Department of Energy
Solid State Lighting Program Meeting
November 13-14, 2003
Doubletree Crystal City, Arlington, VA

Accelerating Not-Yet-Possible Technologies:

Partnering with NIST and the Advanced Technology Program (ATP)

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Crossing the Valley of Death *only to …*

… arrive in the Waters of the Darwinian Sea

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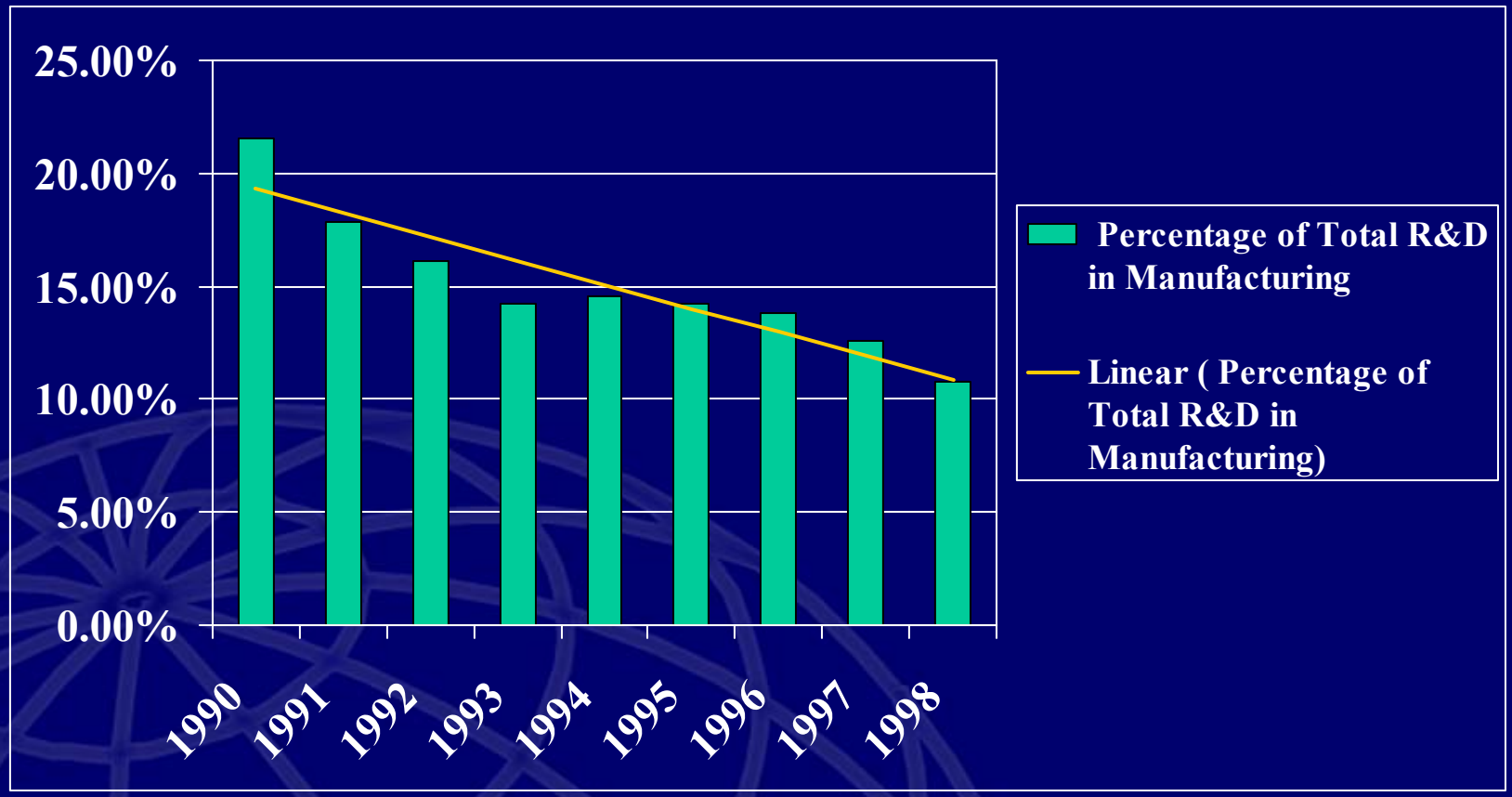
Federal Support for U.S. R&D in Manufacturing



Source: National Science Foundation

ADVANCED TECHNOLOGY PROGRAM

NIST: A Unique Mission and Assets

NIST's mission is to develop and promote measurement, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life.

NIST Assets Include:

- ❑ 3,000 employees
- ❑ 1,600 associates
- ❑ $825 million FY 2003 operating budget
- ❑ NIST Laboratories
- ❑ Advanced Technology Program
- ❑ Manufacturing Extension Partnership
- ❑ Baldrige National Quality Award

ADVANCED TECHNOLOGY PROGRAM

Programs Guided by Stakeholder Roadmaps and Needs Assessment

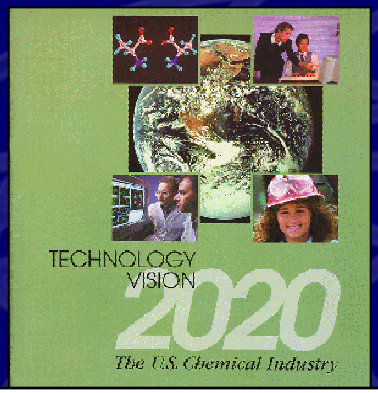
Semiconductor Industry Association

President's Information Technology Advisory Committee

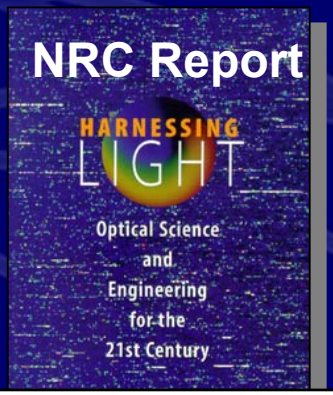
Optoelectronics Industry Development Association

OIDA **Multiple Roadmaps**

Roadmap



Chemical industry vision/roadmap



Optics needs

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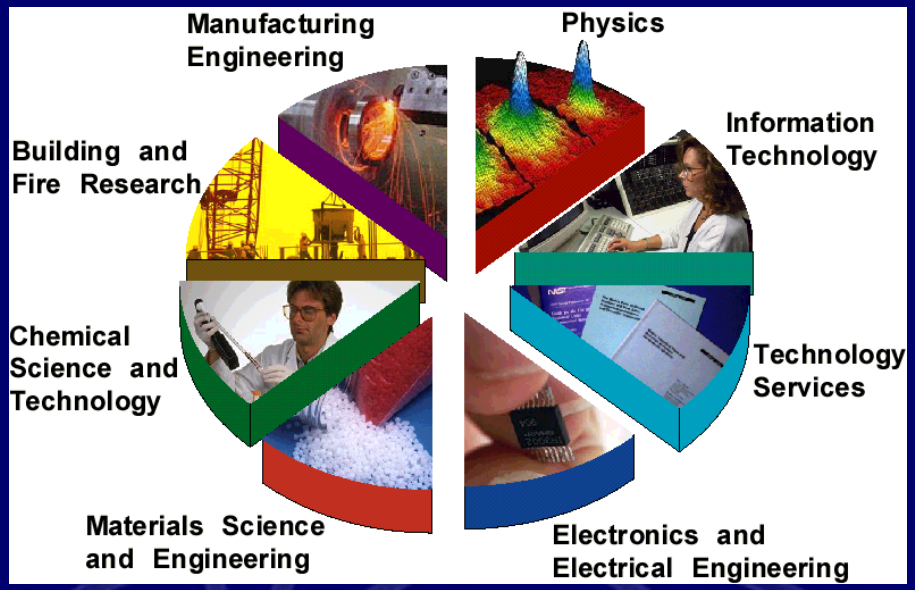
NIST Laboratories



Multidisciplinary expertise to develop measurements and standards to enable:

- ❑ Science
- ❑ Technology innovation
- ❑ Trade
- ❑ Public benefit

NIST plans and works in close collaboration with customers:

- ❑ Industry
- ❑ Universities
- ❑ Other agencies
- ❑ State and local governments
- ❑ Measurement laboratories
- ❑ Standards development organizations

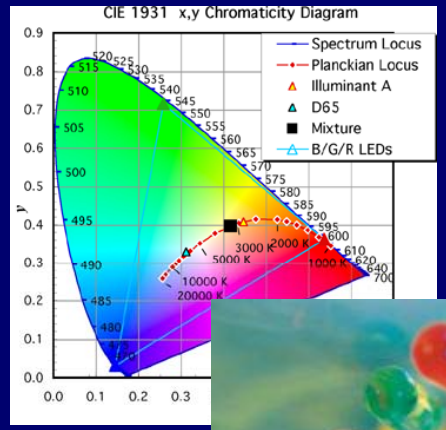
ADVANCED TECHNOLOGY PROGRAM

NIST Laboratories

Lighting : Fundamental Standards and LED Metrology

Objective

- Maintain the fundamental units for light quantities (candela, lumen, watt).
- Provide photometric standards and calibration services
- Concentrated efforts addressing LED uncertainties
  - Calibration services for LED luminous intensity & luminous flux with 3 % uncertainty
  - Standard LEDs for color measurements
  - Standards for phosphor absolute efficiency
  - LED Color Rendering



Physics Laboratory
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NIST

ADVANCED TECHNOLOGY PROGRAM

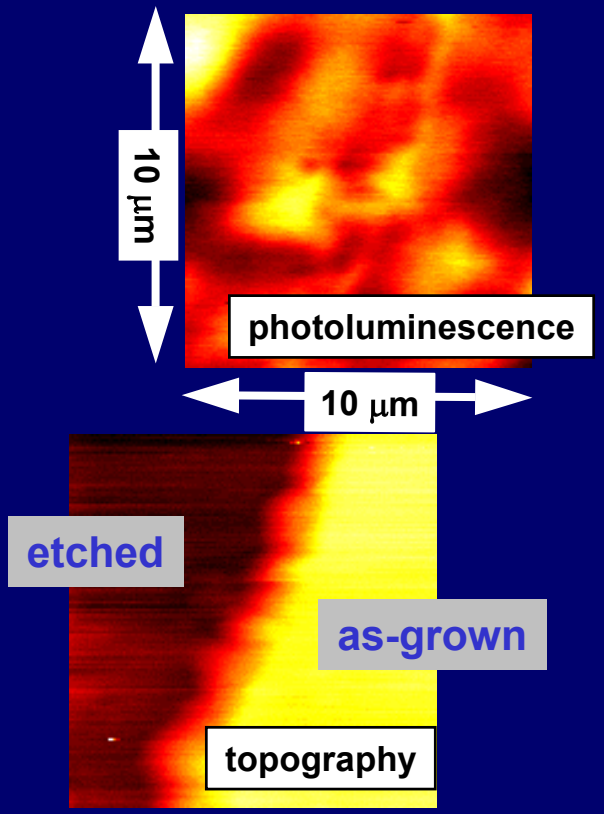
NIST Laboratories

Optoelectronics : SSL Research

Objective

- **Materials Metrology**
  - Linear and nonlinear optical properties of InAlGaN, X-ray diffraction imaging of bulk GaN, Multiple nanoscale methods for characterization of group III-nitrides and ohmic contacts, Epitaxial layer composition standards
- **Nanostructure Strain Measurements**
  - Micro-Raman, Electron backscattering diffraction, Coherent beam electron diffraction
- **Manufacturing**
  - OMVPE gas purity (water in PH3 and NH3), In situ growth monitoring
- **Innovative Materials and Devices**
  - Quantum dot LEDs, GaN nanowires, Quantum dot morphology and control

NSOM Probing of Etch-processed GaN, Critical for Solid-state Lighting and UV Laser Development



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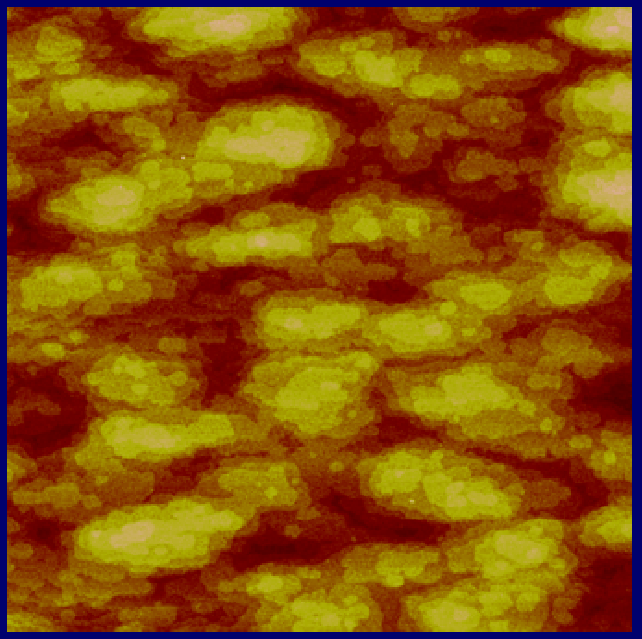
ADVANCED TECHNOLOGY PROGRAM

NIST Laboratories

Materials: Reduction of Strain in Compound Semiconductors

Objective

- Evaluate and improve the structural integrity of buried AlGaAs oxide layers
- Size and shape uniformity of InGaAs on GaAs quantum dots
- Nondestructive ex-situ characterization of InGaAsP/InP heterostructures



AFM images of GaAs buffer layers 500 nm thick grown with pulsed Ga during the first few layers of growth.

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ADVANCED TECHNOLOGY PROGRAM

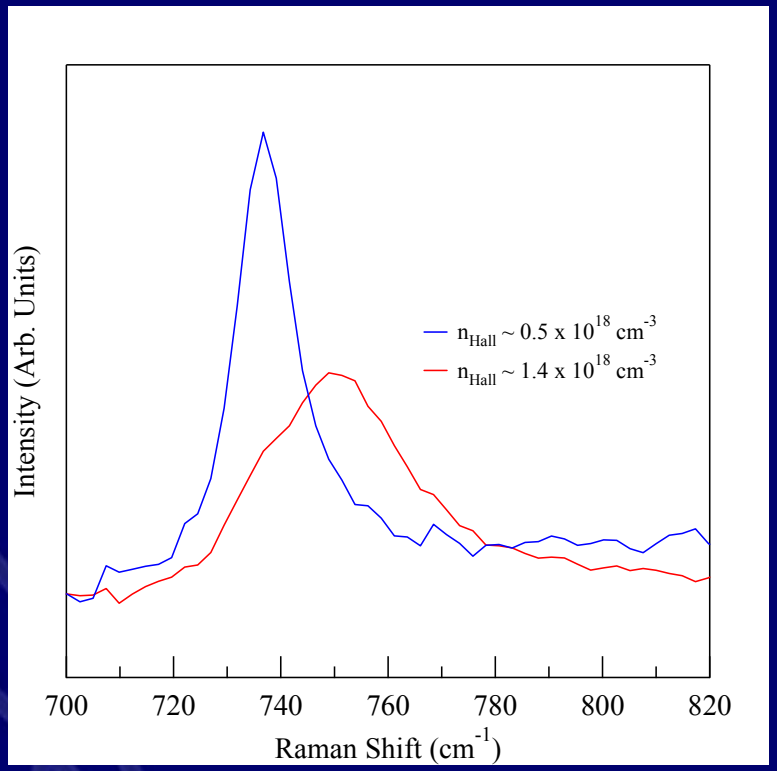
NIST Laboratories

Materials: Non-Contact Electrical Properties Determination

Objective

- Evaluate use of Raman Spectroscopy as a non-contact, non-destructive, and spatially-resolved probe of electrical properties in III-nitride semiconductors .
- Provide guidelines and standard operating procedures useful both for in situ process monitoring and control and for off-line characterization and test.

Raman shift ∝ carrier concentration
Peak width ∝ 1/mobility



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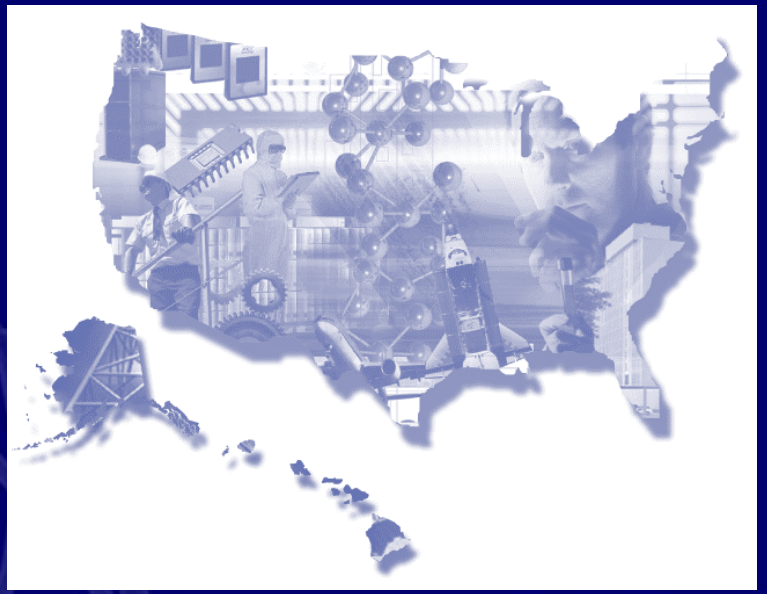
ADVANCED TECHNOLOGY PROGRAM

The Advanced Technology Program (ATP)

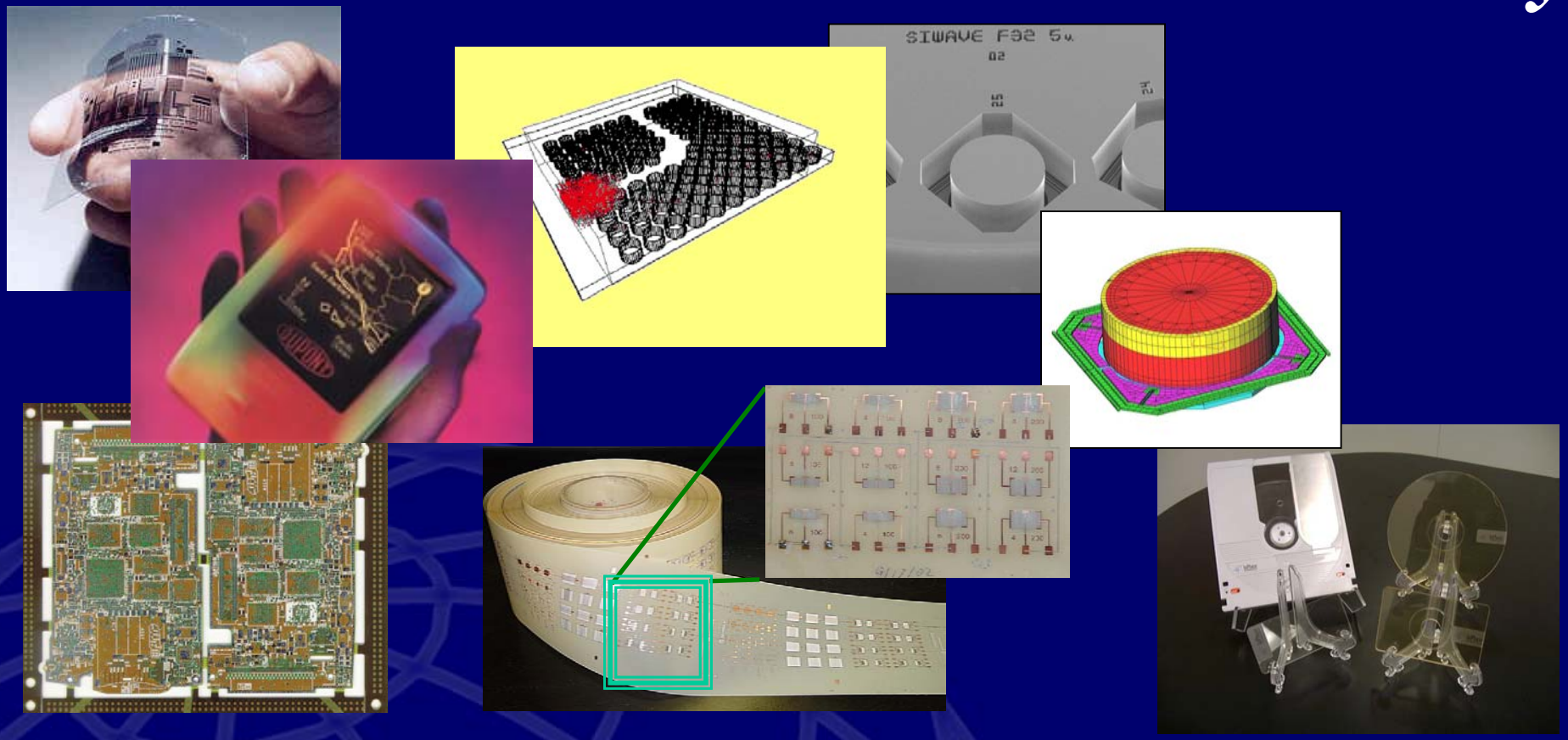
*To **accelerate** the development of **innovative technologies** for **broad national benefit** through **partnerships** with the private sector.*

To Bridge the Gap Between the Laboratory and the Marketplace



ADVANCED TECHNOLOGY PROGRAM

New Technologies for the Nation's Economy



Accelerating... New Ideas, New Technologies, New Markets

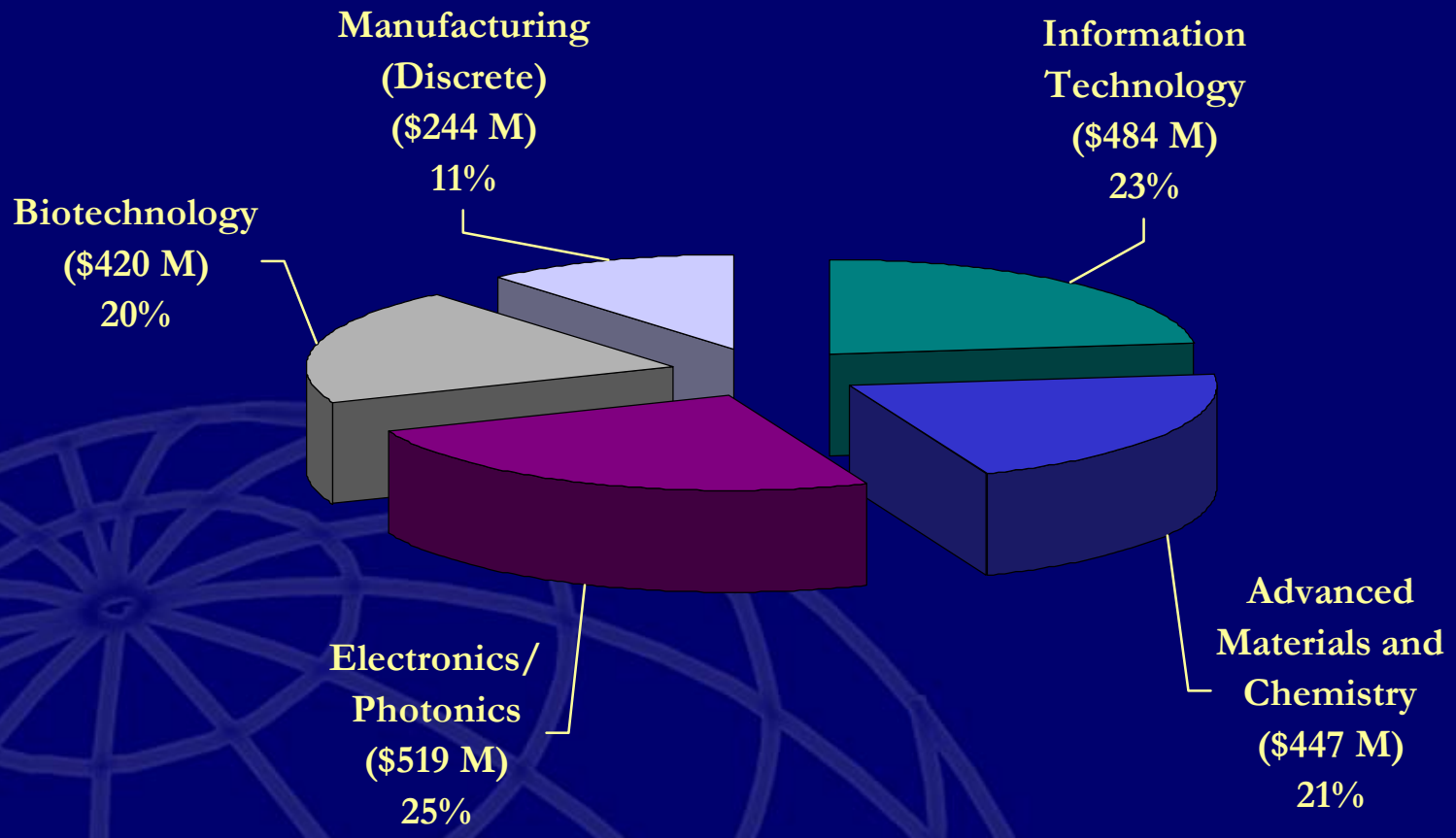
ADVANCED TECHNOLOGY PROGRAM

Fourteen Years of Innovation

- Since 1990, **6,054 proposals** submitted to **43 competitions**, requesting **$12,969 million** from ATP
- **709 projects awarded** with **1,433 participants** and an equal number of subcontractors
- **207 joint ventures** and **502 single companies**
- **$4,101 million** of **high-risk research** funded
  - *ATP share = $2,114 million*
  - *Industry share = $1,987 million*
- **Small businesses are thriving**
  - *65% of projects led by small businesses*
- Over **165 universities** participate
- Over **30 national laboratories** participate

709 ATP Awards by Technology Area

(As a Percent of $2,114 M Awarded)



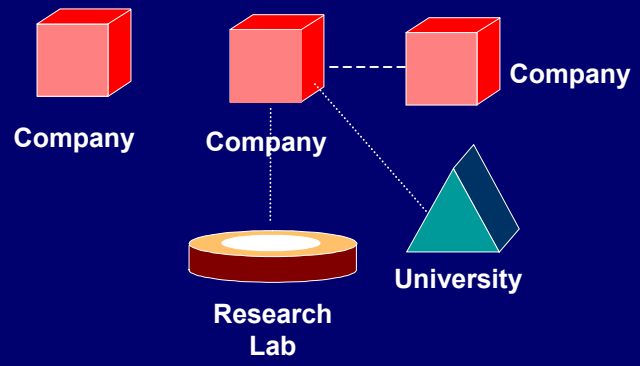
Forty Three Competitions (1990 – September 2003)

ADVANCED TECHNOLOGY PROGRAM

Two Ways to Apply …

As a Single Company:

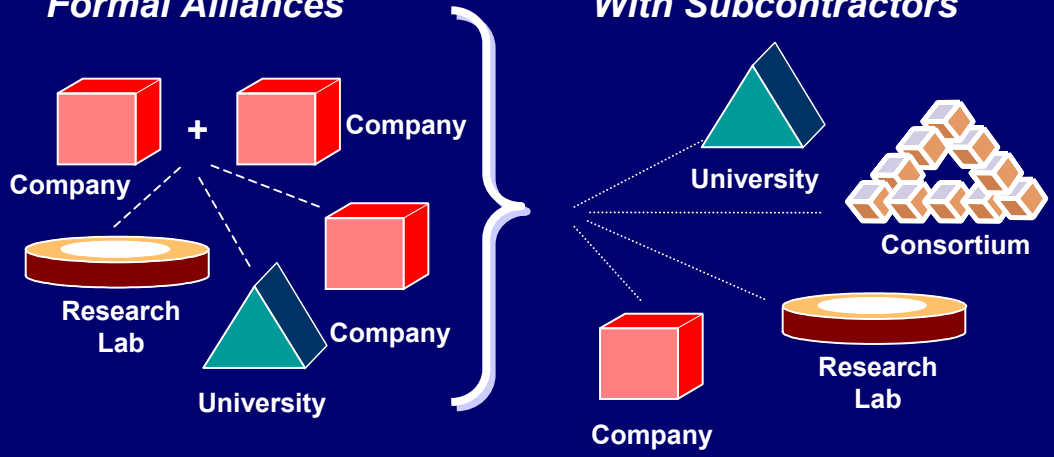
Alone *With Subcontractors*



- For-profit company
- 3-year time limit
- $2M award cap
- Company pays indirect costs
- Large companies cost share at least 60% of total project cost

As a Joint Venture:

Formal Alliances *With Subcontractors*



- At least 2 for-profit companies
- 5-year time limit
- No limit on award amount (other than availability of funds)
- Industry share >50% total cost

- *ATP encourages teaming arrangements*
- *Most projects involve alliances*

ADVANCED TECHNOLOGY PROGRAM

Two Major Criteria

- Scientific and Technological Merit (***50%***)
  - Technical Rationale
    - technological innovation
    - high technical risk & feasibility
  - R&D Plan
- Potential for Broad-Based Economic Benefits (***50%***)
  - National Economic Benefits
  - Need for ATP Funding
  - Pathway to Economic Benefits

ADVANCED TECHNOLOGY PROGRAM

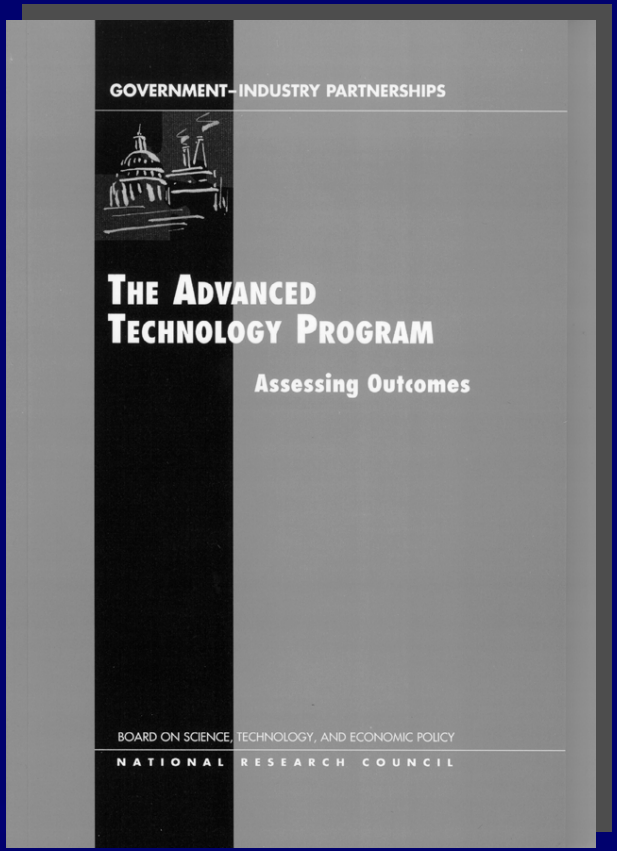
Key Features of the ATP

- Emphasis on innovation for broad national economic benefit
- Industry leadership in planning and implementing projects
- Project selection based on technical and economic merit
- Demonstrated need for ATP funding
- Requirement that projects have well-defined goals/sunset provisions
- Project selection rigorously competitive, based on peer review
- Program evaluation from the outset

ADVANCED TECHNOLOGY PROGRAM

Independent Assessment: National Research Council

- Findings from 2001 NRC Report, *"The Advanced Technology Program: Assessing Outcomes"*
  - Meeting legislative goals
  - Supporting enabling technologies
  - Providing an excellent return on taxpayer investment



ADVANCED TECHNOLOGY PROGRAM

Addressing a National Problem or Need

Evidence

- Federal funding plays a critical role in crossing "Darwinian Sea"
  - ATP represents a more important element in bridging this gap than may have been appreciated
  - VC, State Government and Universities only contribute between 8 and 16% toward early stage technology development
  - ATP and SBIR account for between 21 and 25%

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Aetna Professor of Public Policy
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Kennedy School of Government, Harvard University

Philip E. Auerswald
Assistant Director, Science,
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Kennedy School of Government, Harvard University

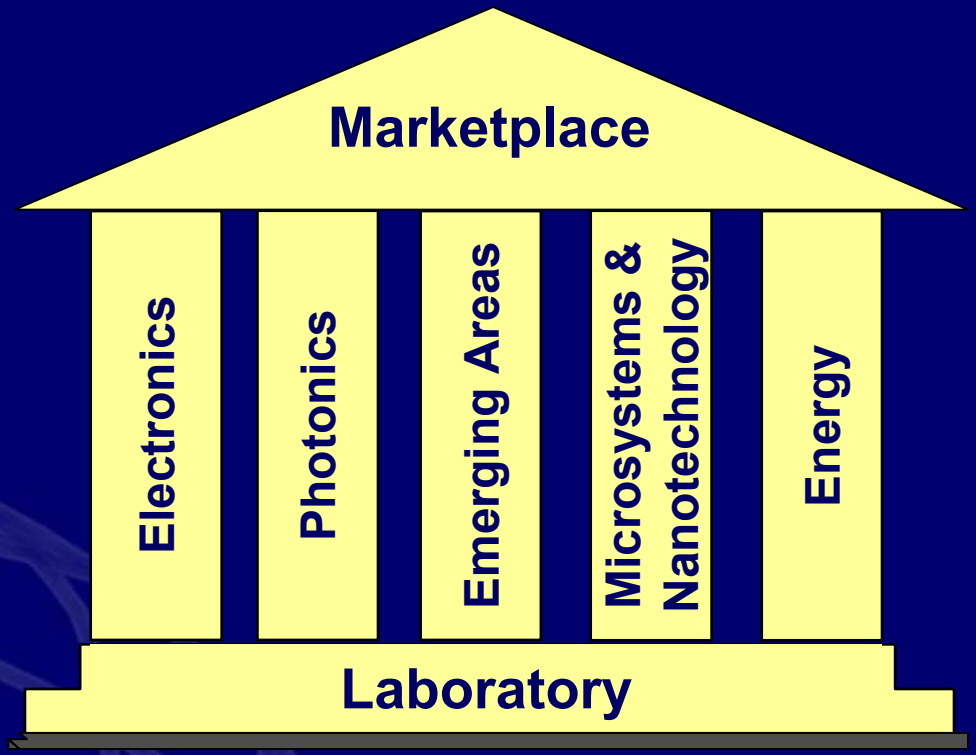
ADVANCED TECHNOLOGY PROGRAM

Current Status

- Congressional appropriations for FY 2003 included $68 million in new awards.
  - Total of 65 awards to date
  - Newest batch (44) announced September 10th
  - Prior batches announced July 1st (16) & May 5th (5)
- FY 2004 appropriations being deliberated within Congress.
  - Large differences exist between House and Senate marks.
- ATP automatically sends out Proposal Kit and announcements to mailing list subscribers

ADVANCED TECHNOLOGY PROGRAM

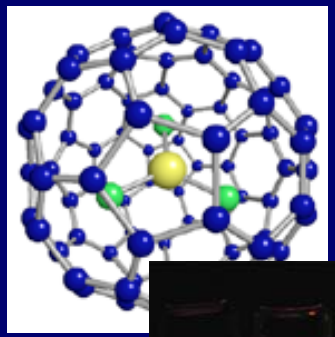
ATP Partnerships in Electronics and Photonics

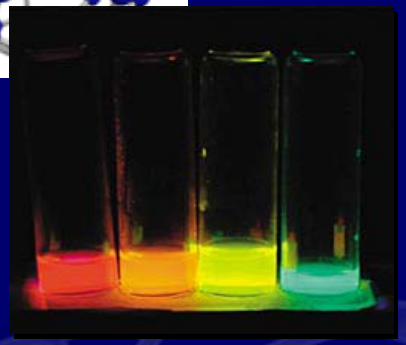


To achieve measurable productivity changes and accelerate new technology introduction into the national economy through advances in electronics, electrical, photonics and information technologies.

ADVANCED TECHNOLOGY PROGRAM

Nanotechnology: An Array of Opportunities





Ongoing ATP Investments

Nanostructured Materials

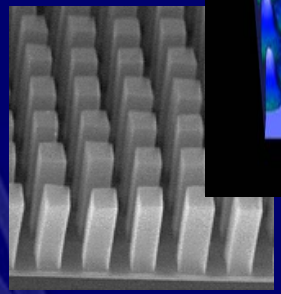
Nanofabrication Techniques & Tools

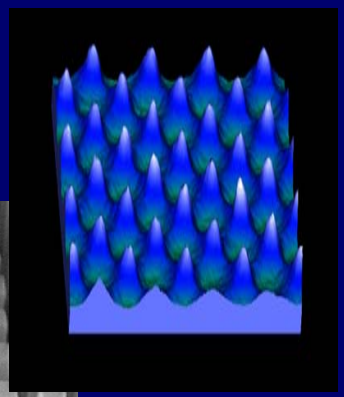
Nanometrology

Nanoelectronics/photonics

Nanodiagnostics

Nanobiotechnology





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Nanotechnology ... since 1991

39 ATP awards in Nanotechnology

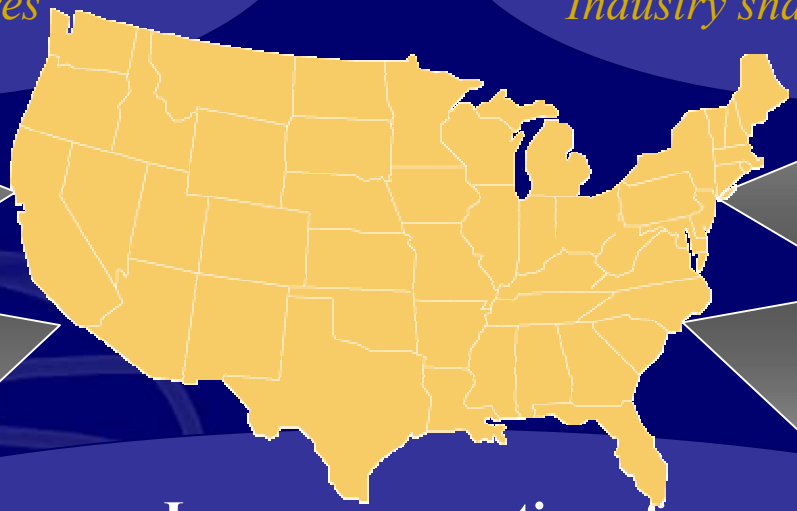
24 Single applicants

15 Joint ventures

Approximately $276 million of high technical risk R&D funded

ATP share = $141.5 million

Industry share = $134.4 million



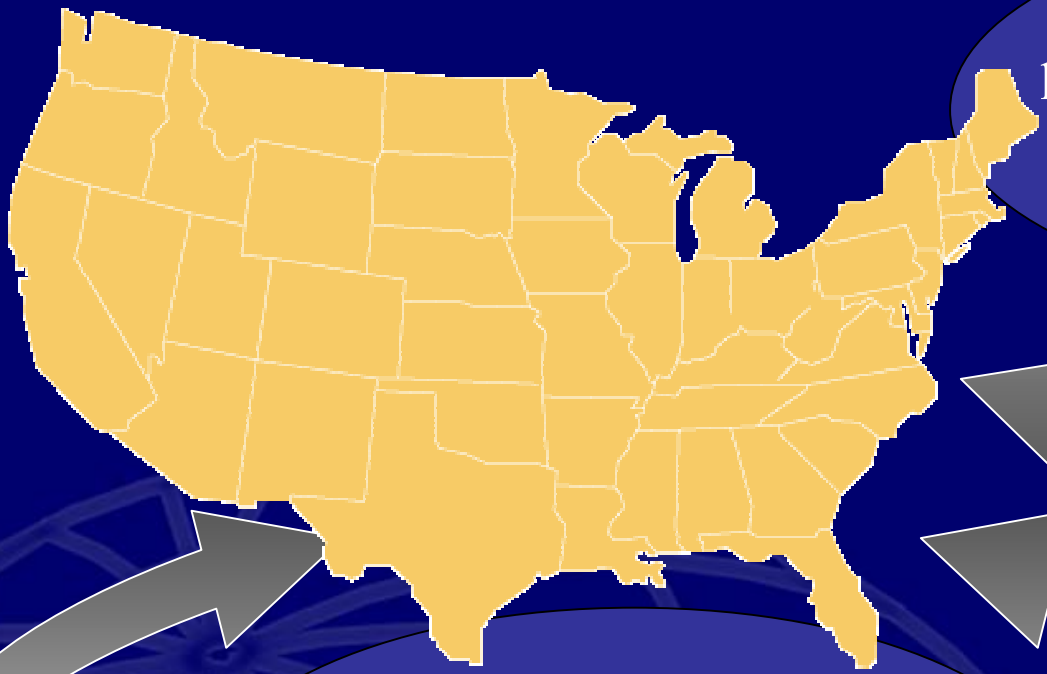
Large cross-section of participants

69 Companies, 2 Non-profits, 4 Universities

Over 90 subcontractors, including 43 universities

ADVANCED TECHNOLOGY PROGRAM

ATP Strengthening America's Photonics Industry … since 1998



Nearly $293 million of high technical risk R&D funded

ATP share = $147 million

Industry share = $146 million

Large cross section of participants

65 Companies, 4 Universities

Plus many subcontractors

ADVANCED TECHNOLOGY PROGRAM

Ongoing Projects in Photonics

Optoelectronics and Lasers

Sensors, Metrology & Inspection

Data Storage

Displays & Imaging

Lighting & Illumination

Bio-photonics

Nanotechnology and Materials

ADVANCED TECHNOLOGY PROGRAM

ATP's Manufacturing Portfolio

Manufacturing / Organic Electronics

Roll-to-Roll Processing to Enable the Organic-Electronics Revolution

General Electric Company, Global Research, Niskayuna, NY

Other Participants: Energy Conversion Devices, Inc. (Rochester Hills, MI)

10/1/2003 - 9/30/2007
Total project budget: $13,061K (est.)
ATP Cost Share: $6,427K (est.)

Project

Revolutionize the electronics industry by developing low-cost roll-to-roll printing technologies for manufacturing large area organic electronic devices.

Potential Impacts

- New manufacturing infrastructure expected to generate $7 billion annually within ten years.
- Enables flexible displays & signage, high-efficiency lighting, embedded sensors, and wearable electronics.
- Helps the U.S. capture the lead in new organic-electronics markets, and save energy through efficient OLED lighting & lower-cost photovoltaics.

ADVANCED TECHNOLOGY PROGRAM

Manufacturing / Solid State Lighting

Manufacturable Solid-State Lighting

Cree Lighting Company (formerly Nitres, Inc./Widegap Technology, LLC), Golita, CA

Other Participants: General Electric Corporate R&D, Schenectady, NY

November 1999 – December 2001

Develop new materials and processing technologies to demonstrate cost-effective manufacturing of white lamps based on light-emitting diodes (LEDs), which could save many millions of dollars in energy costs and open many new markets for LEDs.

Bulk GaN and Homoepitaxial Device Manufacturing

General Electric Company, Global Research, Schenectady, NY

Other Participants: BAE Systems IEWS (formerly Sanders, A Lockheed Martin Co.), Nashua, NH

November 1999 – December 2003

Develop a commercially viable process for producing gallium nitride crystals, an important material for high-performance optoelectronics and electronics, in bulk at low cost.

ADVANCED TECHNOLOGY PROGRAM

Manufacturing / Electronics

Printed Organic Transistors on Plastic for Electronic Displays and Circuits

Sarnoff Corporation, Princeton, NJ

Other Participants: DuPont, Wilmington, Del.; Lucent Technologies, Murray Hill, N.J.

November 2002 to October 2005
Total project budget: $11,489K
ATP Cost Share: $5,734K

Project

Develop and demonstrate printable organic electronic materials and fabrication technologies for low-cost, high-volume production of thin film transistors (TFTs) and displays.

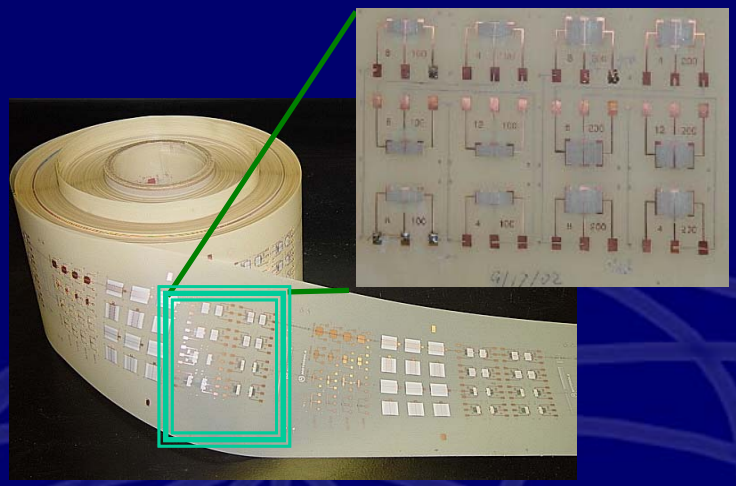
Potential Impacts

- Substantially reduce the cost of active matrix displays and spur the development of new display products.
- Lead to new electronic packaging products.
- Lead to the development of a new industry focusing on ultra low-cost printable electronics.

Printed Organic ASICs: A Disruptive Technology

Motorola, Inc., Schaumburg, IL

Other Participants: Dow Chemical Co., Midland, MI; Xerox XRCC, Mississauga, Canada; PARC, Palo Alto, CA



November 2000 to October 2004
Total project budget: $11,125 K
ATP Cost Share: $5,451 K

Project

Develop novel organic electronic materials and processing technologies for the fabrication of ASIC's using relatively inexpensive printing technologies in lieu of semiconductor lithography.

Potential Impacts

- Enables the production of much less expensive large-area devices using advanced printing techniques.
- Allows for the commercialization of new systems such as electronic paper, displays, smart cards, and automotive electronics, using inexpensive techniques.
- New products could be worth billions of dollars annually and would allow U.S. firms to maintain a technological edge.

ADVANCED TECHNOLOGY PROGRAM

Related Efforts

Continuously Extruded Large Core Fiber

Fiberstars, Inc., Fremont, CA

November 1999 – October 2003

Develop a continuous manufacturing process to produce a new class of very-large-core optical fibers with properties that today are considered mutually exclusive, creating superior performance and cost features to enable lighting systems that are five times more energy efficient than conventional lighting at one-fifth the operating cost.

Ultraminiature Transformer and Inductor Design and Manufacture

BH Electronics, Inc., Burnsville, MN

October 2003 – March 2005

Develop technology for low-cost mass-manufacture of high-frequency electronic transformers and inductors, enabling U.S. production of these commodity components, most of which are now hand manufactured and imported.

ADVANCED TECHNOLOGY PROGRAM

What Can ATP Do for You and the Country?

- Help American companies create a sustainable technical advantage.
  - Set the stage for tomorrow's economic growth
- Drive integration of business and technical planning.
  - Challenge firms to apply best practices
- Provide recognition within industrial, scientific, and financial sectors.
  - Direct the attention of others towards your successes

In return …

- ***Companies own the intellectual property that's developed.***
- ***ATP as a committed, flexible, fair, and firm partner.***

ADVANCED TECHNOLOGY PROGRAM

What does ATP Look For?

- R&D projects that create:
  - Path-breaking technologies that open up new potential markets or make possible wholly new products or industrial processes.
  - Technologies with benefits that extend well beyond the companies involved in the project.
  - Technologies with broad potential applications, particularly across different industrial sectors.

Our bottom line …

Broad benefits for the nation – jobs, economic growth, better quality of life – through innovative R&D.

ADVANCED TECHNOLOGY PROGRAM

For Information on ATP and to Join Our Mailing List . . .

- Call toll-free: 1-800-ATP-FUND (1-800-287-3863)
- Fax your name and address to: 301-926-9524
- Send e-mail to: ***atp@nist.gov***
- Visit ATP's website: ***www.atp.nist.gov/***

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Thank You