0.43
OREGON	2	0	2	$3.58	$4.10
PENNSYLVANIA	1	1	0	$2.94	$3.59
TEXAS	7	4	3	$37.60	$40.60
VIRGINIA	1	0	1	$1.99	$1.51

Funding amounts are a reflection of the state of residence of each award lead company. This table does not indicate the final distribution of funds to states based on the state of residences of JV partners, sub-contractors, universities, or consultants.

Electronics Manufacturing

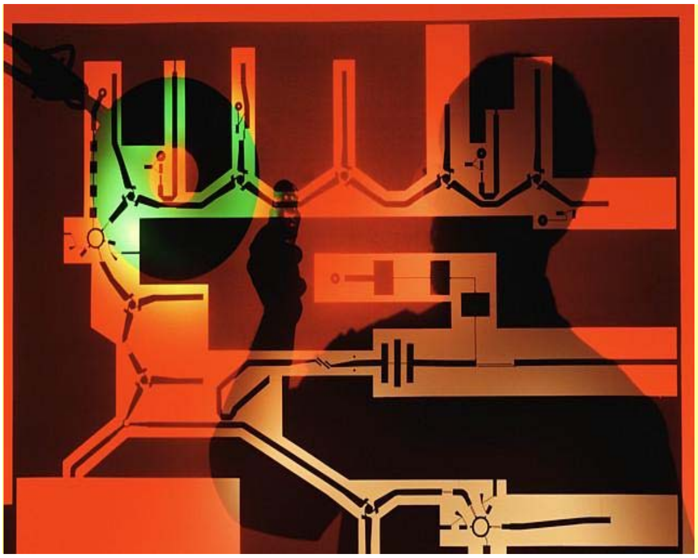
Innovation lies at the heart of U.S. manufacturing leadership and success. Manufacturing advances create more efficient processes and higher quality products to meet consumer demands and customer service expectations. Electronics manufacturers strive to make improvements in manufacturing technologies to reduce cost and lead times. According to the National Association of Manufacturers (NAM):

> *"Manufacturing is the engine that drives American prosperity. It is central to our economic security and national security. Manufacturing: grows the economy, invents the future, competes internationally, generates productivity increases, provides more rewarding employment, and pays taxes."*[6]

ATP has co-funded **23 awards** and stimulated approximately **$184 million of total industry-based R&D** with direct impact in semiconductor and electronics manufacturing. Of this approximately $92 million has come from ATP cost-shares each.

In 1998, ATP conducted a focused program competition on 'Microelectronics Manufacturing Infrastructure'.**[7]** The aim of this program was to help industry develop and improve technologies for microelectronics manufacturing integration, across suppliers and users, from chip to package to board. The objective was to enable world-class competitive electronic product manufacturing through product-driven industrial integration. Thus, the program intended to build manufacturing strengths within U.S. infrastructure companies, improve their capabilities, and improve the competitiveness of themselves, their customers, and the U.S. electronics industry as a whole.

Examples of ATP awards that illustrate innovations in electronics manufacturing include:



Intelligent Control of the Semiconductor Patterning Process

Develop sensors, algorithms, and other components for an intelligent manufacturing control system that will improve the uniformity of the semiconductor wafer patterning process, as a means of restoring rapid reductions in the cost per function of integrated circuits.

Participants: KLA-Tencor Corp., FSI International, Lam Research Corp., Stanford University, University of California at Berkeley, University of California at Irvine, and University of Michigan at Ann Arbor

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[6] National Association of Manufacturers, 'Why Manufacturing is Essential' http://www.nam.org/s_nam/sec.asp?CID=201648&DID=230169.

[7] Microelectronics Manufacturing Infrastructure (MMI), 1998 Focused Program Paper http://www.atp.nist.gov/atp/97wpm212.htm.

Distributed Factory System Framework
Develop software and protocols to coordinate the actions of multiple manufacturing software applications within a factory, resulting in greater factory output, improved customer service, and reduced rework.

Participant: Consilium Inc.

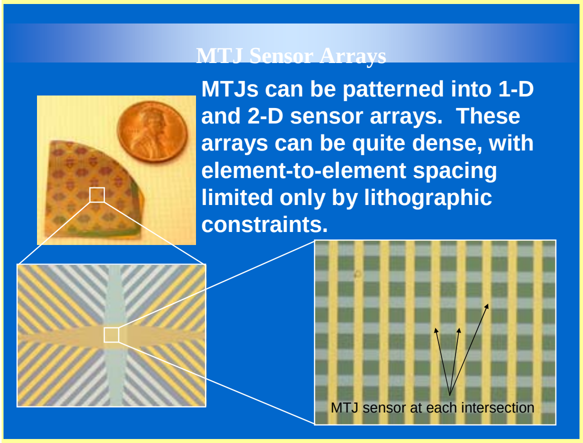
Nanotechnology for Nano-Electronics

Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications.[8] Novel and differentiating properties and functions of nanomaterials and nano-scale devices arise at this critical length scale of matter. Nanotechnology R&D seeks to:

- Provide a fundamental understanding of phenomena and materials properties at the nanoscale, and
- Model, create, characterize, manipulate, and use nano-structures, devices, and systems that have novel properties and functions.

ATP has co-funded **11 awards** and stimulated approximately **$114 million of total industry-based R&D** with direct impact in nanotechnology for nano-electronics. Of this approximately $58 million has come from ATP with approximately $56 million of cost-share from industry.

Examples of ATP awards that illustrate innovations in nanotechnology for nano-electronics include:



MTJ Sensor Arrays

MTJs can be patterned into 1-D and 2-D sensor arrays. These arrays can be quite dense, with element-to-element spacing limited only by lithographic constraints.

Spintronics-Based High-Resolution, Non-Invasive, and Ultrafast Metrology for the Semiconductor Industry
Develop a nanoscale magnetic tunnel junction current-sensing system for integrated circuit inspection that will help maintain the U.S. lead in semiconductors by providing vastly improved metrology for in-process inspection.

Participant: Micro Magnetics Inc.

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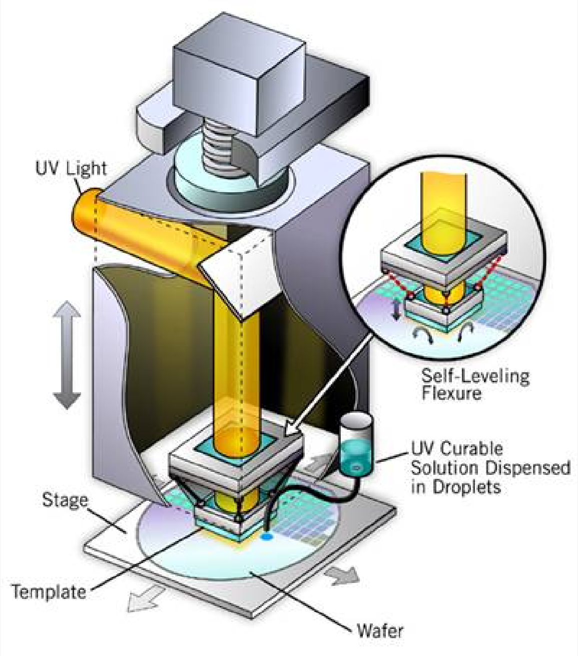
[8] http://www.nano.gov/html/facts/whatIsNano.html



Nano-Imprint Lithography Infrastructure for Low Cost Replication at the 65 nm Node and Beyond

Design and demonstrate technology for step and flash imprint lithography (S-FIL), a novel method of transferring integrated circuit patterns to the surface of a semiconductor wafer by molding of three-dimensional features potentially as small as 20 nanometers or less.

Participants: Molecular Imprints Inc., Motorola Inc.-Motorola Labs, Photonics Inc., KLA-Tencor Corporation, University of Texas at Austin

NIST ATP Awards Aiding International Technology Roadmap for Semiconductors (ITRS) Challenges

The *International Technology Roadmap for Semiconductors (ITRS)*, first produced in 1992 by the Semiconductor Industry Association as the *National Technology Roadmap for Semiconductors,* and now produced by the global semiconductor industry, is an assessment of the semiconductor industry's technology requirements. The document, revised every 2 years, summarizes the technology trends and identifies the technical challenges that the industry will have to overcome to continuously deliver increased functionality at lower costs. The historical trend of reducing cost per function for electronics products - approximately 25-29 % per year – is viewed essential for the industry to realize continued market growth and further productivity increases across the economy.

Today, the ITRS represents an industry-wide view of R&D needs over the next 15-year period. Industry challenges within the 2005 ITRS are organized across specific technical and cross-cut areas.[9]

For the purpose of this report, the 63 ATP awards in semiconductor and micro/nano-electronics have been analyzed and distributed among nine technical categories that generally correspond to the eleven technical and four crosscut areas of the 2005 ITRS.

They are:

1. Front End Processes and Lithography
2. Assembly, Packaging, and Interconnect
3. Metrology, Inspection, and Testing
4. Environment, Safety, and Health
5. Design, Modeling, and Simulation
6. Process Integration, Devices, and Structures
7. Emerging Research Devices and Organic Electronics
8. RF and Analog/Mixed-signal Technologies for Wireless Communications
9. Factory Integration

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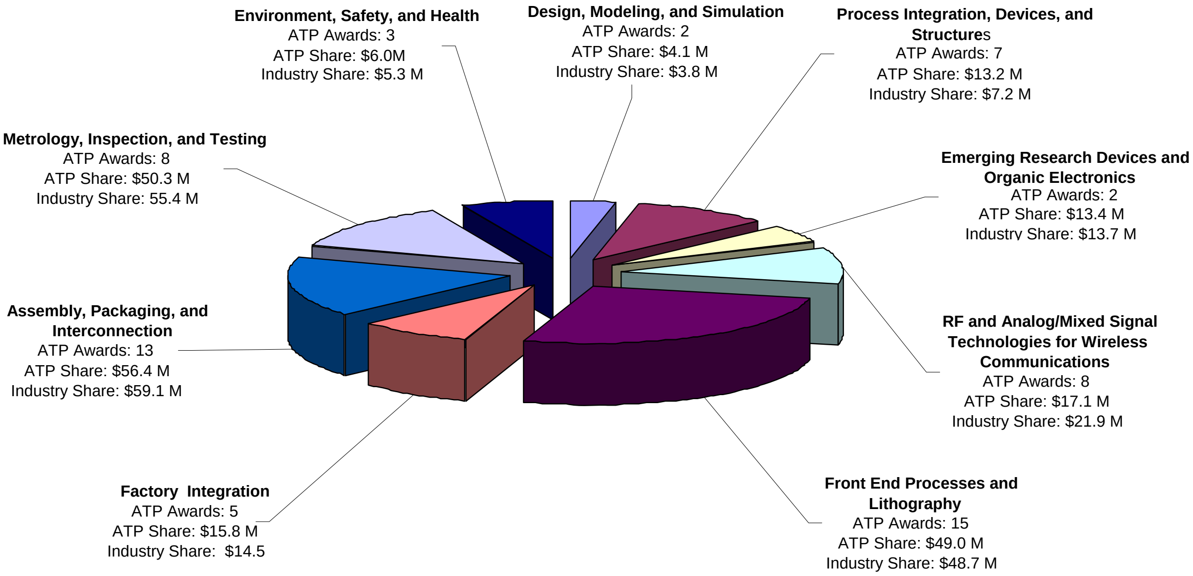
[9] ITRS, 2005 Edition, http://www.itrs.net/Common/2005ITRS/Home2005.htm

Distribution of ATP Awards in ITRS Technologies



The projects are a reflection of industry's pressing concerns and do not reflect any prioritization by ATP to any technical or crosscut area. The remainder of this report provides information for each technical category including examples of ATP co-funded awards. *Appendix C* shows all the ATP awards in these nine technical categories.

1. Front End Processes and Lithography

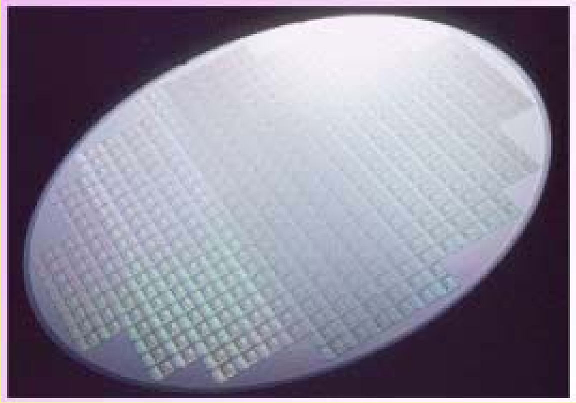
ATP has co-funded **15 awards** and stimulated approximately **$98 million of total industry-based R&D** with direct impact in front end processes and lithography. Of this approximately $49 million has come from ATP with approximately $48.7 million of cost-share from industry.

Technologies related to the fabrication of ICs on the semiconductor wafer are included within this category. The wafer diameters have increased from 200 nm to 300 nm, and are projected to go to 450 nm. At the same time the dimensions of the IC's are shrinking.

Advances in wafer processing and lithography have major impacts on reducing IC dimensions, the cost of manufacturing, and overall reliability. These factors in turn have a direct impact on the performance and cost of products made using ICs. Challenges in this area include: new gate materials and processes; control of critical dimensions; scaling down of CMOS; control of surface interface properties; and new lithography and mask fabrication technologies.

ATP co-funded projects have created advancements in improved processing technologies, process integration, and new lithography technologies for CMOS manufacturing.

Examples of ATP awards that illustrate innovations in front end processes and lithography include:



Development and Demonstration of a Multiple, High-Current-Density Shaped E-Beam Column with Independent Vector Beam Placement

Develop a new technology for a multiple-beam, linear-array electron-beam lithography system to enable cost-effective production of low-volume application-specific integrated circuits (ASICs) through direct-write lithography.

Participant: Multibeam Systems Inc.

Early Prototype Non-Gallium Ion Beam for Lithography and Wafer Manufacturing

Develop new technologies for focused-ion beam systems, a critical tool in the semiconductor manufacturing industry, to replace today's gallium-ion beams that are nearing the limits of effectiveness as semiconductor devices continue to shrink.

Participant: FEI Company-Micrion Division (formerly Micrion Corp)

Gas-Cluster Ion-Beam Manufacturing Tool for Next-Generation Semiconductor Devices

Develop a high-current gas-cluster ion-beam technology suitable for use in high-yield manufacturing lines, enabling the reliable production of ultra thin films with precise compositions and very low contamination levels, for next generation semiconductor manufacturing equipment.

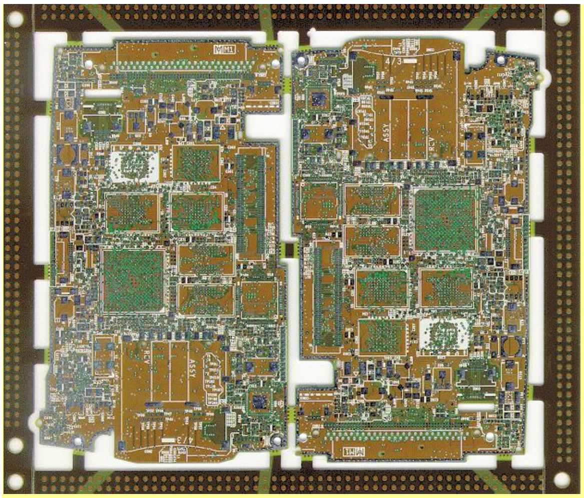
Participant: Epion Corp of JDS Uniphase Corporation (formerly Epion Corporation)

2. Assembly and Packaging

ATP has co-funded **13 awards** and stimulated approximately **$115.5 million of total industry-based R&D** with direct impact in assembly, packaging, and interconnect. Of this approximately $56.4 million has come from ATP with approximately $59.1 million of cost-share from industry.

Technologies related to the interface between the IC and the electronics systems are included within this category. Package design and fabrication is a very important part of the system and addresses issues related to materials, processes, and design. Embedded passive components are required for smaller smaller dimensions, reduced costs, and improved reliability.

Examples of ATP awards that illustrate innovations in assembly, packaging and interconnection include:



Advanced Embedded Passives Technology

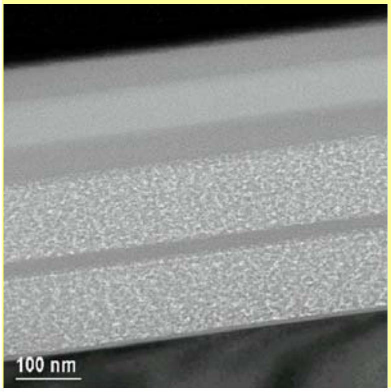
Develop the materials, manufacturing techniques, and design tools necessary for embedding the majority of passive electrical devices--resistors and capacitors--into the structure of the circuit board, thus reducing costs and space requirements and improving reliability and performance of a wide class of electronic devices.

Participants: Advanced Embedded Passives Technology Consortium (c/o NCMS), 3M Company, Hewlett Packard Corporation (formerly Compaq Computer Corporation), Delphi Delco Electronics Systems, DuPont, Microcircuit Materials, MacDermid Inc., Merix Corporation, Northern Telecom Inc., Foresight Systems Inc. (formerly Nu Thena Systems Inc.), Electro Scientific Industries Inc., MicroFab Technologies, Coretec Denver Inc. (formerly SAS Circuits)

Wafer-Scale Applied Reworkable Fluxing Underfill for Direct Chip Attach

Develop new materials and technology needed to allow existing integrated-circuit fabrication facilities using conventional surface mount technology to handle new "direct chip attach" components, enabling more efficient production of these high-performance devices.

Participants: Motorola Inc., Auburn University, Loctite Corporation



Ultra-Low Dielectric Constant Materials for Integrated Circuit

Develop and test new high-performance integrated-circuit insulation materials based on nanoporous polymeric materials and evaluate their suitability for long-term use through several future generations of high-density chips as feature sizes shrink and the demands on the dielectric get tougher.

Participants: Dow Chemical Company, IBM-Almaden Research Center

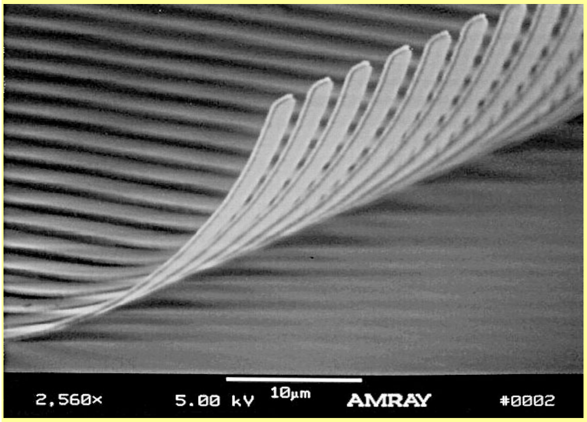
3. Metrology, Inspection, and Testing

ATP has co-funded **eight awards** and stimulated approximately **$105.7 million of total industry-based R&D** with direct impact in metrology, inspection, and testing. Of this approximately $50.3 million has come from ATP with approximately $55.4 million of cost-share from industry.

U.S. manufacturers require a wide range of tools for inspecting and measuring their output for quality and performance. Metrology is essential for development and improvement of new materials, processes, and tools for manufacturing. Inspection of wafers and masks plays a critical role in defect reduction, yield improvement, and cost reduction.

As devices become smaller, the need for defect inspection becomes more and more critical. The need for R&D is in improving sensitivities, ability to detect smaller defects, and in inspection of high-aspect-ratio structures.

Examples of ATP awards that illustrate innovations in metrology, inspection, and testing include:



Micro-Contact Springs for High-Performance Probing and Packaging

Develop a new breakthrough technology based on lithographically formed "micro springs" for high-density, high-reliability interconnects for semiconductor devices, relieving manufacturing bottlenecks in both testing and packaging.

Participants: Palo Alto Research Center Inc. (formerly Xerox PARC), Georgia Institute of Technology, NanoNexus Inc.

Intelligent Mask Inspection System for Next-Generation Lithography

Analyze the types of defects to be expected in future-generation IC photomasks for electron-beam and extreme-ultra-violet lithography, and develop a practical inspection system to detect these defects-- a critical technology for the semiconductor industry as it moves into the regime of sub-100 nanometer feature sizes.

Participants: KLA-Tencor Corporation, DuPont Photomask Inc., EUV LLC, Motorola Inc. Physical Sciences Laboratories, Photronics Inc.

4. Environment, Safety, and Health

ATP has co-funded **three awards** and stimulated approximately **$11 million of total industry-based R&D** with direct impact in environment, safety, and health. Of this approximately $5.3 million has come from ATP with approximately $6 million of cost-share from industry.

Reducing the use of chemicals is one of the key issues in making the semiconductor fabrication process safer and more environmentally friendly. The semiconductor industry addresses environmental issues in various ways including development of alternatives to hazardous chemicals, reduction in emission of pollutants, conservation of natural resources, and substituting environmentally benign solvents in manufacturing. Some key challenges in environmentally benign semiconductor manufacturing include:

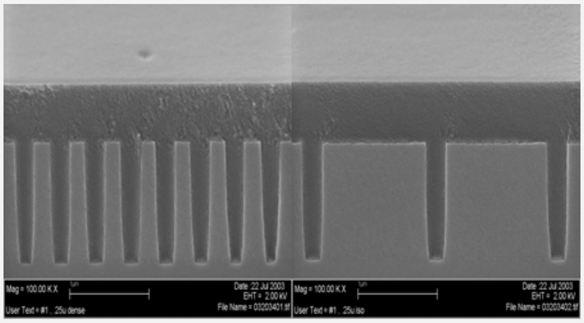
- Per-fluoro compound (PFC) alternatives for wafer patterning and chamber cleaning,
- CMP (chemical-mechanical polishing) wastewater minimization, recycling, and treatment,
- Development of environmentally benign wet (cleaning) processes,
- Reducing process water usage and enhancing wafer rinsing performance,
- Development of new processes and contaminant sensors for rinse water reuse and recycling,
- Development of solvent-less lithography for patterning integrated circuits (ICs), and
- Identification of new and environmentally-friendly processes for creation of barrier and adhesion layers for low-k dielectric polymer thin films.[10]

Examples of ATP awards that illustrate innovations in environment, safety and health include:

ACIM "Point*Suns": Concentrating Energy Through Silent Sound and Clean Water

Design and build an energy-efficient, chemical-free nanoparticle detector and wafer cleaner to enable the semiconductor industry to clean and inspect next-generation wafers reliably and profitably locating a nanoparticle on a wafer is equivalent to finding a specific grain of sand on a baseball field.

Participant: Uncopiers Inc.



Contact Planarization for Microlithographic Processes

Develop and demonstrate rapid, automated processing technology that will improve the flatness of layers in microelectronic integrated circuitry needed to produce advanced computer chips, providing for improved performance, while also reducing costs and environmental impact.

Participant: Brewer Science Inc.

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[10] NSF/SRC Engineering Research Center for Environmentally Benign Semiconductor Manufacturing http://www.erc-assoc.org/factsheets/h/html/erc_h.htm

5. Design, Modeling, and Simulation

ATP has co-funded **two awards** and stimulated approximately **$7.9 million of total industry-based R&D** with direct impact in design, modeling, and simulation. Of this approximately $4.1 million has come from ATP with approximately $3.8 million of cost-share from industry.

This category addresses a critical aspect in advancement of miniaturization in the semiconductor industry. Errors in design lead to lower yields and reduced reliability of ICs and system-on-chip (SoC). Some matters important for further miniaturization include: accurate designs, identification and correction of design errors, designing probes for testing, and efficiently testing for defects. Miniaturization leads to reduced costs of electronic products and increases the scope of applications.

Examples of ATP awards that illustrate innovations in design, modeling and simulation include:

Reconfigurable Infrastructure Platform for Systems-on-Chips

Develop an infrastructure platform for system-on-a-chip (SoC) electronics that implements a new kind of reconfigurable embedded debug logic to detect and fix design errors after fabrication, enabling reduced design cycle time, bypassing manufacturing defects, and improving yields.

Participant: DAFCA Inc.

Membrane Probes for Wafer, Package, and Substrate Testing

Design and demonstrate large-area membrane probes for massively parallel testing of integrated-circuit wafers and other electronic assemblies requiring dense arrays of contact probes, substantially reducing the costs of testing ICs, chip-scale packages and high-density interconnect substrates, while enhancing the high-frequency capabilities of parallel testing and increasing product yields.

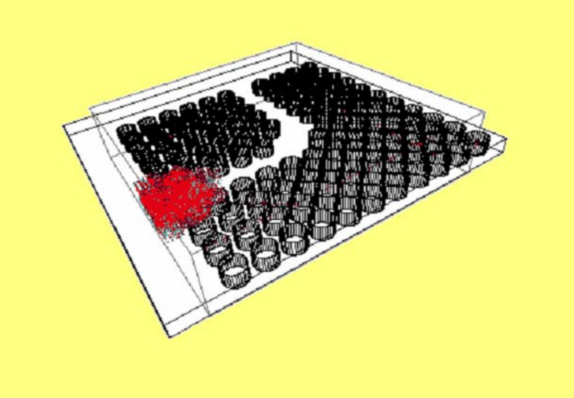
Participant: Cascade Microtech Inc.

6. Process Integration, Devices, and Structures

ATP has co-funded **seven awards** and stimulated approximately **$20.4 million of total industry-based R&D** with direct impact in process integration, devices, and structures. Of this approximately $13.2 million has come from ATP with approximately $7.2 million of cost-share from industry.

Technologies that affect the process flow and manufacturability associated with new ways of integrating active devices with different structures or materials; integrate different types of active devices; integrate active devices with on-chip interconnects; or that integrate different processing technologies are included within this category. Such types of integration enable the use of different materials and technologies, each having unique advantages and performance characteristics, for specific applications.

Examples of ATP awards that illustrate innovations in process integration, devices and structures include:



Nanophotonic Integrated Circuits for Telecommunications and Computing
Design, fabricate, and demonstrate the performance of nanophotonic circuits integrated on semiconductor wafers using standard semiconductor processing equipment.

Participant: Luxtera Inc.

PowerFlow: Next-Generation Intellectual Property Technology for System-on-a-Chip Designs
Develop a system-on-a-chip architecture that blends the flexibility of fully programmable microprocessors with the high performance of function-specific processors, radically lowering design costs and speeding development of devices for embedded applications.

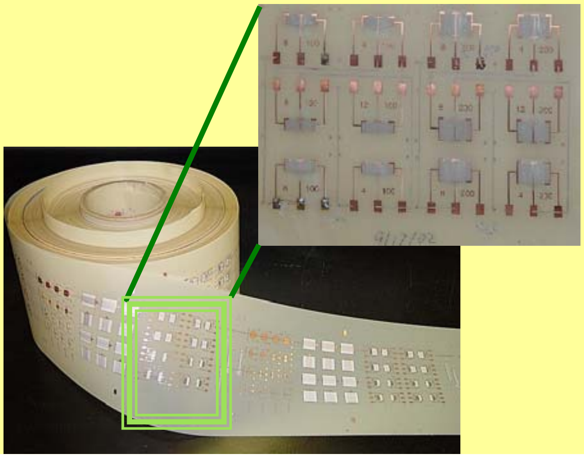
Participant: The Athena Group Inc.

7. Emerging Research Devices

ATP has co-funded **two awards** and stimulated approximately **$27.1 million of total industry-based R&D** with direct impact in emerging research devices and organic electronics. Of this approximately $13.4 million has come from ATP with approximately $13.7 million of cost-share from industry.

Conventional semiconductor materials and processes technologies are not very well suited for large area electronic devices such as displays because of size and cost issues. Flexible electronics, organic semiconductor materials and associated manufacturing technologies offer potential solution to these hurdles.

Examples of ATP awards that illustrate innovations in emerging research devices include:



Printed Organic ASICs: A Disruptive Technology

Develop novel organic electronic materials and processing technologies for application-specific integrated circuits (ASICs) to enable the fabrication of large-area electronic devices, such as displays, using relatively inexpensive printing technologies in lieu of semiconductor lithography.

Participants: Motorola Inc., Dow Chemical Company, PARC Inc.

Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics

Develop and demonstrate the performance of novel materials, for use as interfaces between computer chips and heat sinks that conduct heat 10 times better than today's interface materials.

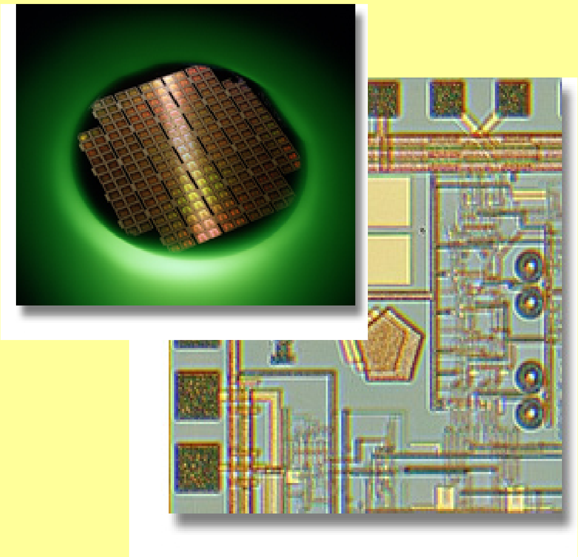
Participants: General Electric Company, Cabot Corporation (formerly Superior MicroPowders LLC), State University of New York (SUNY) at Binghamton

8. RF and Analog/Mixed Signal Technologies for Wireless Communication

ATP has co-funded **eight awards** and stimulated approximately **$39 million of total industry-based R&D** with direct impact in RF and Analog/Mixed-signal technologies for wireless communications. Of this approximately $17.1 million has come from ATP with approximately $21.9 million of cost-share from industry.

Wireless technologies play a critical role in emergency response, military applications, transportation, and manufacturing. Cost and performance determine how widely the technology will be applied. Advancements in wireless telecommunications require development in materials, design, and manufacturing technologies to reduce cost and improve performance.

Examples of ATP awards that illustrate innovations in RF and analog mixed signal technologies for wireless communications include:



Rapid and Comprehensive Development of Advanced Dielectric Materials for Wireless Applications

Develop novel advanced dielectric materials using high-throughput synthesis and diagnostic tools to enable path-breaking improvements in the next generation of wireless telecommunications components.

Participant: Intematix Corporation

Advanced Receiver Front-end Technology for 4G Wireless Systems

Design a system of thin-film, high-temperature, superconductor radio-frequency filters and advanced software to meet the need for improved selectivity and adaptability in cellular base stations to cope with the explosive growth of wireless telephone use.

Participant: STI Inc. (formerly Conductus, Inc.)

9. Factory Integration

ATP has co-funded **five awards** and stimulated approximately **$30.3 million of total industry-based R&D** with direct impact in factory integration. Of this approximately $15.8 million has come from ATP with approximately $14.5 million of cost-share from industry.

Technologies important for improved factory productivity are included within this category. Some challenges include: technologies for operational effectiveness, integrated factory level control system, process and equipment control, manufacturing information and execution systems, data handling, and automated control systems. Overcoming these challenges enables the industry to increase equipment utilization, decrease cycle time, improve yields, and lower cost of production.

Examples of ATP awards that illustrate innovations in factory integration include:

eManufacturing Security Framework to Improve Semiconductor Manufacturing Productivity

Develop, prototype, and validate a security framework for electronic collaboration via the Internet between semiconductor manufacturers and equipment suppliers, as a means of enhancing factory effectiveness and productivity.

Participants: Advanced Micro Devices, ILS Technology LLC, Oceana Sensor Technologies

Intelligent Equipment for Semiconductor Manufacturing

Develop an object-based software architecture that allows semiconductor manufacturing equipment to integrate intelligently with existing or advanced factory automation systems.

Participant: Asyst Connectivity Technologies Inc. (formerly Domain Logix Corporation)

Summary

The Advanced Technology Program (ATP) at the National Institute of Standards and Technology has co-funded, along with industry participants, high-risk innovative research that has a significant impact on the nation's technology base, competitiveness and economic welfare of the nation. Since 1991, ATP has funded 63 awards, across 20 states, involving 215 entities, in innovative technologies important to semiconductor and micro/nano-electronics. This amounts to approximately $454 million of total, industry-based R&D. A large number of these ATP awards have collaborations between companies, universities, and national laboratories, with 22 out of the 63 awards being joint ventures between involving at least two or more companies. Universities have also played a critical role in ATP semiconductor and micro/nano-electronics awards as joint venture partners, subcontractors, or in transfer of technology from university research to commercial applications. A total of 32 instances of university participation, or on average one university for every two ATP awards, have occurred in this technology area.

Contact Information

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For further information on these and other ATP funded projects, visit the ATP website at *www.atp.nist.gov*.

Micro/Nano Electronics Projects

Grant Number	State	Single or Joint	Total ATP $	Total Industry Cost-Share $	Company or JV Lead	Project Title
0H3038	California	JVL	$6,716,870	$7,002,847	KLA-Tencor Corporation	Advanced Wafer Inspection for Next-Generation Lithography
1H3047	California	JVL	$5,047,062	$5,049,082	Advanced Micro Devices	eManufacturing Security Framework to Improve Semiconductor Manufacturing Productivity
6H2002	California	JVL	$4,906,758	$5,101,241	KLA-Tencor (formerly Honeywell, Inc., Technology Center)	Advanced Process Control Framework Initiative
8H4008	California	JVL	$4,933,158	$4,962,997	Palo Alto Research Center, Inc. (formerly Xerox PARC)	Micro-Contact Springs for High-Performance Probing and Packaging
8H4024	California	JVL	$18,912,000	$24,443,000	KLA-Tencor Corporation	Intelligent Mask Inspection System for Next-Generation Lithography
8H4067	California	JVL	$9,110,456	$9,182,319	KLA-Tencor	Intelligent Control of the Semiconductor Patterning Process
0H3032	California	SA	$1,988,968	$4,985,706	STI, Inc. (formerly Conductus, Inc.)	Advanced Receiver Front-end Technology for 4G Wireless Systems
0H3036	California	SA	$2,000,000	$3,709,459	Etec Systems, Inc.	Development of a Short Wavelength Pattern Generator
1H3044	California	SA	$2,000,000	$1,169,688	Intematix Corporation	Rapid and Comprehensive Development of Advanced Dielectric Materials for Wireless Appplications
2H3033	California	SA	$1,999,960	$2,193,728	Luxtera, Inc.	Nanophotonic Integrated Circuits for Telecommunications and Computing
2H3038	California	SA	$2,000,000	$665,454	Xradia, Inc.	Achromatic Fresnel Optic for EIV and X-ray Radiation: An Innovative Camera Concept for Next Generation Lithography
3H1365	California	SA	$1,830,929	$2,952,822	IBM Corporation, Almaden Research Center	Low Dielectric Foams for Microelectronics Applications
3H3001	California	SA	$1,950,000	$1,562,442	RAPT Industries	Reactive Atom Plasma (RAP) Processing-A Novel Process for Rapid Optics Fabrication

Grant Number	State	Single or Joint	Total ATP $	Total Industry Cost-Share $	Company or JV Lead	Project Title
3H3005	California	SA	$1,999,761	$1,004,239	Agility Communications, Inc.	40 Gb/s Widely Tunable Photonic Integrated Transmitter
4H1504	California	SA	$2,000,000	$6,324,896	Vitesse Semiconductor Corporation	GaAs Super Microprocessor Technology Development
4H3016	California	SA	$1,985,240	$940,452	Aether Wire & Location, Inc.	Instant Networks Using Coin-sized Ultrawideband (UWB) Localizers
4H3047	California	SA	$1,999,180	$708,300	Multibeam Systems Inc.,	Development and Demonstration of a Multiple, High-Current-Density Shaped E-Beam Column With Independent Vector Beam Placement
7H3043	California	SA	$2,000,000	$1,353,000	Consilium, Inc.	Distributed Factory System Framework
3H3016	Colorado	SA	$1,989,783	$1,000,000	PowerSicel, Inc.	High Performance Transistors for Broadband Wireless Communications
9H3018	Connecticut	SA	$1,711,348	$2,062,152	ATMI, Inc.	Integrated MEMS Reactor Gas Monitor Using Novel Thin Film Chemistry for the Closed Loop Process Control and Optimization of Plasma Etch and Clean Reactions in the Manufacturing of
3H3032	Florida	SA	$1,999,859	$822,086	The Athena Group, Inc.	PowerFlow: Next-Generation Intellectual Property Technology for System-on-a-Chip Designs
7H3021	Florida	SA	$1,859,669	$415,450	Athena Group, Inc.	High Performance ASIC Technology for Digital Signal Processing
0H3033	Illinois	JVL	$7,675,745	$7,989,041	Motorola, Inc.	Printed Organic ASICs: A Disruptive Technology
8H4007	Illinois	JVL	$4,189,807	$4,494,502	Motorola, Inc.	Wafer-Scale Applied Reworkable Fluxing Underfill for Direct Chip Attach
1H3006	Kansas	SA	$2,000,000	$310,730	Uncopiers, Inc.	ACIM "Point*Suns": Concentrating Energy Through Silent Sound and Clean Water
2H3005	Maryland	SA	$1,968,348	$1,410,453	Neocera, Inc.	Advanced Technology for Non-destructive, Localized, Dielectric Metrology of Future Generation Integrated Circuits

Micro/Nano Electronics Projects

Grant Number	State	Single or Joint	Total ATP $	Total Industry Cost-Share $	Company or JV Lead	Project Title
2H1254	Massachusetts	JVL	$2,776,131	$2,929,177	Kopin Corporation	Scalable High-Density Electronics Based on MultiFilm Modules
3H1383	Massachusetts	SA	$1,327,000	$398,000	Diamond Semiconductor Group, Inc.	New Technology for High-Current, Parallel, Broad-Beam Implanters for Microelectronics Fabrication
3H3039	Massachusetts	SA	$2,000,000	$1,406,744	Micro Magnetics, Inc.	Spintronics-Based High-Resolution, Non-Invasive, and Ultrafast Metrology for the Semiconductor Industry
4H3049	Massachusetts	SA	$1,828,050	$756,642	DAFCA, Inc.	Reconfigurable Infrastructure Platform for Systems-on-Chips
8H4011	Massachusetts	SA	$2,000,000	$2,136,981	Epion Corp of JDS Uniphase Corporation (formerly Epion Corporation)	Gas-Cluster Ion-Beam Manufacturing Tool for Next-Generation Semiconductor Devices
1H1112	Michigan	JVL	$13,782,990	$14,674,484	National Center For Manufacturing Sciences, Inc.	Printed Wiring Board Interconnect Systems
4H3055	Michigan	JVL	$6,560,714	$6,828,495	Dow Chemical Company	High-Speed AFM-Based Platform for Quantitative Nanomechanical Measurements
8H4013	Michigan	JVL	$8,556,629	$9,049,142	Dow Chemical Company	Ultra-Low Dielectric Constant Materials for Integrated Circuit Interconnects
8H4025	Michigan	JVL	$7,804,654	$8,301,846	Advanced Embedded Passives Technology Consortium (c/o NCMS)	Advanced Embedded Passives Technology
4H3001	Michigan	SA	$2,000,000	$1,734,357	Discera, Inc.	Fully Integrated Gigahertz Receiver Front End
1H1118	Minnesota	SA	$1,738,600	$869,300	N V E (formerly Novolatile Electronics, Inc.)	Nonvolatile Magnetoresistive Semiconductor Technology
3H1378	Minnesota	SA	$2,000,000	$3,482,000	FSI International, Inc	Dry Gas-Phase Cleaning Technology for Single-Wafer Surface Conditioning
3H3035	Minnesota	SA	$695,458	$90,930	BH Electronics, Inc.	Ultraminiature Transformer and Inductor Design and Manufacture

Micro/Nano Electronics Projects

Grant Number	State	Single or Joint	Total ATP $	Total Industry Cost-Share $	Company or JV Lead	Project Title
8H4063	Minnesota	SA	$1,813,992	$1,125,208	NVE Corporation (formerly Nonvolatile Electronics Inc.)	Integrated GMR Isolated Devices and Planar Transformers
4H3054	Mississippi	SA	$1,776,466	$761,906	SemiSouth Laboratories, Inc.	Silicon Carbide Smart Power Chip
1H3019	Missouri	SA	$2,000,000	$1,495,840	Brewer Science, Inc.	Contact Planarization for Microlithographic Processes
2H3032	New Jersey	JVL	$5,734,114	$5,755,033	Sarnoff Corporation	Printed Organic Transistors on Plastic for Electronic Displays and Circuits
8H4012	New Jersey	JVL	$2,851,841	$2,909,252	National Starch and Chemical, Inc.	Novel High-Performance Wafer-Level Reworkable Underfill Materials for Flip-Chip Packaging
1H1115	New Jersey	SA	$2,000,000	$3,525,000	Lucent Technologies, Inc. (formerly AT&T Bell Laboratories)	Fabrication and Testing of Precision Optics for Soft X-Ray Projection Lithography
4H3056	New Mexico	SA	$1,833,376	$928,877	STAR Cryoelectronics, LLC	Next-Generation Energy Dispersive Spectrometer for X-Ray Microanalysis
1H1117	New York	JVL	$1,090,000	$1,094,568	Hampshire Instruments, Inc.	Solid-State Laser Technology for Point-Source X-Ray Lithography
2H3034	New York	JVL	$3,506,139	$3,761,381	General Electric Company	Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics
2H3042	New York	SA	$1,739,322	$2,087,186	Starfire Systems	Ceramic Matrix Composite Boards for SOP and SIP Electronic Packaging
4H1520	New York	SA	$1,987,530	$1,422,386	IBM Corporation, T.J. Watson Research Center	Conducting Polymers: Three Dimensional Engineering for Advanced Applications
5H1103	New York	SA	$482,168	$670,889	GE Research (formerly GE Corporate R&D)	Novel Synthetic Fused Quartz for Semiconductor Manufacturing
2H1252	North Carolina	SA	$1,956,853	$434,734	Cree Inc. (formerly Cree Research Inc.	Advancement of Monocrystalline Silicon Carbide Growth Processes

Micro/Nano Electronics Projects

State of: Texas

Grant Number	State	Single or Joint	Total ATP $	Total Industry Cost-Share $	Company or JV Lead	Project Title
8H4009	Oregon	SA	$1,581,605	$727,538	FEI Company, Micrion Division (formerly Micrion Corp)	Early Prototype Non-Gallium Ion Beam for Lithography and Wafer Manufacturing
8H4010	Oregon	SA	$1,996,798	$3,369,652	Cascade Microtech, Inc.	Membrane Probes for Wafer, Package, and Substrate Testing
8H4021	Pennsylvania	JVL	$2,936,781	$3,594,790	ChemIcon, Inc.	Chemical Imaging for Semiconductor Metrology
0H3030	Texas	JVL	$3,119,859	$4,271,618	TriQuint Semiconductor Texas, L.P.	Advanced HBT Power Amplifier Technology for Broadband Communications Systems
0H3034	Texas	JVL	$9,395,604	$9,779,101	nLine Corporation	Digital Holographic Inspection of Semiconductor Devices
4H3012	Texas	JVL	$17,623,118	$19,167,367	Molecular Imprints, Inc.	Nano-Imprint Lithography Infrastructure for Low Cost Replication at the 65 nm Node and Beyond
7H3041	Texas	JVL	$2,394,319	$2,492,049	Advanced Micro Devices	Agent-Enhanced Manufacturing System Initiative
0H3018	Texas	SA	$1,452,110	$494,839	Asyst Connectivity Technologies, Inc. (formerly Domain Logix Corporation)	Intelligent Equipment for Semiconductor Manufacturing
4H1513	Texas	SA	$1,639,000	$798,000	MicroFab Technologies, Inc.	Solder Jet Technology Development
5H1064	Texas	SA	$1,971,000	$3,588,000	Texas Instruments, Inc.	Ultra-Low k Dielectric Materials for High-Performance Interconnects
4H3033	Virginia	SA	$1,999,986	$1,512,032	Innovative Wireless Technologies, Inc.	Unified Radio Architecture - A Cognitive Radio Platform
Total			**$224,727,108**	**$230,241,430**		

Projects Summary
Micro/Nano-Electronics

University Participation

06/15/2006

	Soted by:		ALL data from WIRC System (This count included all participants vs end of project actives per McKneely DB)
Participation	***University***	**Award #**	**Project Title**
JVP	Auburn University	8H4007	Wafer-Scale Applied Reworkable Fluxing Underfill for Direct Chip Attach
SUB	Carleton University	8H4025	Advanced Embedded Passives Technology
JVP	Carnegie Mellon University	0H3038	Advanced Wafer Inspection for Next-Generation Lithography
SUB	Cornell University	8H4007	Wafer-Scale Applied Reworkable Fluxing Underfill for Direct Chip Attach
JVP	Georgia Institute Of Technology	8H4008	Micro-Contact Springs for High-Performance Probing and Packaging
SUB	Georgia Institute Of Technology	2H3042	Ceramic Matrix Composite Boards for SOP and SIP Electronic Packaging
SUB	Georgia Institute of Technology	8H4012	Novel High-Performance Wafer-Level Reworkable Underfill Materials for Flip-Chip Packaging
SUB	Marquette University	4H1513	Solder Jet Technology Development
SUB	Massachusetts Institute Of Technology	9H3018	Integrated MEMS Reactor Gas Monitor Using Novel Thin Film Chemistry for the Closed Loop Process Control and Optimization of Plasma Etch and Clean Reactions in the Manufacturing of Microelectronics
SUB	Massachusetts Institute Of Technology	3H1378	Dry Gas-Phase Cleaning Technology for Single-Wafer Surface Conditioning
SUB	North Carolina State University	2H1252	Advancement of Monocrystalline Silicon Carbide Growth Processes
SUB	Ohio State University	4H1520	Conducting Polymers: Three Dimensional Engineering for Advanced Applications
SUB	Purdue University	2H3034	Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics
JVP	Stanford University	8H4067	Intelligent Control of the Semiconductor Patterning Process
SUB	Stanford University	8H4013	Ultra-Low Dielectric Constant Materials for Integrated Circuit Interconnects
JVP	State University of New York (SUNY) at Binghamton	2H3034	Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics
JVP	University of California at Berkeley	8H4067	Intelligent Control of the Semiconductor Patterning Process
JVP	University of California at Irvine	8H4067	Intelligent Control of the Semiconductor Patterning Process
SUB	University of California at Santa Barbara	4H3055	High-Speed AFM-Based Platform for Quantitative Nanomechanical Measurements
SUB	University of Cincinnati	4H3001	Fully Integrated Gigahertz Receiver Front End
SUB	University of Colorado	2H3034	Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics
SUB	University of Florida	1H3047	eManufacturing Security Framework to Improve Semiconductor Manufacturing Productivity
SUB	University of Maryland	8H4013	Ultra-Low Dielectric Constant Materials for Integrated Circuit Interconnects
SUB	University of Maryland	8H4025	Advanced Embedded Passives Technology
SUB	University of Maryland	2H3005	Advanced Technology for Non-destructive, Localized, Dielectric Metrology of Future Generation Integrated Circuits
SUB	University of Maryland	2H3005	Advanced Technology for Non-destructive, Localized, Dielectric Metrology of Future Generation Integrated Circuits
JVP	University of Michigan at Ann Arbor	8H4067	Intelligent Control of the Semiconductor Patterning Process
SUB	University of Michigan, Electrical Engineering and Computer Science Department	0H3033	Printed Organic ASICs: A Disruptive Technology
SUB	University of Minnesota	1H1118	Nonvolatile Magnetoresistive Semiconductor Technology
SUB	University of Minnesota	8H4063	Integrated GMR Isolated Devices and Planar Transformers
SUB	University of Pennsylvania at Philadelphia	4H1520	Conducting Polymers: Three Dimensional Engineering for Advanced Applications
SUB	University of Texas - Austin	0H3036	Development of a Short Wavelength Pattern Generator
SUB	University of Texas at Austin	1H3047	eManufacturing Security Framework to Improve Semiconductor Manufacturing Productivity
JVP	University of Texas at Austin	4H3012	Nano-Imprint Lithography Infrastructure for Low Cost Replication at the 65 nm Node and Beyond
SUB	Virginia Polytechnic Institute	3H1365	Low Dielectric Foams for Microelectronics Applications
SUB	Washington State University	8H4013	Ultra-Low Dielectric Constant Materials for Integrated Circuit Interconnects
SUB	West Virginia University	8H4021	Chemical Imaging for Semiconductor Metrology

Sorted by:

Participation	University	**Award #**	**Project Title**
JVP	Auburn University	8H4007	Wafer-Scale Applied Reworkable Fluxing Underfill for Direct Chip Attach
JVP	Carnegie Mellon University	0H3038	Advanced Wafer Inspection for Next-Generation Lithography
JVP	Georgia Institute Of Technology	1998-06-0012	Micro-Contact Springs for High-Performance Probing and Packaging
JVP	Stanford University	8H4067	Intelligent Control of the Semiconductor Patterning Process
JVP	State University of New York (SUNY) at Binghamton	2H3034	Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics
JVP	University of California at Berkeley	8H4067	Intelligent Control of the Semiconductor Patterning Process
JVP	University of California at Irvine	8H4067	Intelligent Control of the Semiconductor Patterning Process
JVP	University of Michigan at Ann Arbor	8H4067	Intelligent Control of the Semiconductor Patterning Process
JVP	University of Texas at Austin	4H3012	Nano-Imprint Lithography Infrastructure for Low Cost Replication at the 65 nm Node and Beyond
SUB	Washington State University	8H4013	Ultra-Low Dielectric Constant Materials for Integrated Circuit Interconnects
SUB	West Virginia University	8H4021	Chemical Imaging for Semiconductor Metrology
SUB	Carleton University	8H4025	Advanced Embedded Passives Technology
SUB	Cornell University	8H4007	Wafer-Scale Applied Reworkable Fluxing Underfill for Direct Chip Attach
SUB	Georgia Institute Of Technology	2H3042	Ceramic Matrix Composite Boards for SOP and SIP Electronic Packaging
SUB	Georgia Institute of Technology	8H4012	Novel High-Performance Wafer-Level Reworkable Underfill Materials for Flip-Chip Packaging
SUB	Marquette University	4H1513	Solder Jet Technology Development
SUB	Massachusetts Institute Of Technology	9H3018	Integrated MEMS Reactor Gas Monitor Using Novel Thin Film Chemistry for the Closed Loop Process Control and Optimization of Plasma Etch and Clean Reactions in the Manufacturing of Microelectronics
SUB	Massachusetts Institute Of Technology	3H1378	Dry Gas-Phase Cleaning Technology for Single-Wafer Surface Conditioning
SUB	North Carolina State University	2H1252	Advancement of Monocrystalline Silicon Carbide Growth Processes
SUB	Ohio State University	4H1520	Conducting Polymers: Three Dimensional Engineering for Advanced Applications
SUB	Purdue University	2H3034	Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics
SUB	Stanford University	8H4013	Ultra-Low Dielectric Constant Materials for Integrated Circuit Interconnects
SUB	University of California at Santa Barbara	4H3055	High-Speed AFM-Based Platform for Quantitative Nanomechanical Measurements
SUB	University of Cincinnati	4H3001	Fully Integrated Gigahertz Receiver Front End
SUB	University of Colorado	2H3034	Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics
SUB	University of Florida	1H3047	eManufacturing Security Framework to Improve Semiconductor Manufacturing Productivity
SUB	University of Maryland	8H4013	Ultra-Low Dielectric Constant Materials for Integrated Circuit Interconnects
SUB	University of Maryland	8H4025	Advanced Embedded Passives Technology
SUB	University of Maryland	2H3005	Advanced Technology for Non-destructive, Localized, Dielectric Metrology of Future Generation Integrated Circuits
SUB	University of Maryland	2H3005	Advanced Technology for Non-destructive, Localized, Dielectric Metrology of Future Generation Integrated Circuits
SUB	University of Michigan, Electrical Engineering and Computer Science Department	0H3033	Printed Organic ASICs: A Disruptive Technology
SUB	University of Minnesota	1H1118	Nonvolatile Magnetoresistive Semiconductor Technology
SUB	University of Minnesota	8H4063	Integrated GMR Isolated Devices and Planar Transformers
SUB	University of Pennsylvania at Philadelphia	4H1520	Conducting Polymers: Three Dimensional Engineering for Advanced Applications
SUB	University of Texas - Austin	0H3036	Development of a Short Wavelength Pattern Generator
SUB	University of Texas at Austin	1H3047	eManufacturing Security Framework to Improve Semiconductor Manufacturing Productivity
SUB	Virginia Polytechnic Institute	3H1365	Low Dielectric Foams for Microelectronics Applications

Advanced Technology Program
Inventory of Semiconductor Micro/Nano-Electronics Awards
by ITRS Technical Areas

06/23/2006

Lead Organization	Project Title	ATP $ (Est.)	Industry Cost-Share $ (Est.)	Start	End
1) Front End Processes and Lithography					
ATMI, Inc.	Integrated MEMS Reactor Gas Monitor Using Novel Thin Film Chemistry for the Closed Loop Process Control and Optimization of Plasma Etch and Clean Reactions in the Manufacturing of Microelectronics	$1,711,348	$2,062,152	11/12/99	10/31/02
Cree Inc. (formerly Cree Research Inc.	Advancement of Monocrystalline Silicon Carbide Growth Processes	$1,956,853	$434,734	06/15/92	06/14/94
Diamond Semiconductor Group, Inc.	New Technology for High-Current, Parallel, Broad-Beam Implanters for Microelectronics Fabrication	$1,327,000	$398,000	03/01/93	06/30/94
Epion Corp of JDS Uniphase Corporation (formerly Epion Corporation)	Gas-Cluster Ion-Beam Manufacturing Tool for Next-Generation Semiconductor Devices	$2,000,000	$2,136,981	10/01/98	09/30/01
Etec Systems, Inc.	Development of a Short Wavelength Pattern Generator	$2,000,000	$3,709,459	11/01/00	10/31/03
FEI Company, Micrion Division (formerly Micrion Corp)	Early Prototype Non-Gallium Ion Beam for Lithography and Wafer Manufacturing	$1,581,605	$727,538	11/01/98	12/31/00
GE Research (formerly GE Corporate R&D)	Novel Synthetic Fused Quartz for Semiconductor Manufacturing	$482,168	$670,889	09/01/95	08/31/98
Hampshire Instruments, Inc.	Solid-State Laser Technology for Point-Source X-Ray Lithography	$1,090,000	$1,094,568	07/01/91	09/30/92
IBM Corporation, Almaden Research Center	Low Dielectric Foams for Microelectronics Applications	$1,830,929	$2,952,822	03/01/93	02/28/96
KLA-Tencor	Intelligent Control of the Semiconductor Patterning Process	$9,110,456	$9,182,319	01/01/99	08/30/02
Lucent Technologies, Inc. (formerly AT&T Bell Laboratories)	Fabrication and Testing of Precision Optics for Soft X-Ray Projection Lithography	$2,000,000	$3,525,000	05/15/91	05/14/94
Molecular Imprints, Inc.	Nano-Imprint Lithography Infrastructure for Low Cost Replication at the 65 nm Node and Beyond	$17,623,118	$19,167,367	05/01/04	04/30/07
Multibeam Systems Inc.,	Development and Demonstration of a Multiple, High-Current-Density Shaped E-Beam Column With Independent Vector Beam Placement	$1,999,180	$708,300	10/01/04	09/30/06
RAPT Industries	Reactive Atom Plasma (RAP) Processing-A Novel Process for Rapid Optics Fabrication	$1,950,000	$1,562,442	05/01/03	05/31/06
Xradia, Inc.	Achromatic Fresnel Optic for EIV and X-ray Radiation: An Innovative Camera Concept for Next Generation Lithography	$2,000,000	$665,454	11/01/02	03/31/05
2) Assembly, Packaging, and Interconnect					
Advanced Embedded Passives Technology Consortium (c/o NCMS)	Advanced Embedded Passives Technology	$7,804,654	$8,301,846	02/01/99	01/31/03

Advanced Technology Program
Inventory of Semiconductor Micro/Nano-Electronics Awards
by ITRS Technical Areas

Lead Organization	Project Title	ATP $ (Est.)	Industry Cost-Share $ (Est.)	Start	End
BH Electronics, Inc.	Ultraminiature Transformer and Inductor Design and Manufacture	$695,458	$90,930	10/01/03	06/30/05
Dow Chemical Company	Ultra-Low Dielectric Constant Materials for Integrated Circuit Interconnects	$8,556,629	$9,049,142	04/01/99	09/30/02
General Electric Company	Nanoengineered Thermal Interfaces Enabling Next Generation Microelectronics	$3,506,139	$3,761,381	11/01/02	10/31/05
IBM Corporation, T.J. Watson Research Center	Conducting Polymers: Three Dimensional Engineering for Advanced Applications	$1,987,530	$1,422,386	04/01/94	03/31/97
Kopin Corporation	Scalable High-Density Electronics Based on MultiFilm Modules	$2,776,131	$2,929,177	09/15/92	09/15/95
MicroFab Technologies, Inc.	Solder Jet Technology Development	$1,639,000	$798,000	01/01/94	12/31/96
Motorola, Inc.	Wafer-Scale Applied Reworkable Fluxing Underfill for Direct Chip Attach	$4,189,807	$4,494,502	04/09/99	10/08/03
National Center For Manufacturing Sciences, Inc.	Printed Wiring Board Interconnect Systems	$13,782,990	$14,674,484	04/15/91	04/14/96
National Starch and Chemical, Inc.	Novel High-Performance Wafer-Level Reworkable Underfill Materials for Flip-Chip Packaging	$2,851,841	$2,909,252	12/09/98	12/08/02
Palo Alto Research Center, Inc. (formerly Xerox PARC)	Micro-Contact Springs for High-Performance Probing and Packaging	$4,933,158	$4,962,997	01/01/99	06/30/03
Starfire Systems	Ceramic Matrix Composite Boards for SOP and SIP Electronic Packaging	$1,739,322	$2,087,186	11/01/02	10/31/05
Texas Instruments, Inc.	Ultra-Low k Dielectric Materials for High-Performance Interconnects	$1,971,000	$3,588,000	03/01/95	02/28/98
3) Metrology, Inspection, and Testing					
ChemIcon, Inc.	Chemical Imaging for Semiconductor Metrology	$2,936,781	$3,594,790	10/01/98	09/30/01
Dow Chemical Company	High-Speed AFM-Based Platform for Quantitative Nanomechanical Measurements	$6,560,714	$6,828,495	12/01/04	09/30/07
KLA-Tencor Corporation	Advanced Wafer Inspection for Next-Generation Lithography	$6,716,870	$7,002,847	11/01/00	10/31/04
KLA-Tencor Corporation	Intelligent Mask Inspection System for Next-Generation Lithography	$18,912,000	$24,443,000	05/10/99	08/13/04
Micro Magnetics, Inc.	Spintronics-Based High-Resolution, Non-Invasive, and Ultrafast Metrology for the Semiconductor Industry	$2,000,000	$1,406,744	10/01/03	09/30/06
Neocera, Inc.	Advanced Technology for Non-destructive, Localized, Dielectric Metrology of Future Generation Integrated Circuits	$1,968,348	$1,410,453	06/01/02	05/31/04

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Lead Organization	Project Title	ATP $ (Est.)	Industry Cost-Share $ (Est.)	Start	End
nLine Corporation	Digital Holographic Inspection of Semiconductor Devices	$9,395,604	$9,779,101	11/01/00	05/09/06
STAR Cryoelectronics, LLC	Next-Generation Energy Dispersive Spectrometer for X-Ray Microanalysis	$1,833,376	$928,877	10/01/04	09/30/07
4) Environment, Safety, and Health					
Brewer Science, Inc.	Contact Planarization for Microlithographic Processes	$2,000,000	$1,495,840	10/01/01	01/31/04
FSI International, Inc	Dry Gas-Phase Cleaning Technology for Single-Wafer Surface Conditioning	$2,000,000	$3,482,000	03/01/93	02/28/95
Uncopiers, Inc.	ACIM "Point*Suns": Concentrating Energy Through Silent Sound and Clean Water	$2,000,000	$310,730	09/01/01	08/31/04
5) Design, Modeling, and Simulation					
Cascade Microtech, Inc.	Membrane Probes for Wafer, Package, and Substrate Testing	$1,996,798	$3,369,652	11/01/98	10/31/01
DAFCA, Inc.	Reconfigurable Infrastructure Platform for Systems-on-Chips	$1,828,050	$756,642	10/01/04	09/30/07
6) Process Integration, Devices, and Structures					
Agility Communications, Inc.	40 Gb/s Widely Tunable Photonic Integrated Transmitter	$1,999,761	$1,004,239	06/01/03	05/31/06
Athena Group, Inc.	High Performance ASIC Technology for Digital Signal Processing	$1,859,669	$415,450	10/01/98	09/30/00
Luxtera, Inc.	Nanophotonic Integrated Circuits for Telecommunications and Computing	$1,999,960	$2,193,728	11/01/02	10/31/04
N V E (formerly Novolatile Electronics, Inc.)	Nonvolatile Magnetoresistive Semiconductor Technology	$1,738,600	$869,300	04/01/91	03/31/94
NVE Corporation (formerly Nonvolatile Electronics Inc.)	Integrated GMR Isolated Devices and Planar Transformers	$1,813,992	$1,125,208	11/01/97	10/31/00
SemiSouth Laboratories, Inc.	Silicon Carbide Smart Power Chip	$1,776,466	$761,906	10/01/04	09/30/07
The Athena Group, Inc.	PowerFlow: Next-Generation Intellectual Property Technology for System-on-a-Chip Designs	$1,999,859	$822,086	10/01/03	09/30/06

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Lead Organization	Project Title	ATP $ (Est.)	Industry Cost-Share $ (Est.)	Start	End
7) Emerging Research Devices and Organic Electronics					
Motorola, Inc.	Printed Organic ASICs: A Disruptive Technology	$7,675,745	$7,989,041	11/01/00	10/31/05
Sarnoff Corporation	Printed Organic Transistors on Plastic for Electronic Displays and Circuits	$5,734,114	$5,755,033	11/01/02	10/31/05
8) RF and Analog/Mixed-signal Technologies for Wireless Communications					
Aether Wire & Location, Inc.	Instant Networks Using Coin-sized Ultrawideband (UWB) Localizers	$1,985,240	$940,452	05/01/04	04/30/07
Discera, Inc.	Fully Integrated Gigahertz Receiver Front End	$2,000,000	$1,734,357	05/01/04	01/31/07
Innovative Wireless Technologies, Inc.	Unified Radio Architecture - A Cognitive Radio Platform	$1,999,986	$1,512,032	11/01/04	08/30/07
Intematix Corporation	Rapid and Comprehensive Development of Advanced Dielectric Materials for Wireless Appplications	$2,000,000	$1,169,688	10/01/01	01/31/04
PowerSicel, Inc.	High Performance Transistors for Broadband Wireless Communications	$1,989,783	$1,000,000	07/01/03	06/30/05
STI, Inc. (formerly Conductus, Inc.)	Advanced Receiver Front-end Technology for 4G Wireless Systems	$1,988,968	$4,985,706	11/01/00	10/31/03
TriQuint Semiconductor Texas, L.P.	Advanced HBT Power Amplifier Technology for Broadband Communications Systems	$3,119,859	$4,271,618	11/01/00	03/31/04
Vitesse Semiconductor Corporation	GaAs Super Microprocessor Technology Development	$2,000,000	$6,324,896	03/01/94	12/31/96
9) Factory Integration					
Advanced Micro Devices	eManufacturing Security Framework to Improve Semiconductor Manufacturing Productivity	$5,047,062	$5,049,082	11/01/01	10/31/05
Advanced Micro Devices	Agent-Enhanced Manufacturing System Initiative	$2,394,319	$2,492,049	12/01/97	12/31/01
Asyst Connectivity Technologies, Inc. (formerly Domain Logix Corporation)	Intelligent Equipment for Semiconductor Manufacturing	$1,452,110	$494,839	11/01/00	10/31/02
Consilium, Inc.	Distributed Factory System Framework	$2,000,000	$1,353,000	11/01/97	04/30/99
KLA-Tencor (formerly Honeywell, Inc., Technology Center)	Advanced Process Control Framework Initiative	$4,906,758	$5,101,241	02/01/96	10/31/98