

**NANOTECHNOLOGY RESEARCH AND
DEVELOPMENT: THE BIGGEST
LITTLE THING IN TEXAS**

FIELD HEARING
BEFORE THE
COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES
ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

DECEMBER 5, 2003

Serial No. 108-37

Printed for the use of the Committee on Science



Available via the World Wide Web: <http://www.house.gov/science>

U.S. GOVERNMENT PRINTING OFFICE

90-675PS

WASHINGTON : 2004

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512-1800; DC area (202) 512-1800
Fax: (202) 512-2250 Mail: Stop SSOP, Washington, DC 20402-0001

COMMITTEE ON SCIENCE

HON. SHERWOOD L. BOEHLERT, New York, *Chairman*

LAMAR S. SMITH, Texas	RALPH M. HALL, Texas
CURT WELDON, Pennsylvania	BART GORDON, Tennessee
DANA ROHRABACHER, California	JERRY F. COSTELLO, Illinois
JOE BARTON, Texas	EDDIE BERNICE JOHNSON, Texas
KEN CALVERT, California	LYNN C. WOOLSEY, California
NICK SMITH, Michigan	NICK LAMPSON, Texas
ROSCOE G. BARTLETT, Maryland	JOHN B. LARSON, Connecticut
VERNON J. EHLERS, Michigan	MARK UDALL, Colorado
GIL GUTKNECHT, Minnesota	DAVID WU, Oregon
GEORGE R. NETHERCUTT, JR., Washington	MICHAEL M. HONDA, California
FRANK D. LUCAS, Oklahoma	CHRIS BELL, Texas
JUDY BIGGERT, Illinois	BRAD MILLER, North Carolina
WAYNE T. GILCHREST, Maryland	LINCOLN DAVIS, Tennessee
W. TODD AKIN, Missouri	SHEILA JACKSON LEE, Texas
TIMOTHY V. JOHNSON, Illinois	ZOE LOFGREN, California
MELISSA A. HART, Pennsylvania	BRAD SHERMAN, California
JOHN SULLIVAN, Oklahoma	BRIAN BAIRD, Washington
J. RANDY FORBES, Virginia	DENNIS MOORE, Kansas
PHIL GINGREY, Georgia	ANTHONY D. WEINER, New York
ROB BISHOP, Utah	JIM MATHESON, Utah
MICHAEL C. BURGESS, Texas	DENNIS A. CARDOZA, California
JO BONNER, Alabama	VACANCY
TOM FEENEY, Florida	
RANDY NEUGEBAUER, Texas	

CONTENTS

December 5, 2003

Witness List	Page 2
Hearing Charter	3

Opening Statements

Statement by Representative Michael C. Burgess, Member, Committee on Science, U.S. House of Representatives	8
Written Statement	10
Statement by Representative Ralph M. Hall, Minority Ranking Member, Committee on Science, U.S. House of Representatives	12
Written Statement	14

Witnesses:

Dr. Richard F. Reidy, Professor, Department of Materials Science, University of North Texas	
Oral Statement	14
Written Statement	17
Biography	22
Financial Disclosure	23
Dr. Da Hsuan Feng, Vice President for Research and Graduate Education, University of Texas, Dallas	
Oral Statement	24
Written Statement	27
Biography	30
Financial Disclosure	32
Dr. Ronald L. Elsenbaumer, Vice President for Research, University of Texas, Arlington	
Oral Statement	33
Written Statement	35
Biography	36
Financial Disclosure	38
Mr. Christopher J. Gintz, CEO, NanoHoldings, LLC	
Oral Statement	40
Written Statement	41
Biography	42
Financial Disclosure	45
Dr. John Randall, Chief Technology Officer, Vice President of Research, Zyvex Corporation	
Oral Statement	46
Written Statement of Mr. James R. Von Ehr II, Chairman and CEO, Zyvex Corporation	49
Biography	51
Financial Disclosure	52
Discussion	53

NANOTECHNOLOGY RESEARCH AND DEVELOPMENT: THE BIGGEST LITTLE THING IN TEXAS

FRIDAY, DECEMBER 5, 2003

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE,
Washington, DC.

The Committee met, pursuant to call, at 9 a.m., in the reception area of Research Park, University of North Texas Research Park, 3940 Elm Street North, Denton, Texas, Hon. Michael C. Burgess [acting Chairman of the Committee] presiding.

**COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES**

***Nanotechnology Research and Development:
The Biggest Little Thing in Texas***

Friday, December 5, 2003
9:00 – 11:00 AM
University of North Texas Research Park
3940 Elm Street N., Denton, Texas 76203
(Event to be held in the Reception Area of the Research Park)

Witness List

Dr. Rick Reidy
Professor, Department of Materials Science
University of North Texas

Dr. Da Hsuan Feng
Vice President for Research and Graduate Education
University of Texas, Dallas

Dr. Ron Elsenbaumer
Vice President for Research
University of Texas, Arlington

Mr. Chris Gintz
CEO, NanoHoldings, LLC

Dr. John Randall
Chief Technology Officer, Vice President of Research
Zyvex Corporation

Section 210 of the Congressional Accountability Act of 1995 applies the rights and protections covered under the Americans with Disabilities Act of 1990 to the United States Congress. Accordingly, the Committee on Science strives to accommodate/meet the needs of those requiring special assistance. If you need special accommodation, please contact the Committee on Science in advance of the scheduled event (3 days requested) at (202) 225-6371 or FAX (202) 225-0891. Should you need Committee materials in alternative formats, please contact the Committee as noted above.

HEARING CHARTER

**COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES****Nanotechnology Research and
Development: The Biggest
Little Thing in Texas**

FRIDAY, DECEMBER 5, 2003
9:00 A.M.—11:00 P.M.
UNIVERSITY OF NORTH TEXAS RESEARCH PARK
3940 ELM STREET N., DENTON, TEXAS 76203

1. Purpose

On Friday, December 5, 2003, at 9:00 a.m., the House Science Committee will hold a hearing to examine the emerging nanotechnology industry and the value of research and development programs to job creation and economic development within the U.S. nanotechnology sector.

2. Witnesses

Dr. Rick Reidy, Professor of Materials Science and Engineering, University of North Texas. Dr. Reidy has a Ph.D. in Metals Science and Engineering from Penn State University and B.A. in Chemistry/Biochemistry from Rice University. Before joining the University of North Texas, he worked on nanoporous films for chemical weapons detection at the U.S. Army Chemical and Biological Defense Command, Aberdeen, MD. He is currently developing nanostructured materials and processing methods for semiconductor applications supported by the National Science Foundation, Texas Instruments, and International Sematech.

Dr. Da Hsuan Feng, Vice President for Research and Graduate Education, University of Texas, Dallas. Dr. Feng has a doctorate degree in Theoretical Physics from the University of Minnesota. Since coming to UTD, he has worked to rapidly build the research breadth and depth of the University to make it a major international research university. Dr. Feng is responsible for recruiting much of UTD's nanoscience researchers.

Dr. Ron Elsenbaumer, Vice President for Research, University of Texas, Arlington. Dr. Elsenbaumer has a Ph.D. from Stanford University and a B.S. from Purdue University. His primary research interests include developing new conductive polymer compositions and developing quantitative group additivity principles for constructing conjugating conductive polymers with predictable optical, electrical, and electrochemical properties.

Mr. Chris Gintz, CEO, NanoHoldings, LLC. Mr. Gintz is a well-known designer, marketer and executive in the computer industry, whose experience spans the semiconductor, software and hardware businesses. He is the inventor of the Compaq LTE notebook computer concept and, since 1995, he has been a force behind the incorporation of software technology into school curriculums across the United States.

Dr. John Randall, Chief Technology Officer, Vice President of Research, Zyvex Corporation. Dr. Randall has a Ph.D. in Electrical Engineering from the University of Houston. He has over twenty years of experience in micro- and nanofabrication. He joined Zyvex in March of 2001 after fifteen years at Texas Instruments where he worked in high resolution processing for integrated circuits, MEMS, and quantum effect devices. Prior to working at TI, Dr. Randall worked at MIT's Lincoln Laboratory on ion beam and x-ray lithography.

3. Overarching Questions

The hearing will address the following overarching questions:

1. What is the state of nanotechnology science and engineering? What is the potential for nanotechnology advancements to contribute to future economic growth across various industries, and what challenges exist that may slow or limit this growth?

2. What is the status of private sector investment in nanotechnology research and development? How can the National Nanotechnology Initiative (NNI) and university-industry research partnerships best accelerate commercial applications of nanotechnology by industry?
3. Is the U.S. education system currently producing an adequate number of people with the skills needed to conduct research in nanotechnology and to work in industry on the commercialization of nanotechnology applications? What is the long-term outlook for the nanotechnology workforce, and what types of policies will help the U.S. education system to produce a workforce that meets these demands?

4. Brief Overview

- Nanotechnology is the science of manipulating and characterizing matter at the atomic and molecular level. It is one of the most promising and exciting fields of science today, involving a multitude of science and engineering disciplines, with widespread applications in electronics, advanced materials, medicine, and information technology. For example, nanotechnology likely represents the future of information processing and storage, as computer chips and magnetic disk drive components will increasingly depend on nanotechnology innovations.
- The impact that nanotechnology is currently having on new and existing industries is significant, but the potential for the future is enormous. The National Science Foundation estimates that nanotechnology will have a one trillion dollar impact on the global economy in the next decade. Existing industries, including those not typically characterized as “high tech”, are likely to see their product lines and the way they manufacture them influenced by our growing knowledge in nanotechnology.
- At a hearing before the House Science Committee in March 2003, witnesses testified that just five years ago, there was very little private interest in the nanotechnology research and development (R&D). Today, private investment is in the billions of dollars, with most Fortune 500 companies now funding at least some nanotechnology R&D, and venture capitalists providing almost \$500 million to nanotechnology start-up companies in 2002 alone.
- The National Nanotechnology Initiative (NNI) is an \$849 million research initiative (fiscal year 2004 request) involving 10 federal agencies—and one of the President’s most significant new commitments to continued U.S. leadership in science and technology. The Science Committee has made nanotechnology R&D among its top priorities for 2003, working to strengthen the focus and funding of the NNI.
- On February 13, 2003, Chairman Sherwood Boehlert (R-NY) and Representative Mike Honda (D-CA) introduced H.R. 766, the *Nanotechnology Research and Development Act of 2003*, which authorizes a federal nanotechnology R&D program, thus assuring stable, long-term support. The bill also authorizes appropriations for nanotechnology R&D in those agencies within the Science Committee’s jurisdiction that currently participate in the NNI. A companion bill, S. 189, was introduced in the Senate by Senator George Allen (R-VA) and Senator Ron Wyden (D-OR). A final compromise of the two versions, the *21st Century Nanotechnology Research and Development Act*, passed both chambers of Congress and is expected to be signed by the President very soon.
- The legislation supports the President’s initiative and adds review and oversight mechanisms to assure that new funds are used in the most effective manner possible. It also addresses a number of the recommendations that were raised in a comprehensive report by the National Academy of Sciences and other outside experts.

7. Background

A recent National Academy of Sciences report describes nanotechnology as the “. . .relatively new ability to manipulate and characterize matter at the level of single atoms and small groups of atoms. . . .This capability has led to the astonishing discovery that clusters of small numbers of atoms or molecules often have properties—such as strength, electrical resistivity, electrical conductivity, and optical absorption—that are significantly different from the properties of the same matter at either the single-molecule scale or the bulk scale.” Scientists and engineers anticipate that nanotechnology will lead to “materials and systems with dramatic new properties relevant to virtually every sector of the economy, such as medicine, tele-

communications, and computers, and to areas of national interest such as homeland security.”

A variety of nanotechnology products are already in development or on the market, including stain-resistant, wrinkle-free pants and ultraviolet-light blocking sunscreens. Other applications involve Kodak’s use of scratch-free, transparent coatings and Samsung’s new high-brightness displays. Experts agree that more revolutionary products will emerge from nanotechnology research currently underway. Many small start-up companies have been founded to develop new technologies and new products based on breakthroughs in our understanding of materials at the atomic and molecular level.

The National Nanotechnology Initiative

The National Nanotechnology Initiative (NNI), formally established in 2001, is the President’s most ambitious interagency interdisciplinary science and technology program. Ten federal agencies actively participate in research and development efforts that involve physicists, chemists, biologists, engineers, and researchers from many other disciplines. The initiative has grown rapidly from an initial budget request of \$464 million in fiscal year 2001 to the \$849 million requested for fiscal year 2004 (although these numbers are not strictly comparable as some ongoing research programs have, over time, evolved into nanotechnology research).

While each agency involved in the NNI focuses its research on that agency’s unique mission, the overall effort is organized at the White House level through the articulation of Grand Challenges—or broad, mission-related, technical goals. These include nanotechnology-based innovations in manufacturing, energy production and storage, information technology, medicine, robotics, aeronautics, and defense and homeland security applications.

Recognizing the inherently interdisciplinary nature of nanotechnology science and engineering, the NNI supports research through nanotechnology centers and user facilities, designed to bring researchers from multiple disciplines together, as well as through grants to individual researchers and groups of researchers. The National Science Foundation (NSF), the Department of Energy, and the National Aeronautics and Space Administration (NASA) currently sponsor, or are in the process of establishing, a number of nanotechnology research centers and user facilities around the country. Among the NSF-supported centers, some are focused on specific industries, such as the Center for Nanoscale Systems in Information Technologies at Cornell University. Others are national user facilities, such as the nanofabrication facilities at Stanford University and Pennsylvania State University, and one, the Center on Biological and Environmental Nanotechnology at Rice University, conducts research on the societal implications of nanotechnology development.

The overall federal effort is coordinated by the National Science and Technology Council’s (White House coordinating council composed of the heads of the major research agencies) Subcommittee on Nanoscale Science, Engineering and Technology (NSET), which has responsibility for interagency planning and review. While each agency consults with the NSET Subcommittee, the agency retains control over how resources are allocated against its proposed NNI plan. Each agency then uses its own methods for inviting and evaluating research proposals.

Table 1. National Nanotechnology Initiative Funding (\$\$ Millions)

NNI AGENCY	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Enacted	FY 2004 Requested
NSF	150	199	221	249
DOD	123	180	243	222
DOE	88	91	133	197
NIH	40	41	65	70
DOC	33	38	69	62
NASA	22	46	33	31
USDA	2	2	1	10
EPA	5	--	6	5
DHS (FAA/TSA)	--	2	2	2
DOJ	1	1	1	1
TOTAL	464	600	774	849

Acronyms: NSF—National Science Foundation; DOD—Department of Defense; DOE—Department of Energy; NIH—National Institutes of Health; DOC—Department of Commerce; NASA—National Aeronautics and Space Administration; USDA—U.S. Department of Agriculture; EPA—Environmental Protection Agency; DHS—Department of Homeland Security; DOJ—Department of Justice.

The 21st Century Nanotechnology Research and Development Act

This legislation, a House-Senate compromise of H.R. 766 and S. 189, would cement U.S. economic and technical leadership in nanotechnology by assuring stable, long-term support for nanotechnology research and facilitating the commercialization of nanotechnology applications. The bill establishes an interagency research and development (R&D) program to promote and coordinate federal support of nanotechnology R&D, including grants to researchers and the establishment of interdisciplinary research centers and advanced technology user facilities. The bill also emphasizes the need to perform research into the ethical, legal, environmental, and other appropriate societal concerns related to nanotechnology, to educate the public about nanotechnology, and to involve the public in the debate. The bill aims to protect taxpayers by adding oversight mechanisms—an interagency committee to coordinate the program across multiple agencies, an annual report to Congress, a strategic plan for the program, an advisory panel, and external reviews—to assure funds are spent wisely. The bill authorizes approximately \$3.7 billion of funding at five agencies over four years.

Table 2. Nanotechnology Funding History and Funding Authorized by H.R. 766

AGENCY	FY 2001 Enacted	FY 2002 Enacted	FY 2003 Enacted	FY 2004 Requested	H.R. 766 FY04	H.R. 766 FY05	H.R. 766 FY06
NSF	150	199	221	249	350	385	424
DOE	88	91	133	197	265	292	322
NIST	33	38	69	62	62	68	75
NASA	22	46	33	31	31	34	37
EPA	5	--	6	5	5	5.5	6
TOTAL	298	382	462	544	713	784.5	864

Note: While H.R. 766 authorizes into law a national nanotechnology R&D program to include all participating agencies as designated by the President, appropriations are authorized only for those agencies within the jurisdiction of the Science Committee.

8. Witness Questions

Questions for university witnesses:

- How significant of an impact will nanotechnology have on U.S. economic growth and job creation in the coming decades? In what industry areas will

the impact be most dramatic? What challenges exist that may slow or limit the growth and influence of nanotechnology?

- What in your experience are the best practices to help facilitate the transfer of basic research results to industry? To what extent has your university partnered with industry on nanotechnology research and development challenges, and how can such collaborations be made more effective?
- Has federal support for your research been effective at helping your university achieve its goals? How might Congress strengthen the structure, funding levels, and focus of the National Nanotechnology Initiative?
- Is the U.S. education system currently producing an adequate number of people with the skills needed to conduct research in nanotechnology and to work in industry on the commercialization of nanotechnology applications? What is the longer-term outlook for the nanotechnology workforce, and what changes, if any, should be made to the current education system to ensure these workforce needs are met?

Questions for industry witnesses:

- How significant of an impact will nanotechnology have on U.S. economic growth and job creation in the coming decades? How will nanotechnology influence the industry areas in which your company is most active? What challenges exist that may slow or limit the growth and influence of nanotechnology?
- What is the appropriate federal role in fostering and accelerating the deployment and application of basic nanotechnology research and development by the private sector? How might Congress strengthen the structure, funding levels, and focus of the National Nanotechnology Initiative?
- To what extent is your company involved in research collaborations with universities, and how can such collaborations be made more effective?
- Is the U.S. education system currently producing an adequate number of people with the skills needed to conduct research in nanotechnology and to work in industry on the commercialization of nanotechnology applications? What is the longer-term outlook for the nanotechnology workforce, and what changes, if any, should be made to the current education system to ensure these workforce needs are met?

Chairman BURGESS [presiding]. All right. We do want to be respectful of everyone's time, so we'll try to start on time. Mr. Hall, we'll have you out of here by 11 a.m. Probably during the course of this meeting we will not take—since we are so brief, we probably won't take recesses. So anyone who needs to excuse themselves for a moment or two, that's certainly understandable.

This is the House Science Field Hearing on Nanotechnology. I want to first start off today's hearing by thanking all of those in attendance on our panel's witness list and taking time out of their busy schedules to be here today. I'd also like to thank in absentia Representative Sherwood Boehlert, the Chairman of the House Science Committee, and Representative Nick Smith, who's the Chairman of the House Committee on Science—Nick Smith, who is the Chairman of the Research Subcommittee on Science, for helping making this hearing happen.

Our title for today's hearing is "Nanotechnology R&D: The Biggest Little Thing in Texas," and it's especially appropriate as we sit here in this wonderful facility devoted to research of applied technology based on nanotechnology. The President signed the 21st Century Nanotechnology Research and Development Act into law just two days ago, so our field hearing today is perfectly timed to show how North Texas is and will continue to be the leader in this field.

Here at the Center for Advanced Research and Technology, the University of North Texas, along with federal agencies and private businesses, is working to establish a world class research park that satisfies the growing technological and engineering needs of the North Texas region. This center may well serve as a national nanotechnology shrine acting as an epicenter for the ground breaking developments in materials, computer and the engineering science fields.

One of the most exciting developments here at the Center for Advanced Research and Technology has been the work of several different partners in establishing nanometrology. The University of North Texas continues to invest millions of dollars into this facility. The University funds are on top of future Department of Defense appropriations recently awarded at over \$3 million. The funding will provide facility upgrades and equipment purchases. Corporate partnerships, such as the one with Texas Instruments, have also been critical to the Center's success. The University of North Texas is not the only institution of higher education working to develop similar scientific capabilities here in North Texas. The University of Texas at Arlington and the University of Texas at Dallas have helped to firmly establish the North Texas area as the leading area in nanotechnology research and development.

More and more professionals in this field, and indeed those like myself that hold elected office, are coming to understand the vital need to fully integrate government, business and academic nanotechnology R&D activities. Just recently the United States Congress approved legislation that will chart a path for future developments in this field.

This bill, the 21st Century Nanotechnology Research and Development Act, will give policy makers, scientists and the business community a framework to identify the grand challenges of

nanoscience. The bill will provide a scientific and ethical compass for those in the field. The new National Nanotechnology Research Program authorized by this bill will help foster interdisciplinary research in this exciting new science.

The overarching questions that the hearing wants to address today: What is the state of nanotechnology science and engineering? What is the potential for nanotechnology advancements to contribute to the future economic growth across various industries? And what challenges exist that may slow or limit this growth?

Secondly, what is the status of the private sector investment in nanotechnology research and development? How can the National Nanotechnology Initiative and the university/industry research partnerships best accelerate commercial applications of nanotechnology by industry? And, thirdly, is the United States educational system currently producing an adequate number of people with the skills needed to conduct research in nanotechnology and to work in the industry of commercialization of those applications? What is the long-term outlook for the nanotechnology work force and what types of policies will help the United States education system to produce a work force that must meet these demands?

Being here this morning we are reminded of how critical interdisciplinary research can be, especially in the small science. Just recently we can point to an example where the intersection of mechanical engineering, bioengineering, pharmacology, medicine and surgery quietly and completely joined together to give two young children a chance at a much brighter future. Ahmed and Mohamed Ibrahim are two formerly conjoined twins that underwent a remarkable separation procedure at Children's Medical Center of Dallas not too far from here. Everyone at Children's was involved in the effort, from the doctors, the nurses, the technicians, to theoretical and practical professionals who developed the specialized operating room table, their monitors and the medicines. Perhaps most importantly were individuals from both private and public sector entities who pushed the research and development of these incredible new devices, devices that are smaller and much more precise. Without them the miracle at Dallas Children's Hospital may not have been possible.

Examples such as these are reminders of how important it is to continue pushing the envelope when it comes to nanoscience. This is a field that will impact all of our lives in profound yet unknown ways. Today I'm proud to introduce a very distinguished panel of nanotechnology experts from right here at home.

Dr. Rick Reidy, Professor of Materials Science and Engineering here at the University of North Texas. Dr. Reidy has a Ph.D. in Metals Science and Engineering from Penn State University and a Bachelor's Degree in Chemistry and Biochemistry from Rice University. Before joining the University of North Texas, he worked on nanoporous films for chemical weapons detection at the U.S. Army Chemical and Biological Defense Command in Aberdeen, Maryland. He is currently developing nanostructured materials and processing methods for semiconductor applications supported by the National Science Foundation, Texas Instruments and International Sematech.

Dr. Feng, Vice President for Research and Graduate Education at the University of Texas at Dallas. Dr. Feng has a doctorate degree in Theoretical Physics from the University of Minnesota and I understand an honorary degree from the University of Peking in China. Since coming to the University of Texas at Dallas, he has worked rapidly to build the research breadth and depth of the University to make an international research facility. Dr. Feng is responsible for recruiting much of UTD's nanoscience researchers.

Dr. Ron Elsenbaumer, Vice President for Research at the University of Texas at Arlington. Dr. Elsenbaumer has a Ph.D. from Stanford University and a B.S. from Purdue. His primary research interests include developing new conductive polymer compositions and developing quantitative group additivity principles for constructing conjugating conductive polymers with predictable optical, electrical and electrochemical properties.

Mr. Chris Gintz, Chief Executive Officer of NanoHoldings, LLC. Mr. Gintz is a well-known designer, marketer and executive in the computer industry whose experience spans the semiconductor, software and hardware businesses. He is the inventor of the Compaq LTE notebook computer concept, and since 1995 he's been a force behind the incorporation of software technology into school curricula across the United States.

Dr. John Randall, Chief Technology Officer and Vice President of Research, Zyvex Corporation. Dr. Randall has a Ph.D. in Electrical Engineering from the University of Houston. He has over 20 years of experience in micro- and nanofabrication. He joined Zyvex in March of 2001 after 15 years at Texas Instruments where he worked in high resolution processing for integrated circuits and quantum effect devices. Prior to working at Texas Instruments, Dr. Randall worked at the Massachusetts Institute of Technology's Lincoln Laboratory on ion beam and x-ray lithography.

And then of course the red light's on. I need to turn the microphone over to my distinguished colleague, the Ranking Member on the Science Committee, Mr. Ralph Hall, for his opening remarks. [The prepared statement of Mr. Burgess follows:]

PREPARED STATEMENT OF REPRESENTATIVE MICHAEL C. BURGESS

I want to first start off by thanking all those in attendance and our panel of witnesses for being here today. I'd also like to thank Sherwood Boehlert, Chairman for the Full Science Committee, and Nick Smith, Chairman of the Research Subcommittee for helping make this hearing happen. Our title for today's hearing, "Nanotechnology R&D: The Biggest Little Thing in Texas" is especially appropriate as we sit here in this premier facility devoted to the research of applied technology based on nanotechnology.

Here at the Center for Advanced Research and Technology, the University of North Texas, along with federal agencies and private businesses, are working to establish a world-premier research park that will satisfy the growing technological and engineering needs of the North Texas region. This center will serve a national goal as well, acting as an epicenter for ground-breaking developments in materials, computer, and engineering scientific fields. One of the most exciting developments here at CART has been the work by several different partners to establish a Nanometrology Laboratory. The University of North Texas has already and will continue to invest millions of dollars into this facility, along with a future Department of Defense grant of over \$3 million to continue facility upgrades and equipment purchases. Corporate partnerships, such as the one with Texas Instruments, Inc. have also been critical to the Center's success.

UNT is not the only institution of higher education working to develop similar scientific capabilities here in North Texas. The University of Texas at Arlington and

the University of Texas at Dallas have helped firmly establish North Texas as a leading area for nanotechnology research and development.

More and more professionals in this field, and indeed those like myself that hold elected office, are coming to understand the vital need to fully integrate government, business, and academic nanotechnology R&D activities. Just recently, the U.S. Congress approved legislation that will chart a path for future developments in this field. This bill, the *21st Century Nanotechnology Research and Development Act*, will give policy-makers, scientists, and the business community a framework to identify the grand challenges of nanoscience, and provide a scientific and ethical compass for those in the field. The new National Nanotechnology Research Program authorized by this bill will help foster interdisciplinary research in this exciting new science.

Being here today, we are reminded how critical interdisciplinary research can be, especially in the “small science.” Just recently, we can point to an example where the intersection of mechanical engineering, bioengineering, pharmacology, medicine and surgery quietly and completely joined together to give two young children a chance at a much brighter future. Ahmed and Mohamed Ibrahim are two formerly conjoined twins that underwent a remarkable separation procedure at Children’s Medical Center of Dallas, not too far from here. Everyone at Children’s Medical Center was involved in the effort—from doctors, nurses and technicians, to the theoretical and practical professionals who developed the specialized O.R. table, monitors and medicines. Perhaps most importantly were the individuals from both the private and public sector entities who pushed the research and development of the incredible new devices—devices that are smaller and much more precise. Without them, the miracle at Dallas’ Children’s Hospital may not have been possible.

Examples such as these are reminders of how important it to continue pushing the envelope when it comes to nanoscience. This is a field that will impact all of our lives in profound and yet unknown ways. Today I’m proud to introduce a very distinguished panel of nanotechnology experts from right here in Texas. . .

Dr. Rick Reidy, Professor of Materials Science and Engineering, University of North Texas. Dr. Reidy has a Ph.D. in Metals Science and Engineering from Penn State University and B.A. in Chemistry/Biochemistry from Rice University. Before joining the University of North Texas, he worked on nanoporous films for chemical weapons detection at the U.S. Army Chemical and Biological Defense Command, Aberdeen, MD. He is currently developing nanostructured materials and processing methods for semiconductor applications supported by the National Science Foundation, Texas Instruments, and International Sematech.

Also joining us is **Dr. Da Hsuan Feng**, Vice President for Research and Graduate Education, University of Texas, Dallas. Dr. Feng has a doctorate degree in Theoretical Physics from the University of Minnesota. Since coming to UTD, he has worked to rapidly build the research breath and depth of the University to make it a major international research university. Dr. Feng is responsible for recruiting much of UTD’s nanoscience researchers.

Dr. Ron Elsenbaumer is the Vice President for Research at the University of Texas, Arlington. Dr. Elsenbaumer has a Ph.D. from Stanford University and a B.S. from Purdue University. His primary research interests include developing new conductive polymer compositions and developing quantitative group additivity principles for constructing conjugating conductive polymers with predictable optical, electrical, and electrochemical properties.

We also have **Mr. Chris Gintz**, CEO of NanoHoldings, LLC. Mr. Gintz is a well-known designer, marketer and executive in the computer industry, whose experience spans the semiconductor, software and hardware businesses. He is the inventor of the Compaq LTE notebook computer concept and, and since 1995, he has been a force behind the incorporation of software technology into school curriculums across the United States.

And finally, we have **Dr. John Randall**, Chief Technology Officer and Vice President of Research at Zyvex Corporation. Dr. Randall has a Ph.D. in Electrical Engineering from the University of Houston. He has over twenty years of experience in micro- and nanofabrication. He joined Zyvex in March of 2001 after fifteen years at Texas Instruments where he worked in high resolution processing for integrated circuits, MEMS, and quantum effect devices. Prior to working at TI, Dr. Randall worked at MIT’s Lincoln Laboratory on ion beam and x-ray lithography.

I look forward to hearing your testimony and entertaining our questions toward the conclusion of the hearing.

Thank you and now I'll turn over the microphone to my distinguished colleague, Ralph Hall, for his opening remarks. Mr. Hall.

Mr. HALL. Thank you, Mike. appreciate it, and I'm honored to be here, and I'll be brief. You've covered the waterfront as usual. We have a distinguished panel here. I would respect all of them. I would not have liked any of them because it's guys like you, and women like you, that ruined the curve for me when I was at SMU and University of Texas.

[Laughter.]

We're honored to have your time because we know you're not only giving this time today but it took some time to get here, it took some time to prepare for this, and you're generous to let the Chairman here have the benefit of your knowledge and answer some questions that we will have, that will be part of the record, that will be submitted to each Member of our Committee. Mike will see that the Republicans have it, and I'll see that the Democrats have it, and for any of the Republicans that can't read it, I'll have some of my Democrats read it to them.

[Laughter.]

Seriously, it's an honor to be here with the doctor. He's not only a good guy, he's a great doctor, he's a fine Member of Congress and one that we all admire and respect. But that doesn't mean anything because I even like Dick Armev.

Let me just be very brief with my statement because I know we need to hear the testimony. Of course I'm pleased to be here, and we're at a threshold of an age of materials that can be fashioned, as they say, atom by atom. As a result of the growing capability, the new materials can be designed with specified and often very novel characteristics to satisfy specific purposes. There are really huge consequences for this pursuit for industry, for manufacturers, for medicine and for health. A lot of you are aware that the Science Committee's been working to develop some bipartisan legislation, and that's the way the Science Committee operates. Just as Mike and I are working together here today and support one another, we work together up there, believe it or not, Republicans and Democrats. We had very few split votes up there.

We work things out and Sherry Boehlert is the Chairman and I'm Ranking Democrat. We sit right side by side and we're an unusual pair because I represent the Democratic side of it and Sherry represents the Republican side, but I can get more votes off the Republican side than Sherry can, and he can get more votes off the Democratic side than I can, because Sherry is kind of a liberal Republican and I'm a conservative Democrat. The book on us is that I keep him from spending all the money on saving the whales, and he keeps me from drilling on cemetery lots.

[Laughter.]

There's good offset there for all of us, and the Doc referees up there usually. But it's an interesting committee, but Boehlert is a very intelligent and a probing-type Chairman and a fair Chairman that gives us input.

I'm glad to see Dr. Feng. I've worked on many situations with him, and I've admired him from afar and from up close. I've seen him in testimony before committees in Washington, I've seen him working with various industries to promote what Jeremy Bethum

called the greatest good for the greatest number, and that's after all what we're here to do today.

As a lot of you are aware, the Science Committee did work that as a bipartisan piece of legislation. I think it passed overwhelmingly. It may have even passed by a voice vote when we passed out of the House and out of our subcommittees. But it passed both Houses of Congress, and this week it was signed into law by the President. Did you go up and see him sign it? I didn't either. He called my house early the morning that he was to sign it, and that's giving me an awful lot of notice.

Chairman BURGESS. At least you got a call.

[Laughter.]

Mr. HALL. I didn't get to go up there. Well, he called me one time before he signed the trade bill, and he called me that time because that trade bill passed the first time, and the most important vote we had on it was a 215 to 214 vote, and you can imagine how many of us claimed we were that 215th vote, but I certainly laid claim to that and I made him believe that maybe I was the one that passed it. So he called me to come watch him sign it. I asked him then—I didn't ask him, I asked Andrew Card who was with him, "Well, when's he going to sign," and he said, "This afternoon at 2 o'clock." I had on jeans and boots that weren't clean boots and I was about an hour and 15 minutes from the airport and he was going to sign at 2 o'clock, and I said, "Well, I just can't come," and the President said, "Well, if you'll come, I'll give you a ride back." Well, not being accustomed to riding on Air Force One I decided that I'd try to make it.

I broke and ran with the boots and jeans and the dirty shirt and old jacket I had on thinking that I'd get to my apartment and change clothes and get over there in time for the signing. Well, I got there in time, I got to my apartment, and my son, one of my sons had been there the week before in my apartment, driving my car and had taken the keys off that go to the apartment and left them inside the apartment. I couldn't get in to change clothes and I couldn't go to the White House with the way my boots looked. First, they wouldn't have let me track in there.

Anyway, I didn't go and see the signing but I did meet him out at the airport to ride home. And, Mike, first thing he asked me—I had him for about an hour and a half or two hours there just to pound him with every kind of question, suggestion I wanted to. I've known him since he was 11. I didn't think then he'd ever be President. And I knew him when he was 21, and I was positive then he wasn't going to be President. But I think we have a good President, and I think it's high time that Republicans and Democrats, liberals, conservatives unite behind him, support him. We're a nation at war with people who hate us. We have a good Commander-in-Chief. I know he's a Godly man. I know he's intelligent. I know he's ours. I don't understand why Republicans and Democrats both 100 percent don't support him. Maybe we'll go back after having been home here for two, three, four weeks with a different attitude, because we need to get behind him. He's the only Commander-in-Chief we have, and he not only needs our support, he needs our prayers.

Mike, thank you for allowing me to be a part of this today. I yield back my time.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF REPRESENTATIVE RALPH M. HALL

I am pleased to be here in Denton this morning to join the Chairman in welcoming our witnesses to this hearing on nanotechnology—which the hearing title characterizes as the “biggest little thing in Texas.”

We are at the threshold of an age in which materials can be fashioned atom-by-atom. As a result of this growing capability, new materials can be designed with specified, and often novel, characteristics to satisfy specific purposes.

Nanotechnology will have enormous consequences for the information industry, for manufacturing, and for medicine and health. Indeed, the scope of this technology is so broad as to leave virtually no product untouched.

As many of you are aware, the Science Committee has been working to develop bipartisan legislation to authorize a federal, interagency initiative on nanotechnology research and development. This legislation recently passed both houses of Congress and, this week, was signed into law by the President.

In addition to setting funding goals, the new statute puts in place mechanisms for planning and coordinating the interagency research program. It also includes provision for outside, expert advice to help guide the research program and ensure its relevance to emerging technological opportunities and to industry.

One major goal of the legislation is to forge research relationships between academic institutions and industry in order to accelerate progress and facilitate technology transfer in areas with high potential for useful applications of commercial value. Therefore, I am pleased that we have the opportunity today to hear from both academic researchers and industry representatives.

I hope to learn more about R&D activities on nanotechnology here in Texas and to explore how university/industry research partnerships can be developed and strengthened. I also encourage our witnesses to share their views on how federal efforts to advance nanotechnology could be made more effective.

I want to thank the Chairman for organizing a hearing on this emerging technology, which will be of increasing importance for our economic growth and for national security. I am pleased to be able to join him here today in Denton, and I appreciate the attendance of our witnesses and look forward to our discussion.

Chairman BURGESS. Well, I’ll be glad to yield the gentleman some more time if he wants to continue.

Mr. HALL. Well, if you have plenty of time, I will; I’ll just go on.
[Laughter.]

The President asked me when I got in there after we ate some Texas barbecue flying back, he said, “Well, all right, Hall, what all do you want?” And I said, “Well, first, I’d like for you to let all my wife’s folks out of the federal penitentiary.”

[Laughter.]

It went on from there. But I thought he needed a little levity. The guy is uptight, he’s working about 22 hours a day, and I didn’t want him to let any of them out because they just work on their cars out in front of my house.

[Laughter.]

Let’s get to work. You ready? You have any more time for me?

Chairman BURGESS. No, sir.

Mr. HALL. All right.

Chairman BURGESS. We’ll go first to Dr. Rick Reidy, the Research Professor at the University of North Texas.

STATEMENT OF DR. RICHARD F. REIDY, PROFESSOR OF MATERIALS SCIENCE AND ENGINEERING, UNIVERSITY OF NORTH TEXAS

Dr. REIDY. Mr. Chairman, Congressman Hall, and you are a tough act to follow, sir. I wish to thank you and Chairman Boehlert

for the invitation to speak here today. It is most gratifying to hear of Wednesday's signing of the 21st Century Nanotechnology Research and Development Act. In the decades to come, this commitment to nanotechnology research will dramatically impact our daily lives, our economy and our place in the world.

It is clear today that nanotechnology advancements will continue in electronics, biotechnology, sensors and nanoparticles. I believe that we should continue to see faster, smarter and smaller microchips despite some material limits looming in the forefront. We shall have new weapons to fight and study disease and means to rapidly detect and detoxify dangerous chemicals. Beyond our current horizons we can speculate that advancements in nanotechnology will change our lives as dramatically as PCs and cell phones.

Effective growth in nanotechnology can be managed by—must be managed by balancing support of basic, applied and engineering research. While basic research will likely remain the province of universities and national laboratories, more applied efforts must involve contributions from industry. Universities must be open to non-traditional collaborations to encourage the infusion of industry-specialized knowledge and to ease technology transfer. As industry continues to lower the prominence of the R in research and development, it is incumbent on government and industrial consortia to support universities as R&D representatives and to fund university purchases of equipment in user facilities to expand the capabilities of local industry. It is critical to develop and maintain a talented and trained work force. If demand for researchers and technologists exceeds our supply, then growth will slow and industry will seek talent from beyond the borders. Neither alternative is in the best interest of the United States. We should prepare for this coming need as our nation did in the late '60's and early '70's during the space race.

Some universities have very well staffed—sorry, I'm trying to coordinate these two things. I'm not as good as I—some universities have well staffed industrial liaison organizations to market the intellectual wares of their faculty. This model has led to many valuable patent licensing agreements and start-up companies. For universities without such infrastructure, this business model may not be practical. Integrated joint research ventures in which basic and applied research are conducted at the university and product development remains with industrial partners may be more suitable for many universities.

My colleagues, Dennis Mueller, here at UNT, Dr. Moon Kim is in the audience, at UT, Dallas, and Dr. Phil Matz, Texas Instruments, and I have settled on a collaboration that we believe is a win-win scenario for both industry and university. This work focuses—our work focuses on nanoscale properties of integrated circuit insulators and the development of new insulator properties—new insulator materials with controlled nanometer-size structures. This research is supported by the Grant Opportunities for Academic Liaison with Industry, short GOALI, Program. In addition to getting funding from the National Science Foundation, Texas Instruments has agreed to provide substantial in-kind support, including access to instrumentation and wafers. As both co-investi-

gator and Texas Instrument liaison, Dr. Matz meets with both students and faculty regularly to collaborate on research topics and facilitate experiments at Texas Instruments facilities.

All investigators have been granted access to the relevant facilities at Texas Instruments; in fact, TI has actually allowed me to have an office where I can coordinate experiments and discuss research topics with TI personnel. This arrangement efficiently integrates the need of both Texas Instruments to conduct long-term research and provides UNT students and faculty the opportunity to work on very practical problems and to directly interface with industry.

Federal support of University of North Texas spans many areas. Specifically, in Fiscal Year 2003, UNT has received over \$760,000 in federal nanotechnology research funds, and thanks to Congressman Burgess will receive \$3.1 million from the Department of Defense to work on this facility here and buy a high resolution electron microscope. It is a goal of our university to play a major role in the development of nanotechnology and subsequent job creation in the North Texas region. The formation of CART and the purchase of equipment will permit UNT to study materials on the atomic scale, collaborate with local industry, and incubate new technology companies.

It is critical that we examine issues of outreach. Current budget constraints at state and local levels require that changes in curriculum be at a minimum of revenue neutral. We can simply not ask local schools to pay for any of the new technology we want to introduce or any new curricula we want to introduce. It's something that has to come from the federal level. We must also make it worth the teachers' time to spend time to learn all these things. Teachers, as we are aware, are hard-working enough.

One of the other issues I think that's relevant to discuss today is that a large fraction of math and science teachers countrywide do not actually have degrees in their subject area, and those that have them have an average of about 15 years experience, so we must consider the fact that many of them are trained as of 1988, and any new curricula that we try to share with them must go back on that information. These are hard-working people and very learned and very interested in teaching our children, but we must include the fact that they need to be brought up to speed in a lot of these programs.

I'd like to speak kind of personally. One of the programs that got cut in the 1980's was the High School National Science Foundation Summer Science Program. I can attest to its value because I wouldn't be here today if it were not for that program. Summer Science Program for High School Juniors similar to the current National Science Foundation Research Experience for Undergraduate Program I believe should be instituted at universities across the country.

I believe one of the other issues regarding outreach is that there are simply not enough national technology centers, centers of excellence, to actually spread the outreach across the country. I believe this is the responsibility of all nanotechnologists and all people working in nanotechnology to share this information at local

schools. I don't think it should be something that spreads from specific locuses, I believe it's all our responsibility.

I believe regarding our potential work forces, there are current shortages in state budgets that are massively affecting our local school districts. For example, several school districts in North Texas are considering cutting back on advanced placement courses. While the pressure on local school boards are immense, such cut-backs are shortsighted and could have long-term effects on math and science education. A longer-term suggestion is to increase the number and improve the quality of science and engineering students for our future. I believe that we are in desperate need of funding to increase the number of trained middle and high school math and science teachers. I believe that science curriculum coordination should include input from industry personnel who are trained in research. I believe that university state and engineering programs should be expanded to include some of the new areas of research. We need to introduce curriculum that actually follows along with that research.

I believe also an interesting point is that we also need to look—and if I may speak off the cuff for just a moment—the university research and engineering programs should also be looking at K through 20. We need to be looking at people beyond school systems. I think it's important that as educators we educate the public because people are not going to vote, people are not going to support technology unless they understand it. If you look at some of the movements in Europe involving genetically modified foods, there is a groundswell against a lot of technology. And I'm not saying that they're right, I'm not saying that they're wrong. As Congressman Hall pointed out, this is a non-partisan sort of discussion, but I think it's critical that we educate the public so the information is available.

So I thank you, Congressman Burgess, for inviting us today, and I appreciate the opportunity to talk with you.

[Applause.]

[The prepared statement of Dr. Reidy follows:]

PREPARED STATEMENT OF RICHARD F. REIDY

Introduction

Nanotechnology will remain an extremely fertile research arena for the foreseeable future. It is the eventual progression of man's quest to control the basic building blocks of our world. The Apollo program expressed our desire to journey beyond Earth; nanotechnology evinces our curiosity preceding the microscopic. Like the space program, the world of the ultra-small can spur the imagination and vocations of budding scientists. Fostering this resource is critical to the future advancement of nanotechnology. Creating the "destiny of discovery" that the Lunar Landing evoked must be a parallel mission of the National Nanotechnology Initiative as we can ill-afford to make this a race for the select few. The National Science Foundation has long held that K-12 outreach was a critical element of academic research. Programs to cultivate youth interest should be as creative and fresh as our research. Directing new talent into science and engineering will provide the researchers necessary to meet the ever-expanding challenges in nanotechnology.

What new advances should we expect from nanotechnology? The: "possible" of a few years ago has now become reality. I believe that the history of integrated circuits points to an amazing future. The semiconductor industry has repeatedly met the lofty expectations of Moore's Law (i.e., the number of transistors in a chip double every 1-2 years) despite facing extremely difficult issues with each generation of microchip. The power of personal computers exemplify this advancement; the Intel 486, the premier PC chip just over a decade ago, contained approximately 1.2

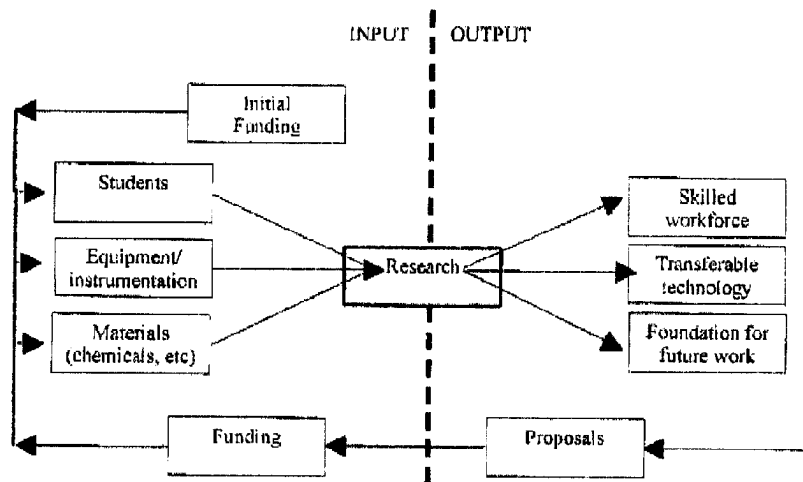
million transistors while the current Pentium 4 has over 42 million. I have been fortunate to be a member of the International Technology Roadmap for Semiconductors (the organization that plots development and expectations of future technology requirements), and I marvel at the planning and knowledge breadth that created this record of success. While many issues loom within the next decade as potential “show stoppers” to the progress of continued microchip development, past performance and sheer mass of talent will likely overcome these issues.

The discovery and development of carbon nanotubes offer an additional hopeful scenario for the progression of nanotechnology. In less than a decade, these nanometer scaled structures have been studied for a wide range of applications crossing many disciplines: high strength composite materials, nanowires, artificial kidneys, chemical weapons sensing, solar energy, and non-volatile memory. The breadth of this research highlights the need for cross-disciplinary nanotechnology research teams and the cooperative efforts of industry, government, and universities.

University-based research programs differ somewhat from industry due to the graduation of researchers and funding cycles of 1–4 years. These aspects necessitate a critical need for initial kickoff funding. The next section describes this process.

Summary of University Research Requirements and Output Dependencies

The schematic below is an abbreviated outline of nanotechnology research requirements and potential outcomes. All research of merit must have some initial funding to pay students, buy materials and maintain equipment. Excellent ideas are “grounded” without student researchers, appropriate equipment and instrumentation, and working materials. In the past, most federal agencies required some threshold of previous work to consider a program for funding. Because much of the nanoworld is unexplored, this burden of proof has lessened considerably. This “lower bar” permits rapid testing of ideas, but increases the risk of these ventures. To account for this risk, many nanotechnology proposals are funded as one-year exploratory grants. While exploratory grants will support many strong research ideas, many more will scramble for internal or other sources of funding to initiate research. Research institutions should be encouraged to provide sufficient funding for researchers to overcome the “proof or concept” burden necessary to garner external funding.



Funding for equipment and instrumentation presents another issue. The study of the very small requires specialized and often expensive instrumentation. While some large well-funded institutions can often support purchases of six and seven figure capital equipment, smaller institutions must rely on federal and State outlays to support these purchases. The recent work by Rep. Burgess to support the purchase of a high-resolution transmission electron microscope here at UNT is an example of such an outlay. Major research instrument funding from the National Science

Foundation is highly competitive, and strong proposals have often gone unfunded. It is critical that financial support of major equipment purchases be accessible to all institutions with a proven need. Without accessibility to specialized instrumentation, nanotechnology will become the province of only a few universities. To summarize, issues of concern are:

- initial funding to “kickoff” research and prove basic concepts
- accessibility of instruments necessary to develop nanoscaled materials and systems.

Responses to Questions

How significant of an impact will nanotechnology have on U.S. economic growth and job creation in the coming decades? In what industry areas will the impact be most dramatic? What challenges exist that may slow or limit the growth and influence of nanotechnology?

Advancements in nanoscience will permit faster, smarter, and more selective techniques to overcome both mundane and exotic problems. Powders that rapidly detoxify chemical weapons, frictionless surfaces, cancer drugs that repair defected gene sequences, and clothing that regulates skin temperature are all topics of research interest. From process control to smaller and smarter computers, few automated industries will not benefit from nanotechnology advancements. However, the industries most likely to see dramatic improvements are electronics and biotechnology.

Recent estimates suggest that one million jobs will result from applications of nanotechnology. Over the last four years, venture capitalists have invested over \$900 million in nanotechnology—\$386 million in 2002. The current environment is ripe for the creation of nanotechnology startup ventures. In addition to its focus on nanotechnology research, the newly formed Center for Advanced Research and Technology (CART) can become an incubator for small technology companies. In this role, CART can foster technology development and job growth in the North Texas region.

Limits to Nanotechnology Growth

Effective growth can be managed by balancing support of basic, applied, and engineering research. While basic research will likely remain the province of universities and national laboratories, more applied efforts must involve active contributions from industry. Universities must be open to non-traditional collaborations to encourage the infusion of industry-specialized knowledge and to ease technology transfer. As industry continues to lower the prominence of the “r” in research and development, it is incumbent on government and industrial consortia to support universities as R and D alternatives and to fund university purchases of “dual use” equipment to expand the capabilities of local industries.

It is critical to develop and maintain a trained workforce. If demand for researchers and technologists exceeds our supply, then growth will slow or industry will seek talent from outside the U.S. Neither alternative is in the best interest of the U.S. We should prepare for this coming need as the Nation did in the late 1950’s and early 1960’s during the space race.

What, in your experience, are the best practices to help facilitate the transfer of basic research results to industry? To what extent has UNT partnered with industry on nanotechnology research and development challenges, and how can such collaborations be made more effective?

Transfer of Basic Research to Industry

Some universities have well-staffed industrial liaison organizations to market the intellectual wares of their faculty. This model has led to many valuable patent licensing agreements and startup companies. For universities without such infrastructure, this business model may not be practical. Integrated joint research ventures in which basic and applied research are conducted at the university and product development remains with the industrial partner may be more suitable for many universities. Contracts detailing confidentiality, intellectual property rights, and licensing agreements permit sharing of information and experience that will greatly assist the university researchers. Planning and status meetings should include as many participants as possible, including graduate researchers. These same practices would be effective in business incubators.

UNT Partnerships With Industry

UNT has initiated nanotechnology collaborations with a range of industrial partners: Carbon Nanotechnologies Incorporated, Kraft Foods, Clarisay, Texas Instruments, as well as industrial consortia such as Semiconductor Research Corporation and International Sematech.

My work with colleagues Dr. Dennis Mueller of UNT, Dr. Moon Kim of UT–Dallas, and Dr. Phil Matz of Texas Instruments focuses on the nanoscale properties of integrated circuit insulators and the development of new insulator materials with controlled nanometer-sized structures. This work is supported by the National Science Foundation “Grant Opportunities for Academic Liaison with Industry” (GOALI) program. In addition to funding from NSF, Texas Instruments (TI) has agreed to provide substantial in-kind support including access to instrumentation and processed wafers. As both a co-investigator and TI liaison, Dr. Matz meets with both students and faculty regularly to collaborate on research topics and facilitate experiments at TI facilities. All of the investigators have been granted access to relevant facilities, and TI has provided me with an office to stage and coordinate experiments. This arrangement efficiently integrates the need of Texas Instruments to conduct long-term research and provides UNT students the opportunity to work on very practical problems and to directly interface with industry.

Examples of our work on the nanoscale: The electron microscopy images below (all are of the same type of SiO₂ insulator material) illustrate our ability to control structure and, consequently, to impart desired properties to these materials.



Has federal support for your research been effective at helping UNT achieve its goals? How might Congress strengthen the structure, funding levels, and focus of the National Nanotechnology Initiative?

Federal Support to Achieve UNT Goals

In FY 2003, UNT received over \$760,000 in federal nanotechnology research funding and \$3.1 million from the Department of Defense for the establishment of the Center of Advanced Research and Technology. These funds produced very interesting results and have leveraged additional support from other agencies. It is the goal of our university to play a major role in the development of nanotechnology and the subsequent creation of jobs in the North Texas region. The formation of CART and the purchase of a high-resolution transmission electron microscope will permit UNT to study materials on the atomic scale, collaborate with local industry, and incubate new technology companies.

Congressional Strengthening of Structure, Funding Levels and Focus of NNI

Funding for nanotechnology will need to increase as new promising avenues of research are revealed. Periodic assessment of how budgets are meeting needs, especially in the areas of outreach, will be necessary. While the NNI has included workforce preparation as part of its mission, there exist several key issues that affect the integration of nanotechnology course material into current K–12 curriculum:¹

- Current budget constraints at State and local levels require that changes in curriculum would inflict cost increases on those who are already facing fund-

¹Many of these discussion points are described in “Extending Outreach Success for the National Nanoscale Science and Engineering Centers—A Handbook for Universities,” James G. Batterson of the National Nanotechnology Coordinating Office, January 2, 2002.

ing cutbacks. Such changes should be at a minimum revenue neutral; therefore, funding of new materials or teacher education should be absorbed by NNI (under the auspices of Centers of Excellence or NIRT grants).

- Likewise, compensation to teachers for their involvement in nanotechnology summer workshops should reflect these recent restrictions in funding. Simply put, we must make it financially worth their time to participate. Teachers are often seriously underpaid, and these programs need incentives to induce the necessary levels of participation.
- A large fraction of math and science teachers does not have degrees in their subject area. The average teacher has 15 years experience; therefore, most teachers have not had formal science training since 1988. It is critical that teacher outreach programs involve language and context commensurate with these issues. These are experienced professionals who are willing to learn, but, in many cases, may need some leveling materials in the initial stages. Being cognizant of our outreach audience's background is critical to effectively convey the possibilities of nanotechnology research. It is our goal to infuse an enthusiasm to teachers that will carry over to their students.
- One of the best ways to influence career choices of young people is through summer job experiences. As a product of NSF summer science program, I can attest to the value of my first real experience with research. Summer science programs similar to the NSF REU (Research Experience for Undergraduates) should be instituted at universities across the Nation. Programs will have specialties based on their research. Students will be responsible for room and board although financial aid should be available.

I believe that there are simply not enough Nanotechnology Centers of Excellence to conduct nationwide outreach programs. Extending this responsibility to other nanotechnology grant holders would expand the scope of the program. To avoid conflicting motivations, additional funds should be available for outreach for non-center grant holders. The funding of these education programs should be evaluated separately from the research aspects of the grants and could be funded after the research grants expire. Outreach programs are difficult to set up and critical to development of a trained workforce; therefore, existing programs should be nurtured and supported without interruptions if possible.

Is the U.S. education system currently producing an adequate number of people with the skills needed to conduct research in nanotechnology and to work in industry on the commercialization of nanotechnology applications? What is the longer-term outlook for the nanotechnology workforce, and what changes, if any, should be made to the current education system to ensure these workforce needs are met?

Capabilities of U.S. Educational Institutions to Meet Future Needs

At present, elementary, secondary, community college and university systems are not producing graduates with the skill sets to meet nanotechnology challenges. In part this failure is a hangover from the 1990's—business degrees and computer science were preferred over natural science and engineering degrees as means to rapid wealth. The pendulum will no doubt swing back toward engineering and natural sciences; however, we lack the teachers at all levels to meet our growing need.

The current shortages in State budgets are impacting local school districts. For example, several school districts in North Texas are considering cutting back on advanced placement courses. While the pressures on local school boards are immense, such cutbacks are shortsighted and could have long-term effects on math and science education. Some longer-term suggestions to increase the number and improve the quality of science and engineering students:

- Federal, State, and local funding outlays are necessary to increase middle and high school math and science teachers.
- Science curriculum coordination should include personnel with research experience.
- Science and engineering doctoral students should be encouraged to teach at the secondary levels.
- University science and engineering programs should be expanded to include new areas of research.
- K through 20+ pedagogy should encourage cross-disciplinary problem-solving and collaboration.

Summary

Nanotechnology will no doubt change our world, but it presents new challenges to our educational system, our industries, and our Federal, State and local governments. Many important issues regarding the funding and value of nanotechnology must be decided by an educated and informed populace. It is the responsibility of the National Nanotechnology Initiative and its supported researchers to make new and exciting discoveries and to prepare our nation to meet the challenges of this new world.

BIOGRAPHY FOR RICHARD F. REIDY

Dr. Richard F. Reidy is Assistant Professor of Materials Science and Engineering at the University of North Texas. Dr. Reidy has a Ph.D. in Metals Science and Engineering from Penn State University and BA in Chemistry/Biochemistry from Rice University. Before joining the University of North Texas, he worked on nanoporous films for chemical weapons detection at the U.S. Army Chemical and Biological Defense Command, Aberdeen, MD. He is currently developing nanostructured materials and processing methods for semiconductor applications supported by the National Science Foundation, Texas Instruments, and International Sematech.

UNIVERSITY *of*
NORTH TEXAS

*College of Engineering
Department of Materials Science and Engineering*

December 10, 2003

The Honorable Sherwood Boehlert
Chairman, Research Subcommittee
2320 Rayburn Office Building
Washington, DC 20515

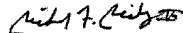
Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on December 5 for the hearing entitled *Nanotechnology Research and Development: The Biggest Little Thing in Texas*. In accordance with the Rules Governing Testimony, this letter serves as formal notice of the Federal funding I currently receive in support of my research. The following list details all of my current Federal funding.

- \$992,000, *GOAL: Nanoscale Characterization and Development of Ultra Low-k Dielectric Xerogel Films* (Award #0316916) National Science Foundation, Division of Materials Research, Funded FY 2003
- \$9,000, *U.S.-Mexico Collaborative Research: Formation and Characterization of Calcium Hydroxyapatite Deposited on Silica Aerogels and Xerogels* (Award # 0102797), National Science Foundation, International Division, Funded FY 2001

Please let me know if you have any questions regarding these funding sources.

Sincerely,



Richard F. Reidy
Assistant Professor of Materials Science and Engineering
PO Box 305310
University of North Texas
Denton TX 76203-5310
940-369-7115
reidy@unt.edu

Chairman BURGESS. Thank you, Dr. Reidy.

We'll now hear from Dr. Da Hsuan Feng, Vice President for Research and Graduate Education at the University of Texas at Dallas.

STATEMENT OF DR. DA HSUAN FENG, VICE PRESIDENT FOR RESEARCH AND GRADUATE EDUCATION, UNIVERSITY OF TEXAS, DALLAS

Dr. FENG. Mr. Chairman and Congressman Hall, it is indeed an honor and privilege for me to be here today to deliver this testimony. We in the Metroplex in particular, and the United States in general, are very fortunate to have Congressional Members and leaders—and other leaders of the Nation, such as yourselves, who have led in promoting nanotechnology in the region and the Nation. Countries around the world have followed the lead of our nation in making investment in nanotechnology a national priority.

In human history, whenever a fundamentally new type of material emerged a new economy was born. This certainly happened during the stone, iron, bronze and plastic ages. Instead of pertaining to a single material, nanotechnology provides the opportunity to so fundamentally change virtually any material that a groundswell of new businesses will arise. Those countries and companies that do not lead in the development and application of nanotechnology are at great risk of becoming non-competitive. Recent avalanching advances in the ability to manipulate materials at the sub-microscopic scale mean that the materials of the future can have properties that were only imagined in the past. The vision of taking nations' nanosized building blocks to create manmade materials first proposed by the legendary Richard Feynman some 44 years ago is the fundamental guiding principle of this now exploding field of nanotechnology.

The Nanotechnology Institute of the University of Texas at Dallas is a new one. It was founded only two years ago. We did this at the university by strategically hiring some of the best people in the Nation or in the world to propel our activities in this arena. The institute is led by its Director Ray Baughman, the Deputy Director Anvar Zakhidov and Dr. Alan MacDiarmid, a Nobel laureate in Chemistry in 2000 and holder of the James Von Ehr Distinguished Chair in Science and Technology. I'm extremely pleased to say that by working as a team, which includes our senior management of UTD, the various schools within the university and the technological and economic planning communities of North Texas, the institute has grown rapidly to include some 60 people from all over the world now. We are inspiring and educating students of all ages of the work force and creating knowledge and technologies that will generate new businesses and job growth. Physicists, chemists, biologists, ceramicists, metallurgists and mathematicians are teaming with engineers to solve problems. We're eliminating boundaries that interfere with the transition from science to technology and from technology to product. The Nanotech Institute has an atmosphere of excitement, fun and creativity that inspires researchers from 8th graders to senior citizens working in our laboratories in the quest of new basic understanding and new technologies.

Finding and effectively utilizing new energy sources without damaging the environment is one of the primary challenges of our nation and the world. For this reason, the Nanotech Institute has identified nanoenergetics as an area of focus, and there are four of them. While every category deserves a full and detailed description, within the time constraint, I will merely underscore that one important aspect is the assembly of nanofibers into high performance fibers that can be used in building devices. All known bulk synthesis methods produce carbon single-walled nanotubes as impure soot. An important challenge is to develop practical technologies for transforming this soot into continuous fibers that can have useful properties for important applications, such as converting waste thermal and mechanical energy to electrical mechanical energy absorption in safe harnesses and energy storage in textiles for the soldier. By using a novel spinning apparatus, spinning solutions and spinning coagulants, the scientists at UTD's NanoTech Institute have spun nanotube fibers with record lengths, tensile strengths and energy-to-break. No known fibers of any type are nearly as tough. The landmark importance of the advances published in the prestigious journal called Nature was indicated by news coverage from all over the world, from here to Europe to Asia.

Mr. Chairman, in the late '70's, I was privileged to spend a year as a visiting professor at the Niels Bohr Institute at the University of Copenhagen, then one of the world centers for nuclear science research. At the NBI, led by two Nobel laureates, there was great scientific excitement, great works and discoveries were made routinely by scientists all over the world. It was quite an intellectual atmosphere. I am therefore extremely pleased to observe a similar intensity of intellectual excitement about a new and fast-paced field of science and technology permeating in UTD's NanoTech Institute.

Mr. Chairman, in the long run I believe that most products will depend upon nanotechnology, from products for detecting and treating cancer, to smaller and faster computers, to improved sensors for homeland security and to the skins of our most advanced aircraft. Anytime fundamentally new materials and exciting properties are created new business can result. Nanotechnology is generic. Avalanching abilities and manipulating of self-assembling on the nanoscale are creating fundamentally new materials of all kinds, from metals, semiconductors, superconductors to even plastics. An economic base of new materials and devices can simply offer the ability to carry out our traditional tasks more efficiently and, more often than not, to carry out tasks that were previously impossible. Also, it can mean having materials that are multifunctional like the nanotube fibers at UTD, which might eventually be used in the soldiers' uniform as both a power source and for anti-ballistic protection.

Material producers are wary, on the other hand, of risking money on improving and upscaling material production until customers are clearly identified, and users are wary of investing money on evaluating the materials in the products until they can be guaranteed low material costs. Cradle-grave assurance of material and product safety is another important issue for nanotechnology-based

materials but probably no more than for other materials and chemicals.

The evolution of nanotechnology advances into new economics is still in its early phase, but there are already noteworthy successes. Overcoming the barriers between early technology breakthroughs and products is always challenging, and targeted government funding can make the difference between shelf technology and a commercial success. Two years ago at a nanotechnology conference in Richardson, Jack Kilby, one of the scientific giants of the 20th century from Texas Instruments and the year 2000 Nobel laureate for discovering the integrated circuit, said, and I paraphrase, "If it was not for the military, the integrated circuit may still be on the shelf today." In a sense, the discoveries of nanotechnology are similar to IC discoveries in the early days. Achieving commercial applications may or may not be straightforward depending on the technology. The best practice is for universities to partner early on with the most appropriate companies. Throwing early technology results over the fence to industry generally doesn't work, so finding ways to facilitate the partnering of industry and universities is critical. We are doing that at the moment and sometimes with great difficulty but we are working very hard in that direction.

The successes achieved by UTD's Nanotech Institute research programs would not have existed were it not for the support of various federal agencies as well as the visionary leadership of statesmen such as you. The same is true for virtually all the major nanotechnology efforts in universities that are ongoing in our country today. Continuation and strengthening of this support is absolutely critical for our nation's maintaining and increasing its leadership role. Industrial managers, especially in large companies, are often forced to focus on next year's product so that research commitment to revolutionary products is severely weakened.

Targeted funding, such as that of NIST ATP Program, can help industry take risks that are in the longer-term interests of our economy and the companies and facilitate partnering between industries and universities. Programs for small business like the SBIR Program are critical, and increases in Phase I funding levels could provide the industrial focus that enables success.

Mr. Chairman, I do not believe that I am exaggerating to say that many of our research universities are among the best in the world. However, the number of Americans obtaining Ph.D.s has not grown with our population and with the increasing needs of our industry. Indeed, our nation's intellectual and economic growth has long been closely linked to our ability to absorb the best and the brightest from all corners of the globe. Innovations carried out in American university laboratories are powered by students, postdocs and faculty members from across the United States and from all regions on Earth, and many of these individuals join American industry to forge the products of the future.

At the Nanotech Institute of UTD, it is just a microcosm of this trend. For example, at our laboratories, you may find nearly around the clock, in fact around the clock, American students, postdocs, faculty members, community members working hand in hand with their colleagues from Russia, Uzbekistan, China, Korea,

Philippines, Brazil, India, Germany, Ireland, Spain, Australia and many other countries.

Mr. Chairman, in the wake of the war on terror, a situation has arisen because of the serious limitation of visas issued to countries that are becoming the world's technical powers. At the most obvious level, the ability of international scientists to attend scientific conferences in the United States has become problematic. Often even invited speakers are unable to receive a visa in time. Unless this visa problem is corrected, I fear that many international conferences will rarely be held in this country so that our students, technologists and industrialists will lose rapid access to information. The world's brain drains of the past have served to enrich the United States, and I fear that the present visa crisis is now closing our borders to much of the intellectual powers around the world. We are in danger of no longer being a technology melting pot.

At the same time as we are seriously restricting visas for other countries, American companies are creating major research laboratories elsewhere. Business is usually done with those you know, often face-to-face interactions, and I further fear that the visa problem will eventually decrease our ability to conduct commercial interactions with rapidly developing economies of the world. Mr. Chairman, the visa issue—

Chairman BURGESS. Let me just—I'll stop you there if I could, and we can certainly get that in the record, but I want to be respectful of everyone's time.

Dr. FENG. Sure. Thank you.

[The prepared statement of Dr. Feng follows:]

PREPARED STATEMENT OF DA HSUAN FENG

This testimony by Da Hsuan Feng (Vice President of Research at the University of Texas at Dallas) comprises (A) Overview of the Research and Development Activities of the NanoTech Institute and (B) Responses to Addressed Questions.

Dear Congressional Members: It is indeed an honor and privilege for me to be here today to deliver this testimony. As you know, my colleague, Professor Ray Baughman, UTD's NanoTech Institute director was invited to be here, but had the prior obligation of serving on a National Science Foundation panel today.

We in the Metroplex are very fortunate to have Congressional Members, such as yourselves, who have led in promoting nanotechnology in the region and the Nation. Countries around the world have followed the lead of our nation in making investment in nanotechnology a national priority.

In human history, whenever a fundamentally new type of material emerged, a new economy was born. This certainly happened during the Stone, Iron, Bronze, and Plastic Ages. Instead of pertaining to a single material, nanotechnology provides the opportunity to so fundamentally change virtually any material that a groundswell of new businesses will arise. Those countries and companies that do not lead in the development and application of nanotechnology are at great risk of becoming non-competitive. Recent avalanching advances in the ability to manipulate materials at the sub-microscopic scale mean that the materials of the future can have properties that were only imagined in the past. Taking an example from biology, nature has long been manipulating virus and cells at the submicroscopic level. This ability of nature to operate at a very small scale eventually cascaded to the diverse functionality of higher organisms. However, it took approximately 600 million years after the formation of the Earth for nature to achieve the single cell, and less than a million years afterwards to develop the first organism. Materials made possible by nanotechnology will include those having some of the capabilities of biological systems, like the ability to appropriately change properties in response to the environment and to self-repair. This vision of taking nature's nanosize building blocks to create manmade materials, first proposed by the legendary Richard Feynman

some 44 years ago, is the fundamental guiding principle of this now exploding field of nanotechnology.

A. Overview of the NanoTech Institute at the University of Texas at Dallas

The NanoTech Institute of the University of Texas at Dallas was founded merely two years ago. We did this by strategically hiring some of the best people in the world to propel our activities in this arena. The Institute is led by its Director, Dr. Ray Baughman, its Deputy Director, Dr. Anvar Zakhidov, and Dr. Alan MacDiarmid, a Nobel laureate in Chemistry in 2000 and holder of the James Von Ehr Distinguished Chair in Science and Technology. I am extremely pleased to say that by working as a team, which includes senior management of UTD, the various Schools within the university, and the technological and economic planning communities in North Texas, the Institute has grown rapidly to include more than 60 people from all over the world. We are inspiring and educating students of all ages for the work force and creating knowledge and technologies that will generate new businesses and job growth. Physicists, chemists, biologists, ceramicists, metallurgists, and mathematicians are teaming with engineers to solve problems. We are eliminating boundaries that interfere with the transition from science to technology, and from technology to product. The NanoTech Institute has an atmosphere of excitement, fun, and creativity that inspires—researchers from 8th graders to senior citizens work in our laboratories in the quest for new basic understanding and new technologies.

Finding and effectively utilizing new energy sources without damaging the environment is one of the primary challenges of our nation and the world. For this reason, the Nanotech Institute has identified NanoEnergetics as an area of focus. We are using carbon nanotube fibers for the:

- (a) transformation of electrical energy to mechanical energy in nanotube artificial muscles,
- (b) reversible transformation of electrical energy to chemical energy in super-capacitor and battery fibers that can be woven into electronic textiles,
- (c) transformation of mechanical energy to elastic energy and thermal energy in super-tough carbon nanotube composite fibers, and
- (d) transformation of waste thermal energy into electrical energy in electro-chemical thermal energy harvesting devices.

While every category deserves a full and detailed description, within the time constraint, I will merely underscore that one important aspect is the assembly of nanofibers into high performance fibers that can be used in building devices. All known bulk synthesis methods produce carbon single walled nanotubes as impure soot. An important challenge is to develop practical technologies for transforming this soot into continuous fibers that have useful properties for important applications, such as converting waste thermal and mechanical energy to electricity, mechanical energy absorption in safety harnesses, and energy storage in textiles for the soldier. By using a novel spinning apparatus, spinning solutions, and spinning coagulants, the scientists in UTD's NanoTech Institute have spun nanotube fibers with record lengths, tensile strengths, and energy-to-break (toughness). No known fibers of any type are nearly as tough. The landmark importance of the advance (published in *Nature* and reported in *Science*) was indicated by news coverage from around the world (*Wall Street Journal*, *New York Times*, *U.S. Today*, *China Peoples Daily*, *Discover Magazine*, NBC and ABC television, Voice of America, *Science*, *Physic Today*, *C&E News*, etc.).

Mr. Chairman, in the late seventies, I was privileged to spend a year as a visiting professor in the Niels Bohr Institute in University of Copenhagen, then one of the world centers of nuclear science research. At the NBI, led by the two Nobel laureates, there was great scientific excitement there, and great works and discoveries were made routinely by scientists from all over the world. It was quite an intellectual atmosphere. I am therefore extremely pleased to observe a similar intensity of intellectual excitement about a new and fast paced field of science and technology, permeating in UTD's NanoTech Institute.

B. Questions and Responses

- *How significant of an impact will nanotechnology have on U.S. economic growth and job creation in the coming decades? In what industry areas will the impact be most dramatic? What challenges exist that may slow or limit the growth and influence of nanotechnology?*

Mr. Chairman, in the long-term, I believe that most products will depend upon nanotechnology, from products for detecting and treating cancer, to smaller and

faster computers, to improved sensors for home land security, and to the skins of our most advanced aircraft. Anytime fundamentally new materials with exciting properties are created, new businesses can result. Nanotechnology is generic, avalanching abilities in manipulating and self-assembling on the nanoscale are creating fundamentally new materials of all kinds—from metals, semiconductors and superconductors to plastics. An economic base of new materials and devices can simply offer the ability to carry out traditional tasks more efficiently, or more often than not, to carry out tasks which were previously impossible. Also, it can mean having materials that are multifunctional, like nanotube fibers fabricated at UTD's NanoTech Institute, which might eventually be used in a soldier's uniform as both a power source and for antiballistic protection. Nanotechnology also can provide intelligent materials, like the NanoTech Institutes nanotube sheets, which can detect the composition of the fuel mixture in an engine and automatically open or close a valve—all without the need for an external power source. Mr. Chairman, advances in nanotechnology will likely impact virtually all industries, from materials, clothing, aerospace, communications, biotechnology, and computing industries to industries that have not yet been conceived. As for any new area, there are a host of challenges that must be solved. One is the high cost of producing materials on laboratory scales. Materials producers are wary of risking money on improving and up-scaling material production until customers are clearly identified, and users are wary of investing money on evaluating the materials in their products until they can be guaranteed low material cost. Cradle-grave assurance of material and product safety is another important issue for nanotechnology-based materials, but probably no more than for other materials and chemicals.

- *What in your experience are the best practices to help facilitate the transfer of basic research results to industry? To what extent has the Institute partnered with industry on nanotechnology research and development challenges, and how can such collaborations be made more effective?*

The evolution of nanotechnology advances into new economies is still at the early phase, but there are already noteworthy successes, like the commercialization of remarkable biomedical test kits, multiwalled nanotubes as conducting additives for plastics, and nanofiber coated textiles for ordinary clothing (jeans). Overcoming the barriers between early technological breakthroughs and products is always challenging, and targeted governmental funding can make the difference between a shelved technology and a commercial success. Two years ago, at a nanotechnology conference in Richardson, Texas, Jack Kilby, one of the scientific giants of the 20th century from Texas Instruments and the year 2000 Nobel laureate for discovering the integrated circuit (IC) said that, and I paraphrase, "if it was not for the military, the IC may still be on the shelf today." In a sense, the discoveries of nanotechnology are similar to the IC discoveries in the early days. Achieving commercial application may or may not be straightforward, depending upon the technology. The best practice is for universities to partner early on with the most appropriate companies. Throwing early technology results over a fence to industry generally doesn't work, so finding ways to facilitate the partnering of industry and universities is critical. UTD is partnering with a host of companies in the area of flexible light-emitting displays, and is partnering with industry on federally funded work in the nanotube area.

- *Has federal support for your research been effective at helping the Institute achieve its goals? How might Congress strengthen the structure, funding levels, and focus of the National Nanotechnology Initiative?*

The successes achieved by UTD's NanoTech Institute research programs would not have existed were it not for the support of various federal agencies as well as the visionary leadership of statesmen such as you. The same is true for virtually all of the major nanotechnology efforts in universities that are ongoing in our country today. Continuation and strengthening of this support is critical for our nation's maintaining and increasing its leadership position. Industrial managers, especially in large companies, are often forced to focus on next year's product, so that the research commitment to revolutionary products is severely weakened. Targeted funding like that of the NIST ATP program can help industry take risks that are in the longer-term interest of our economy and the companies, and facilitate partnering between industry and universities. Programs for small businesses, like the SBIR program, are critical, and increases in phase I funding levels could provide the industrial focus that enables success.

- *Is the U.S. education system currently producing an adequate number of people with the skills needed to conduct research in nanotechnology and to work*

in industry on the commercialization of nanotechnology applications? What is the longer-term outlook for the nanotechnology workforce, and what changes, if any, should be made to the current education system to ensure these workforce needs are met?

Mr. Chairman, I do not think I am exaggerating to say that many of our research universities are among the best in the world. However, the number of Americans obtaining Ph.D.s has not grown with our population and with the increasing needs of our industry. Indeed, our nation's intellectual and economic growth has long been closely linked to our ability to absorb the best and the brightest from all corners of the globe. Innovations carried out in American university laboratories are powered by students, postdocs, and faculty members from across the United States and from all regions of the Earth, and many of these individuals join American industry to forge the products of the future. The NanoTech Institute of UTD is but a microcosm of this trend. For example, in the NanoTech Institute's laboratories, you will find nearly around the clock, American students, postdocs and faculty members working hand-in-hand with their colleagues from Russia, Uzbekistan, China, Korea, Philippines, Brazil, India, Germany, Ireland, Spain, Australia, and other countries. Mr. Chairman, in the wake of the War on Terror, a situation has arisen because of the serious limitation of visas issued in countries that are becoming the world's technical powers. At the most obvious level, the ability of international scientists to attend scientific conferences in the United States has become problematic. Often even invited speakers are unable to receive a visa in time. Unless this visa problem is corrected, I fear that major international conferences will be rarely held in our country, so our students, technologists, and industries will lose rapid access to information. The world's brain drain of the past has served to enrich America, and I fear that present visa crisis is now closing our borders to much of the intellectual power around the world. We are in danger of no longer being a "technology" melting pot. (See *Nature* 426, 5 (2003)). At the same time as we are seriously restricting visas for these countries, important American companies are creating major research laboratories in China and India. Business is usually done with those you know, often through face-to-face interactions, and I further fear that the visa problem will eventually decrease our ability to conduct commercial interactions with rapidly developing economies around the world. Mr. Chairman, the visa issue is beginning to effectively isolate American science and technology and decrease our ability to attract the brightest and most productive scientists to our shores. Unless, solutions are found we could be jeopardizing both our economic progress and security built on leadership in nanotechnology and many other fields.

In the final analysis, Mr. Chairman, the chronic shortage of scientists and engineers facing our nation requires a long-term and sustainable solution by the Federal Government. The best solution is to truly excite our students in the K-12 levels in science and mathematics, and the only way we can achieve that is to greatly enhance the number of skilled teachers at those levels.

In summary, Mr. Chairman, nanotechnology is a quickly changing field. I think everyone would agree with me that not so long ago, North Texas was not known for its nanotechnology efforts. Now, we are on the national and international radar screen. Your assistance and understanding of all the issues surrounding the region's ability to maintain a healthy scientific and economic landscape will be critical to our future.

BIOGRAPHY FOR DA HSUAN FENG

Dr. Feng is an expert in mathematical physics, nuclear physics, nuclear astrophysics, quantum optics, fundamental issues of quantum mechanics, network architecture and computational physics. He has been a consultant to the theoretical physics groups of Los Alamos National Laboratory, Oak Ridge National Laboratory, Brookhaven National Laboratory and United Kingdom's Daresbury Laboratory.

Dr. Feng is responsible for successfully recruiting and securing the funds for the James Von Ehr Distinguished Chair in Science and Technology for Dr. Alan MacDiarmid, the 2000 Nobel Laureate in Chemistry. He also painstakingly recruited the nanotechnology research team of Honeywell Corporation in New Jersey. This team is now the backbone of UTD's rapidly growing nanoscience program. In addition, Dr. Feng also initiated a SPRING (Strategic Partnership of Research in Nanotechnology) project, which linked together, besides UTD, Rice University, the University of Texas at Austin, and the University of Texas at Arlington. For FY03 and FY04, Dr. Feng worked closely with the Congressional delegation of Texas to secure \$6 million and \$10 million, respectively, for SPRING funding. He also founded the Medical Device Action Group, a regional effort to promote interdisciplinary

research in this technological arena. Research funding for UTD has increased from \$16 million to \$28 million during the past three years.

On December 9, 2000, Dr. Feng assumed the position of Vice President for Research and Graduate Education and Professor of Physics at the University of Texas at Dallas. Dr. Feng's objective at the University of Texas at Dallas, as designated by the President and the Provost, is to rapidly build the research breadth and depth of the University. The goal is to drive the University to be a major international research University. To that end, he has articulated three concentrations of excellence for UTD in this decade: digital communications, advanced materials and instrumentations and last but not least, disease centric post genomic research.

Dr. Feng received his undergraduate education from Drew University in New Jersey and doctorate in Theoretical Physics from the University of Minnesota. Prior to joining the Physics Department of Drexel University in 1976, where he eventually became the M. Russell Wehr Chair Professor of Physics, he was a United Kingdom Science Research Council fellow at the Department of Theoretical Physics of the University of Manchester (1972–74) and a Senior Scientist at the Center for Nuclear Studies of the University of Texas at Austin (1974–76). During his tenure at Drexel University, he served for two years as Program Director of Theoretical Physics at the National Science Foundation (1983–85) and visiting Professor of the Niels Bohr Institute of the University of Copenhagen (1979–80).

Dr. Feng has published more than 190 scientific papers, edited more than 20 books, and served as editor of four scientific journals. In recognition of his contribution to the field of physics, Dr. Feng received the accolade "Fellow of the American Physical Society." Each year, no more than one-half of one percent of the current membership of the Society is recognized by their peers for election to the status of Fellow. He also is the Honorary Professor/Senior Research Fellow of six universities/academy of sciences in China and the honorary member of the Board of Trustees of one of China's top universities, Nanjing University.



THE UNIVERSITY OF TEXAS AT DALLAS

BOX 830688 MP15 RICHARDSON, TEXAS 75083-0688
(972) 883-4566 FAX (972) 883-4567

OFFICE OF THE VICE PRESIDENT
FOR RESEARCH & GRADUATE EDUCATION

January 27th, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on December 5th for the hearing entitled *Nanotechnology Research and Development: The Biggest Little Thing in Texas*. In accordance with the Rules Governing Testimony, this letter serves as formal notice of the Federal funding I currently receive in support of my research.

I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two preceding fiscal years.

Sincerely,

A handwritten signature in black ink, appearing to read 'Da Hsuan Feng', written over a horizontal line.

Da Hsuan Feng, Ph.D.
Vice President for Research and Graduate Education and Professor of Physics
The University of Texas at Dallas

Chairman BURGESS. So we probably then should move on to Dr. Ron Elsenbaumer, the Vice President for Research at the University of Texas at Arlington.

STATEMENT OF DR. RONALD L. ELSENBAUMER, VICE PRESIDENT FOR RESEARCH, UNIVERSITY OF TEXAS, ARLINGTON

Dr. ELSENBAUMER. Thank you. Mr. Chairman, Congressman Hall, it's my pleasure to be here today to offer my testimony on the impacts of nanotechnology on economic growth and job creation in the future. Nanotechnology will be the driving force for developing smaller, lighter, more energy efficient, less costly and stronger materials, devices and processes by fostering the creation of new functional materials and devices that exhibit novel phenomena and properties at the nanometer length scale. As this is realized, nanotechnology will be pervasive in our future and will be a major factor in U.S. economic growth and job creation in the technology sector for decades to come.

Based on current trends, it appears as though the impact will be most dramatic in the electronics industries, medical industries and in the energy sector. For example, work ongoing at UT-Arlington and our nanofab research and teaching facility and our College of Engineering and in our Center for Nanostructured materials and our College of Science is directed at nanotechnology development for these industries. Specifically, in our nanofab facility, we are developing nanostructured interfaces for semiconductor device interconnects as well as nanoporous materials for use as low dielectric separating copper-connected nanoscale transistor devices.

These research projects will help realize the next generation of high performance computer chips. Nanocontact printing techniques being developed at other academic institutions could revolutionize the way semiconductor devices are manufactured and drastically reduce manufacturing costs. Together, these new technologies will generate inexpensive, very powerful computing devices that will be incorporated into nearly every aspect of our daily lives, even more so than what they are already are, leading to continued changes in our quality and way of life.

In medical applications, we are already seeing that nanoscopic materials can readily travel throughout the body. Thus, nanomagnetic materials being developed at UT-Arlington and our Center for Nanostructured Material might be used in conjunction with drug therapies to direct drug delivery to targeted areas of the body. Likewise, these materials, as well as other nanostructured materials being developed elsewhere, could be used for developing very powerful imaging technologies for medical diagnoses. And nanotechnology will undoubtedly play a major role in the development of renewable, cost effective, clean sources of energy, such as hydrogen. Nanotechnology will also lead the way to developing more efficient lighting, transportation and electromechanical devices, all of which will result in significant reductions in fossil fuel consumption.

But with these opportunities come formidable challenges. New materials require new processes for making them, and many of these processes have not yet been developed or are not yet cost effective for commercialization. The situation is similar for device

fabrication and assembly. How can we control fabrication processes at these incredibly small dimensions. Paradigm shifts in manufacturing technologies will have to occur and new processes are generally slow to be accepted by industry. Similarly, concerns that the general public might have with perceived dangers associated with nanotechnology, such as environmental, bioethical and yet unrecognized societal impacts could slow acceptance of certain nanotechnology or even prevent them from being developed.

Overcoming these challenges and potential limitations will take considerable effort, and here it is imperative that the Federal Government take the long view and fund longer-term and in some cases wider-ranging research projects, as, generally, the private sector will not. I believe this concept needs to be seriously considered as the Federal Government shapes its funding and research policy issues across its various agencies.

The best approaches I have seen for facilitating the transfer of basis research results to industry are two-fold. One is through development of industry, university and government partnerships early on in the process. Integrating basic research approaches with industry development needs at the onset, and with continued adjustment throughout the process, ensures compatibility between the research outcomes and industry's acceptance and willingness to integrate them into their products and processes.

Another is through the creation of small businesses that are facilitated through technology incubators, such as the Arlington Technology Incubator. The Arlington Technology Incubator was created through a partnership between UT-Arlington and the Arlington Chamber of Commerce to help foster new technology and new technology-led development in the Arlington-Dallas-Ft. Worth region. It provides a mechanism by which faculty can take their research discoveries made at the university and develop commercial enterprises to capitalize on them. UT-Arlington is engaged in both approaches. Joint industry-university research partnerships are ongoing in multiple electronic device and materials areas with several electronics companies, and several of our faculty members are beginning to move technology developed at the university into small start-up companies.

Federal research support plays an important role in both of these approaches, and I would encourage funding agencies to be more aggressive in supporting these types of activities. Specifically relating to the National Nanotechnology Initiatives, policies that support and encourage government, academia and industry partnerships and fund these activities for longer periods of time could be given—should be given more consideration. Consider that the average time for a Ph.D. student to graduate is now more than five years, yet typical research funding periods are for only three years. Likewise, levels of financial support for graduate students as well as their earning power upon graduation are generally not adequate to attract U.S. citizens into pursuing science or engineering professions. This is perhaps a particular concern for security-sensitive industries and professions where the number of skilled workers in nanotechnology will clearly not be adequate to meet demand. Also, as nanotechnology becomes more integrated into industrial practices, the demand for more highly trained workers will outpace

supply. And, of course, this will occur faster as the economy gets stronger, further widening the gap.

To help meet these future work force needs, several changes in our educational process will need to take place. Perhaps a high priority one should be directed at strengthening the math and science skills of K to 12 students and subsequently improving the preparedness of U.S. students entering college. Another is glorifying nanoscience and technology to students at an early age, and these two activities will go a long way to significantly help increase the pipeline of students seeking and ultimately being trained for professions in research and development in nanotechnology. Thank you.

[Applause.]

[The prepared statement of Dr. Elsenbaumer follows:]

PREPARED STATEMENT OF RONALD L. ELSENBAUMER

Nanotechnology will be the driving force for developing smaller, lighter, more energy efficient, less costly, and stronger materials, devices and processes by fostering the creation of new functional materials and devices that exhibit novel phenomena and properties at the nanometer length scale. As this is realized, "nanotechnology" will be pervasive in our future and will be a major factor in U.S. economic growth and job creation in the technology sector for decades to come. Based on current trends, it appears as though the impact will be most dramatic in the electronics industries, medical industries, and in the energy sector. For example, work ongoing at UT-Arlington on developing nanostructured interfaces for semiconductor device interconnects and nanostructured porous materials as low dielectrics separating copper connected nanoscale transistor devices are helping to realize the next generation of high performance computer chips. Nano-contact printing techniques being developed at other institutions could revolutionize the way semiconductor devices are manufactured and drastically reduce manufacturing costs. Together, these new technologies will generate inexpensive, very powerful computing devices that would be incorporated into nearly every aspect of our daily lives—even more so than what they already are—leading to continued changes in our quality and way of life.

In medical applications, we are already seeing that nanoscopic materials can readily travel throughout the body. Thus, nanomagnetic materials being developed at UT-Arlington could be used in conjunction with drug therapies to direct drug delivery to targeted areas of the body. Likewise, these materials, as well as others being developed elsewhere, could be used for developing very powerful imaging techniques for medical diagnoses.

And, nanotechnology will undoubtedly play a major role in the development of renewable, cost effective, clean sources of energy, such as hydrogen. Nanotechnology will also lead the way to developing more efficient lighting, transportation, and electromechanical devices; all of which will result in significant reductions in fossil fuel consumption.

But, with these great opportunities come formidable challenges. New materials require new processes for making them—and many of these processes have not been developed yet, or are not yet cost effective for commercialization. The situation is similar for device fabrication and assembly. How can we control fabrication processes at these incredibly small dimensions? Paradigm shifts in manufacturing technologies will have to occur, and new processes are generally slow to be accepted by industry.

Similarly, concerns that the general public might have with perceived dangers associated with nanotechnology, such as environmental, bio-ethical, and unrecognized societal impacts, could slow acceptance of certain nanotechnologies or prevent them from being developed.

Overcoming these challenges and potential limitations will take considerable effort. And here, it is imperative that the Federal Government take the long view and fund longer-term, and in some cases wider ranging research projects, as generally, the private sector will not. I believe this concept needs to be seriously considered as the Federal Government shapes its funding and research policy issues across its various agencies.

The best approaches I have seen for facilitating the transfer of basic research results to industry are two-fold. One is through development of industry, university, and government partnerships early on in the process. Integrating basic research ap-

proaches with industry development needs at the outset, and with continued adjustment throughout the process, ensures compatibility between the research outcomes and industry's acceptance and willingness to integrate them into their products and processes. Another is through the creation of new small businesses that are facilitated through technology incubators, such as the Arlington Technology Incubator. The Arlington Technology Incubator was created through a partnership between UT-Arlington and the Arlington Chamber of Commerce to help foster new technology led economic development in the Arlington, Dallas-Fort Worth region. It provides a mechanism by which faculty can take their research discoveries made at the University and develop commercial enterprises to capitalize on them. UT-Arlington is engaged in both approaches. Joint industry/university research partnerships are ongoing in multiple electronic device and materials areas with several electronics companies. And, several of our faculty members are beginning to move technology developed at the university into small start-up companies. Federal research support plays an important role in both of these approaches. And, I would encourage funding agencies to be more aggressive in supporting these activities. Specifically, relating to the National Nanotechnology Initiative, policies that support and encourage government, academia, and industry partnerships, *and fund these activities for longer periods of time* should be given more consideration. Consider that the average time for Ph.D. students to graduate is more than five years, yet typical research funding periods are for only three years. Likewise, levels of financial support for graduate students, as well as their earning power upon graduation, are generally not adequate to attract U.S. citizens into pursuing science or engineering professions. This is perhaps of particular concern for security sensitive industries and professions, where the number of skilled workers in nanotechnology will clearly not be adequate to meet demands. Also, as nanotechnology becomes more integrated into industrial practices, the demand for more highly trained workers will out-pace supply. Of course, this will occur faster as the economy gets stronger, further widening the gap. To help meet these future workforce needs, several changes in our educational process will need to take place. Perhaps a high priority one should be directed at strengthening the math and science skills of K-12 students, and subsequently improving the preparedness of U.S. students entering college. Another is glorifying nanoscience and technology to students at an early age. These two activities will go a long way to significantly help increase the pipeline of students seeking and ultimately being trained for professions in research and development in nanotechnology.

BIOGRAPHY FOR RONALD L. ELSENBAUMER

Education:

B.S. With Honors in Chemistry, Purdue University, 1973

Ph.D. Chemistry, Stanford University, 1978

Employment:

The University of Texas at Arlington, 1991 to present

Interim Vice President for Research, November 2003-

Associate Vice President for Research, 2003-

Director, Nano-Fabrication Research and Teaching Facility, 2003

Interim Director, Nano-Fabrication Research and Teaching Facility, 2002-2003

Chair, Department of Chemistry and Biochemistry, January 1996-2003

Chair/Director, Materials Science and Engineering Program, 1991-2003

Professor of Chemistry and Polymer Chemistry, 1991-present

AlliedSignal, Inc. (Allied Chemical) Dec. 1977 to Oct. 1991 Corporate Research, Morristown, NJ 07962

Senior Research Associate, 1989-1991

Research Associate and Group Leader, 1982-1989

Senior Research Chemist, 1980-1982

Research Chemist III, 1977-1980

Publications:

Authored or co-authored 85 publications

Awarded 30 U.S. Patents

Research Thrust Areas:

Electrically Conductive Polymers

Flame Retardants for Polymers

Enhanced Lubricant Technologies



THE UNIVERSITY OF TEXAS AT ARLINGTON

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

January 14, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on December 5, 2003 for the hearing entitled "Nanotechnology Research and Development: The Biggest Little Thing in Texas." In accordance with the Rules Governing Testimony, this letter serves as formal notice of the Federal funding I currently receive in support of my research.

Please see the attached table for a list of the Federal funding I receive.

Sincerely,

A handwritten signature in cursive script that reads 'Ronald L. Eisenbaumer'.

Ronald L. Eisenbaumer
Interim Vice President for Research

<u>Department</u>	<u>PI</u>	<u>ACCT</u>	<u>Start</u>	<u>End</u>	<u>Sponsor</u>	<u>Title</u>	<u>Award</u>
Chemistry	Eisenbaumer	14-7610-75	01-Jan-04	31-Dec-05	Texas Higher Education Coordinating Board	ATP: An Environmentally Friendly Route to Commercially Important Conducting Polymers	\$ 152,000
Chemistry	Eisenbaumer	26-1001-75	15-Feb-03	28-Feb-06	National Science Foundation	An Upgrade of a 300 MHz NMR Spectrometer for Teaching and Research	\$ 164,950
Chemistry	Eisenbaumer	26-7402-08	01-Jun-03	31-May-04	Welch Foundation	Designed Intermolecular Orbital Overlap in Supramolecular Architecture Derived from Linear Conjugated Molecules Self-Assembled	\$ 50,000
Materials Science & Eng.	Eisenbaumer	26-7602-24	01-Jan-02	31-Aug-04	Platinum Research Organization (PRO)	Environmentally Friendly High Performance Lubricants and Anti-Icing Aircraft Coatings	\$ 70,000
Office of VP for Research and IT	Eisenbaumer	26-0101-05	01-Jul-03	30-Jun-04	Defence Advanced Research Projects Agency (DARPA)	Nanostructured Magnetic, Electronic, and Optical Materials and Devices	\$ 2,350,000
Office of VP for Research and IT	Eisenbaumer	26-2901-02	15-Oct-03	14-Oct-08	Department of Housing & Urban Development	Nanotech Research Institute	\$ 402,367

Chairman BURGESS. Thank you.
Next we'll go to Mr. Chris Gintz, NanoHoldings, LLC.

**STATEMENT OF MR. CHRISTOPHER J. GINTZ, CEO,
NANO HOLDINGS, LLC**

Mr. GINTZ. Congressman Burgess, Congressman Hall, ladies and gentlemen, I'm happy to report to you on behalf of all the little companies out there that innovation in nanotechnology is alive and well here in Texas. Approximately 80 percent of our time is spent with researchers, both here in north and south Texas, at University of North Texas, at the University of Texas at Dallas and also at Rice University in Houston.

We're an investment company that builds early-stage nanotechnology companies around exclusive licenses from leading universities for their most promising nanotechnology discoveries. We focus exclusively on core technologies that can have a major impact on existing multibillion dollar markets. In doing so, we anticipate being able to catalyze significant research and development into breakthrough products and processes that can improve our national industrial competitive position and also enhance the effectiveness of our military.

We started over 18 months ago by extending our reach to research universities that have reported promising developments in the fields of electronics, energy and advanced materials and process fields at the nanoscale. An example of our research and our reach is found here today. We believe, for example, that Dr. Timothy Imholt, a graduate student here at the University of North Texas, has made an important discovery, and we have been working with him to enhance his discoveries. We provided direct financial support for his research and we've formed a company called NanoStar to commercialize a portion of his discovery, and we're in the process of concluding an exclusive license with the University of North Texas, and we've been invited by them to locate NanoStar as one of the first commercial companies in the incubator. I believe it's in this facility.

Our scope is long-term. While we want to solve very big and complex national problems, we're extremely disciplined in our business approach. We target very specific short-term milestones that validate the science, we seek out only the best management teams to add to each nanodevelopment company that we form, we're relentless in our drive to ensure that our development company delivers its first commercial products within three years from its entry into the incubator.

I believe a drive to commercialization is critical to be able to successfully leverage the major government investment in this exceptional field of science. When I was the Director of Technology Planning and Development at Compaq Computer I focused on the creation of technological solutions leading to the formation of major industrial partnerships with a variety of companies. At their zenith they had annual sales of over \$50 billion a year. Some of these investments were with Conner Peripherals, with Nexgen Microsystems, with In Focus Systems, Sanyo Electric Battery and Citizen Watch. As the inventor of the first notebook computer concept, which became the Compaq LT Notebook family, this product had

a first year sales success of \$1.5 billion. So when I say I'm focused on commercialization, I say so with a history of having done so successfully with a burning desire to do so again. I also know how critical it is to be able to allocate private capital sensibly to each promising innovation, and I'm lucky to have an experienced venture capitalist, Justin Hall-Tipping, as my partner.

The potential economic impact of the commercialization of nanotech discoveries, like Dr. Imholt's, is fueling a global foot race between developed nations whose governments clearly understand that leadership in this field may be critical to their future economies. The National Science Foundation predicts that in the United States alone nanotechnology innovation may have a trillion dollar impact within the next 15 years, but that will only occur if we have a good working relationship between private capital sources and government.

Clearly, the recent approval of the nanotechnology bill is evidence of the United States government's commitment to the science. We are delighted that much of the funding is targeted at academia. We have seen firsthand because of our relationships with two very good research universities here in North Texas that they're ideally structured to acquire the grant funding process and to foster the out-of-the-box thinking and global collaboration that will be vital for breakthroughs in this field. This was a major determinant in NanoHoldings' decision to invest early in partnerships with universities here in Texas and their scientists to develop the core technologies that we feel will form the bedrock of new industries to come.

We hope that the promise of these scientific developments will also facilitate the local economy by providing many good paying skilled jobs. But it most certainly cannot occur without a sizable investment in the science and research nor in the development of the local infrastructure. Only by working with the university can we expect to mobilize our efforts along with the public sector. All of the ingredients for success are here. Progressive, forward-thinking university administrators work hand in hand with local development officials and are creating the environment for a small company like ours to succeed. Close cooperation between the government at all levels of the private sector is a fundamental requirement to create the scale of investment that is a basic requirement for successful entrepreneurial activity at the nanoscale. Our competition is international and intense.

Thank you for giving us the opportunity to have a voice today. We look forward to working with you as a partner, and we hope to ensure that we can bring these innovations to the market. Good morning.

[Applause.]

[The prepared statement of Mr. Gintz follows:]

PREPARED STATEMENT OF CHRISTOPHER J. GINTZ

Good Morning Ladies and Gentlemen. I am Christopher J. Gintz, Managing Partner of NanoHoldings, LLC.

NanoHoldings is an investment company that builds early stage nanotechnology companies around exclusive licenses from leading universities for their most promising nanotechnology discoveries. We focus exclusively on core technologies that can have a major impact on existing multi-billion dollar markets. In doing so, we antici-

pate being able to catalyze significant research and development into breakthrough products and processes that could improve our national industrial competitive position and also enhance the effectiveness of our military.

We started over eighteen months ago by extending our reach to research universities that had reported promising developments in electronics, energy, and advanced materials and process fields at the nanoscale. An example of our reach is found here today. We believe that Mr. Timothy Imholt made an important discovery last year at the University of North Texas. We have provided direct financial support for his research and have formed a Company, NanoStar, to commercialize a portion of his discovery. We are in the process of concluding our exclusive licensing agreement with the University and have been invited by them to locate NanoStar as the first commercial company in their new incubator.

Our scope is long-term. While we want to solve very big and complex national problems, we are extremely disciplined in our business approach. We target very specific short-term milestones that validate the science. We seek out only the best management teams to add to each nano-development company we form. We are relentless in our drive to ensure each development company delivers its first commercial products within three years from its entry into the incubator.

I believe a drive to commercialization is critical to be able to successfully leverage major government investment in this exceptional field of science. When I was the Director of Technology, Planning and Development for Compaq Computer, I focused on the creation of technological solutions leading to the formation of major industrial partnerships with Conner Peripherals, Nexgen Microsystems, In Focus Systems, Sanyo Electric Battery, and Citizen Watch. I was also the inventor of the first notebook computer concept, (U.S. Design Patent #317,442), which became the Compaq LTE Notebook Compute family. That product had first year sales in excess of \$1.5 billion. So when I say I am focused on commercialization, I say so with a history of having done so successfully, and a burning desire to do so again. I also know how critical it is to be able to allocate capital sensibly to each promising innovation, and I am lucky to have an experienced venture capitalist, Justin Hall-Tipping, as my partner.

The potential economic impact of the commercialization of nanotech discoveries like Timothy Imholt's is fueling a global "foot race" between developed nations whose governments clearly understand that leadership in this field may be critical to their future economies. The National Science Foundation predicts that in the United States alone, nanotechnology innovation may have a \$1 trillion impact within the next 15 years. Clearly, the recent approval of the Nanotechnology bill is evidence of the United States' commitment to this science.

We are delighted that much of this funding is targeted at academia. We have seen first hand that university centers like the University of North Texas are ideally structured to acquire the grant funding and foster the out-of-the-box thinking and global collaboration that will be vital for breakthroughs in this field. This was a major determinant in NanoHoldings' decision to invest early in partnership with universities and their scientists to develop the core technologies that will form the bedrock of new industries to come.

We hope that the promise of these scientific developments will also facilitate the local economy by providing many good paying skilled jobs. But it most certainly cannot occur without a sizable investment in the science and research nor in the development of the local infrastructure.

Only by working with the University can we expect to mobilize our efforts along with the public sector. All of the ingredients for success are here. Progressive, forward-thinking university administrators working hand-in-hand with local development officials are creating the environment for us to succeed. Close cooperation between the government at all levels and the private sector is a fundamental requirement to create the scale of investment that is a basic requirement for successful entrepreneurial activity at the nanoscale. Our competition is international and intense.

Thank you for giving NanoHoldings the opportunity to have a voice today. We look forward to working with you as a partner to create some of the breakthrough innovations that will ensure that America maintains a strong leadership position in this emerging global economy. Good Morning.

BIOGRAPHY FOR CHRISTOPHER J. GINTZ

DEMOGRAPHICS:

Married, two children aged 8 and 11

SUMMARY:

Christopher J. Gintz, 50, is a well-known designer, marketer and executive in the computer industry. He led the product and technology teams in start-ups and established companies. His experience spans the semiconductor, software and hardware businesses. As a life-long inventor and entrepreneur, he defined technologies into end-user products that are market based. As an early employee at Compaq Computer, he focused on the creation of technology partnerships and the formation of joint ventures with Conner Peripherals, Nexgen Microsystems, In Focus Systems, and Citizen Watch. He is the inventor of the Compaq LTE notebook computer concept and holds U.S. and foreign patents on the design, U.S. Patent #317,442. Since 1995, he is a force behind the incorporation of software technology into school curriculums across the United States.

EXPERIENCE:

September 1995–Present: Optimum Resource, Inc., Hilton Head Island, South Carolina

Chief Operating Officer, Director

Responsible for the day-to-day management of a leading educational software publisher's operations including product definition, sales and marketing, engineering, finance, fulfillment, personnel, and legal functions. The company, under his guidance, created over 60 products and broadened its brands to include a comprehensive set of curriculum-based pre-K-grade 12 solutions that are cross-platform compatible. Company is profitable the past four years despite a rapid consolidation in the industry.

January 1995–September 1995: Summary Corporation, Houston, Texas

Chief Operating Officer, Director

Responsible for arranging the first round of public financing and redirecting product development efforts.

August 1992–December 1994: The Bardehle Law Firm, Houston, Texas

Technology and Licensing Consultant to International Companies

Managed the firm's worldwide electronic technology licensing practice. Produced major engineering analyses in the disciplines of cellular telephone, semiconductor manufacturing and computer hardware and software technology in preparation for complex licensing and patent litigation. Developed strategies for technology licensing clients in the United States, Japan, and Europe. Cross-trained in the copyright and trademark practices in the global electronics industry.

August 1991–August 1992: Compaq Computer Corporation, Houston, Texas

Director, Corporate Development; reported to the new President and Chairman of the Board

Appointed by the new President in management reorganization to identify, form, and manage cross-functional teams to restructure the Company's business processes. Developed a plan, in conjunction with a 20-person McKinsey consulting team, to develop a strategy to broaden the company's distribution and product line accelerating the company's growth from 5.5 billion to 10 billion dollars. Reduced payroll by \$25 million dollars, operating expenses by \$200 million annually and product development and manufacturing costs by 30 percent.

August 1985–August 1991: Compaq Computer Corporation, Houston, Texas

Director, Technology, Planning and Development; reported to the Founders of the Company

Managed the worldwide technology diligence process for all semi-conductor, computer hardware and software technologies fitting into the company's product planning and business processes. Completed over \$50 million in early stage investments in relevant technologies. Company earned over a billion dollars on these investments either by selling shares when the companies went public or when technologies were leveraged into products that enabled the company to command higher gross profit margins for its products.

Developed the notebook computer product concept and put together a joint venture with Citizen Watch Company, Japan to manufacture a family of products. Over 2,000,000 LTE Family computers sold over a seven-year period, generating annual revenue in excess of \$1.5 billion dollars.

Managed the standards making process as the company's designated CBEMA, ECMA, ANSI and CSPP technology policy-making representative worldwide.

July 1984–August 1985: CTI Data Corporation, Raleigh, North Carolina

Director, Marketing and Product Planning; reported to the lead investor and Board

Initial start-up team member recruited by the investors to develop a marketing and product strategy for a development stage venture capital start-up designing remote switches for data networks. Engineering team could not cost effectively engineer the product and the company sold for its net loss carry-forward.

April, 1983–July 1984: Compaq Computer Corporation, Houston, Texas

Manager, Product Planning; reported to Company Founder

Planned all of the initial portable computer products and developed business plan for the entry into the desktop computer business. Products generated over \$1.5 billion in sales during a three-year period.

November 1980–April 1983: Texas Instruments, Inc., Houston, Texas

Manager, Data Communications and Storage Products Semi-conductor Business

Developed business plans and managed a group that was responsible for implementing products utilizing the token ring chip set and hard disk interfacing chips in digital device applications.

August 1979–November 1980: Bunker Ramo Information Systems, Trumbull, Connecticut

Software Project Engineer

Developed software for complex international funds transfer systems in Iran, the Philippines, and Europe.

May 1978–August 1979: Incoterm Corporation, Boston, and Massachusetts

Software Engineer and Technical Writer

Developed computer programs and software documentation for the first airlines reservation system for United, Delta, TWA, Eastern, and Braniff Airlines.

May 1974–July 1978: State of South Carolina, Columbia, South Carolina

Designed computer information systems for manpower, planning, administration, and scientific computer applications in a large IBM mainframe environment.

EDUCATION:

Graduate, Cathedral Preparatory School for Boys, Erie, Pennsylvania, 1969

Bachelor of Arts, English, University of South Carolina, Columbia, 1972

Bachelor of Science, Computer Science, University of South Carolina, Columbia, 1979

Master of Education, Research and Statistics, University of South Carolina, Columbia, 1974

PATENTS:

Design Patent Number 317,442, June 11, 1991; Notebook Computer assigned to Compaq Computer Corporation, Houston, Texas

REFERENCES:

Available on Request.

NANO HOLDINGS LLC

January 15, 2004

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on December 5 for the hearing entitled Nanotechnology Research and Development: The Biggest Little Thing in Texas. In accordance with the Rules Governing Testimony, this letter serves as formal notice of Federal funding I currently receive in support of my research.

- I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two preceding fiscal years.

Sincerely,



Christopher J. Gintz
Partner, NanoHoldings LLC

Chairman BURGESS. Thank you.
And then Dr. John Randall, Chief Technology Officer and Vice President of Research at the Zyvex Corporation.

STATEMENT OF DR. JOHN RANDALL, CHIEF TECHNOLOGY OFFICER, VICE PRESIDENT OF RESEARCH, ZYVEX CORPORATION

Dr. RANDALL. Thank you, Mr. Chairman. I am John Randall, Chief Technology Officer of Zyvex Corporation. Unfortunately, Zyvex's Chairman, CEO and my friend, Jim Von Ehr, was unable to be here this morning, so he has given me the honor of reading his testimony before this Committee.

Many of us here today believe that the future impact of nanotechnology on our lives will be profound. We owe a great deal of thanks to people such as Jim Von Ehr who have donated \$4 million to universities, another \$200,000 to fund the Texas Nanotechnology Initiative, and to date has expended \$34 million of his own personal money to nanotechnology, more than any other single person on Earth. He's not only a great businessman, he's a great American, and as a member of Zyvex, one of the first nanotechnology businesses, I'm proud to share his thoughts with you today. So this is the testimony of James Von Ehr, Chairman and CEO of Zyvex Corporation.

First of all, I would like to thank President Bush, Chairman Sherwood Boehlert, Representative Mike Honda, Senator George Allen, Senator Ron Wyden, all of the Members of the Science Committee who have taken the time to confront the challenges of ensuring our nation's future well being. We would not be gathered here today if it had not been for their efforts.

It was just three days ago that I stood behind the President in the Oval Office as he signed the 21st Century Nanotechnology Research and Development Act. It was both a humbling and an expiring moment. We have taken the first steps to bring the promise of nanotechnology to the American people, but the Members of the Science Committee know that although we've made great strides in passing this bill, much work still needs to be done to ensure that it is the United States who continues to be the world leader in science, technology and business. We need to commercialize university research, create more opportunities and competition for small businesses to perform innovative nanotechnology R&D and issue grand challenges that the American public can understand and embrace. This needs to happen if we're going to bring the vision of nanotechnology to fruition.

Thanks to my previous business success, I've been able to fund Zyvex to become one of the leading nanotechnology companies in the world. I've also given money to a number of universities to help them enter this field. With this experience I feel entitled to comment on technology transfer and commercialization. International competitors are aggressively developing their own nanotechnology industries, often based on discoveries first made in university labs here in the United States. When universities protect their intellectual property it ultimately benefits the Nation but only if there's a successful technology transfer to a U.S. company that is able to develop it into applications and services. Yet we know the tech-

nology transfer programs at our nation's leading universities have produced dismal results.

The barriers for small and large industry to commercialize this long-term research under federal dollars have brought very little economic benefit to the American public. Right now there are breakthrough technologies sitting on the shelves in academia. In the hands of the right businesses, these technologies could be developed cures for diseases, conserve energy or streamline manufacturing with the additional benefits of creating thousands of jobs for Americans.

Stockholders' gauge a business performance to decide if it's a worthy investment. A similar measurement component needs to be in place when awarding universities federal R&D dollars. The award decision should be based on the university's track record as well as their plan for successfully transferring their technology to American businesses. The measurement system would encourage universities to be more discerning about which intellectual property they decide to protect and more flexible about licensing terms.

I used to be opposed to government funding for any industry. I have always believed, and still do, that the private sector makes the best investment decisions. Yet some important investments are too long-term or risky for private capital. It is reasonable for government to encourage economic competitiveness for national security reasons. As a businessman, I am concerned about the industrial policy implications. As an American citizen, I'm even more concerned about losing nanotechnology to foreign countries with investors willing to invest beyond two to three years. On a trip to Taiwan last year, I witnessed ITRI, a government-industry partnership, staffed with 6,000 researchers, developing an advanced technology base and focusing on industrial competitiveness. Other countries such as Singapore, Japan and China are setting up similar programs. They understand that creating programs that leverage government, university and business partnerships will position them to be leaders in a new global economy. Private funding today is short-term oriented, but taking research from the lab to the marketplace is a long-term endeavor. The gap between lab and market leads to a valley of death funding crisis, and it is rare to find investors willing to take the risk of investment lasting more than five years.

It is estimated that 95 percent of the \$3.7 billion authorized for this act will go to scientific research and development, about 60 percent to academia and 35 percent to government labs. Additionally, it will be used to fund big government and university programs. We should inject private sector competition and businesses into our nanotechnology program. The result would be smaller programs that through the nature of competition will achieve better results.

We need an R&D technology program that engages small businesses. The Commerce Department has the NIST Advance Technology Program, which has been instrumental to Zyvex in overcoming this funding gap. It helps fund high-risk, high-reward projects and evaluating commercialization plans as a venture capitalist would. The NIST ATP Program requires in many cases, including ours, cost-sharing by the company. The ATP helps put

small companies on a more even research and development footing with large companies. The program wisely recognizes that small businesses are unable to afford the kind of R&D of an IBM or a Lucent yet are responsible for the majority of our nation's innovations and technical achievements. Thanks to our ATP we have hired 15 new employees in 2003, and we support researchers at Universities in Texas, Virginia and New York. We are developing new manufacturing technology that will drive innovation in the silicon micromachine domain. The impact of parallel microassembly on the broader economy will be in the billions of dollars and ultimately create thousands of jobs here in America.

In order for the United States to be competitive in the future global market, our U.S. industries are going to need the best and the brightest engineers, scientists and business people. However, the increased immigration restrictions are making it more and more difficult for American universities to attract foreign students. Many countries such as Korea and China have upgraded their university facilities to keep their best students at home, and student applications here are declining as a result. We need to welcome students to our American universities and yet find ways to balance our security concerns.

In order to encourage more Americans to study science and engineering, we need to inspire and motivate them. A Grand Challenge would do that. We need government, universities and industry to work in a partnership to achieve the great promises of nanotechnology through a program similar to the Man on the Moon Challenge. The National Nanotechnology Initiative has worked very hard to find nine grand challenges, yet many Americans have a difficult time embracing these. What if we had one or two grand challenges that solved serious problems of our nation, problems like reducing our dependence on imported energy and regaining our position as the world leader in manufacturing? Every American would embrace and stand behind these challenges.

In conclusion, we have a great responsibility to the American people to ensure that nanotechnology provides the benefits that we claim. We must create ways to make technology transfer successful. We must create ways for small businesses to compete with one another to sell the best innovations and applications in the global marketplace. We must help our universities thrive. And, most importantly, we must come together as a nation to solve some of our toughest problems, energy independence and manufacturing. Once again, I commend President Bush, Senator George Allen, Senator Ron Wyden, Representative Mike Honda, the House Science Committee Chairman Sherwood Boehlert, the Congressmen at this hearing and our other leaders who have created the legacy through the passage of this bill. Mr. Chairman and Members of the Committee, thank you for your time and for this great honor.

[Applause.]

Mr. James Von Ehr II was unable to attend the hearing and was represented by Dr. John Randall. Mr. Von Ehr did submit written testimony.

[The prepared statement of Mr. Von Ehr follows:]

PREPARED STATEMENT OF JAMES R. VON EHR II
CHAIRMAN AND CEO, ZYVEX CORPORATION

INTRODUCTION

First, I would like to thank President Bush, Chairman Sherwood Boehlert, Representative Mike Honda, Senator George Allen, Senator Ron Wyden and all the Members of the Science Committee who have taken the time to confront the challenges of ensuring our nation's future well being. We would not be gathered here today, if it had not been for their efforts.

It was just three days ago that I stood behind the President in the Oval Office as he signed the *21st Century Nanotechnology Research and Development Act*. It was a humbling and yet inspiring moment.

We have taken the first steps to bring the promise of nanotechnology to the American people. Our nation has accomplished so much. But Members of the Science Committee know that although we have made great strides by the passage of this bill, much work still needs to be done. We now have to build and strengthen the infrastructure to ensure that it will be the United States who continues to be the world leader in science, technology, and business.

We need to commercialize university research, create more opportunities and competition for small businesses to perform innovative nanotechnology R&D, and issue Grand Challenges that the American public can understand and embrace. This needs to happen if we are to bring the vision of nanotechnology to fruition.

TECHNOLOGY TRANSFER

Thanks to my previous, significant business success, I've been able to generously fund Zyvex to become one of the leading nanotechnology companies in the world. I've also given money to a number of universities to help them enter this field. With this experience, I feel entitled to comment on technology transfer and commercialization.

International competitors are aggressively developing their own nanotechnology industry, quite often based on discoveries first made in our own university labs here in the United States. When Universities protect their intellectual property, it ultimately benefits the Nation. But only if there is a successful technology transfer to a U.S. company that is able to develop it into applications and services.

Yet we all know the technology transfer programs at our nation's leading universities have produced dismal results. The barriers for small and large industry to commercialize this "long-term" research performed under federal dollars have brought very little economic benefit to the American public. Right now, there are breakthrough technologies sitting on the shelves of academia. In the hands of the right business, these technologies could be used to develop cures for rare diseases, conserve energy, or streamline manufacturing—with the additional benefit of creating thousands of jobs for Americans.

Stockholders gauge a business's performance to decide if it is worthy of an investment. A similar measurement component needs to be in place when awarding universities federal R&D dollars. The award decision should be based on the universities' track record, as well as their plan for successfully transferring their technology to American businesses. This measurement system would encourage universities to be more discerning about which intellectual property they decide to protect and more flexible about licensing terms. We are spending a lot of money filing patents that are not being used, and we should ask for a return on that patent investment.

COMPETITION

I used to oppose government funding for any industry. I have always believed, and still do, that the private sector makes the best investment decisions. Yet, some important investments are too long-term, or risky, for private capital. It is reasonable for the government to encourage economic competitiveness for national security reasons.

As a businessman, I am concerned about the "industrial policy" implications. As an American citizen, I am even more concerned about losing nanotechnology to foreign countries with investors willing to invest beyond two to three years. On a trip to Taiwan last year, I witnessed ITRI, a government/industry partnership staffed with 6,000 researchers developing an advanced technology base and focused on industrial competitiveness. Other countries, such as Singapore, Japan, and China, are setting up similar programs. They understand that creating programs that leverage government, university, and business partnerships will position them to be the leaders in the new global economy.

Private equity funding today is short-term oriented. But taking research from the lab into the marketplace is a long-term endeavor. The gap between lab and market leads to the “valley of death” funding crisis—and it is rare to find investors willing to take the risk of an investment lasting five years or more.

It is estimated that 95 percent of the \$3.7 billion authorized from this Act will go to scientific research and development—about 60 percent for academia and 35 percent for government labs. Additionally, it will be used to fund “big” government and university programs. We should inject private sector competition and businesses into our R&D nanotechnology program. The result will be “smaller” programs that through the nature of competition achieve better results.

We need a nanotechnology R&D program that engages small businesses. Our small businesses employ 39 percent of high tech workers and are responsible for 45 percent of the jobs in our nation. Small businesses produce 13–14 times more patents per employee than large firms. These patents are also twice as likely to be among the one percent most cited.

Of course, we have SBIR programs aimed at small businesses, but the amount of paperwork involved for the relatively small amount of money, \$100K maximum, makes this program marginal in today’s fast-paced environment.

The Commerce Department has the NIST Advanced Technology Program, which has been instrumental to Zyvex in overcoming this funding gap. It helps fund high-risk, high-reward projects, evaluating commercialization plans as a venture capitalist would. The NIST-ATP program requires, in many cases, including ours, cost sharing by the company. The ATP helps put small companies on a more even research and development footing with large companies. The program wisely recognizes that small businesses are unable to afford the kind of R&D of an IBM or Lucent, yet are responsible for a majority of our nation’s innovations and technical advancements.

Thanks to our ATP, we will have hired fifteen new employees in 2003; we also support researchers at universities in Texas, Virginia, and New York. We are developing a new manufacturing technology that will drive innovation in the silicon micro-machine domain. The impact of parallel micro-assembly on the broader economy will be in the billions of dollars and will ultimately create thousands of jobs here in America.

EDUCATION AND OUR FUTURE WORK FORCE

In order for the U.S. to be competitive in this future global market, our U.S. industries are going to need the best and brightest, engineers, scientists, and business people.

However, increased immigration restrictions are making it more and more difficult for American universities to attract foreign students. Many countries such as Korea and China have upgraded their university facilities to keep their best students at home, and we’re starting to see declines in student applications as a result. We need to welcome students into our American universities and find ways to balance security concerns.

We have an international workforce at Zyvex. While we try to hire American citizens whenever possible, with the decline in American science and technology students, sometimes we have to look offshore. We should find a way to continue to import highly skilled employees to the USA, rather than export the job to another country, or even worse, export the company.

GRAND CHALLENGE

In order to encourage more Americans to study science and engineering, we need to inspire and motivate them. A Grand Challenge would do that. We need government, universities, and industry to work in partnership to achieve the great promises of nanotechnology through a Grand Challenge program similar to the “man on the moon” challenge. The National Nanotechnology Initiative has worked very hard to define nine “grand challenges,” but it is difficult to focus on nine things with undefined outcomes. Many Americans have a difficult time embracing these challenges. What if we had one or two Grand Challenges that solved serious problems for our nation? Problems like reducing our dependence on imported energy and re-gaining our position as the world leader in manufacturing.

Every American would embrace and stand behind these challenges.

CONCLUSION

We have a great responsibility to the American people to assure that nanotechnology provides the benefits we claim it will. We must create ways to make technology transfer successful. We must create ways for small businesses to compete with one another to sell the best innovations and applications in a global marketplace. We must help our universities thrive. And, most importantly, we must come

together as a nation to solve some of our toughest problems—energy independence and manufacturing.

Once again, I commend President Bush, Senator George Allen, Senator Ron Wyden, U.S. House Representative Mike Honda, House Science Committee Chairman Sherwood Boehlert, the Congressmen at this hearing, and our other leaders who have created a legacy through the passage of this bill.

Mr. Chairman and Members of this committee—thank you for your time and for this honor.

BIOGRAPHY FOR JOHN RANDALL

Chief Technology Officer, Zyvex Corporation

Dr. Randall has over twenty years of experience in micro- and nanofabrication. He joined Zyvex in March of 2001 after fifteen years at Texas Instruments where he worked in high resolution processing for integrated circuits, MEMS, and quantum effect devices. Prior to working at TI, Dr. Randall worked at MIT's Lincoln Laboratory on ion beam and x-ray lithography. Dr. Randall has a Ph.D., M.S., and B.S. in Electrical Engineering, all from the University of Houston.



December 18, 2003

The Honorable Sherwood Boehlert
Chairman, Research Subcommittee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the U.S. House of Representatives Committee on Science on December 5 for the hearing entitled *Nanotechnology Research and Development: The Biggest Little Thing in Texas*. In accordance with the Rules Governing Testimony, this letter serves as formal notice of the Federal funding I currently receive in support of my research.

\$12,500,000	Award #70NANB1H3021	NIST-ATP	2001
\$599,633	Award#NNJ04JA18C	NASA	2003
\$98,637	Award#DAAH01-03-R217	DARPA	2003

Sincerely,

A handwritten signature in black ink, appearing to read "James Von Ehr II".

James Von Ehr II
Founder, Chairman, and CEO

DISCUSSION

Chairman BURGESS. The format for the questioning will be Mr. Hall and I will alternate. I'll begin and we'll try to restrict our question and answer periods to five minutes each so we get to more material. The first question actually goes to the entire panel. The information technology [IT] revolution that led to unprecedented productivity gains has been the real driving force behind the economy in the last 15 to 20 years, helping in some ways to offset the gradual decline in some areas of the manufacturing sector. Many believe the impact of future nanotechnology advancements on productivity and the economy will dwarf that of the information technology revolution by comparison, so I would ask the panel what is your opinion of this, and is the State of Texas or the North Texas area particularly, are we adequately poised to become a leader in this area? And we'll start with Dr. Reidy and move down.

Dr. REIDY. Congressman, I think that the issue can be broken into two ways. First of all, the information technology revolution spawned many businesses which were effectively trial and error. They were not building anything, and one of the great complaints in many cases was that people were using the Internet as a means of kind of testing the facility out, see what they can do with it. There was a great deal of money made and lost, as some of us are aware with our 401Ks, during this revolution. I think that the difference between the IT revolution and the nanotechnology revolution basically goes down to I believe what former Secretary Reich once said is pie-building rather than pie-dividing. The fact is that we will increase manufacturing and manufacturing probably will maintain long-term markets. Things like, as have been discussed by various panel members, anything involving electronics, biotechnology, energy, all those things are not going away anytime soon. And I think—so on the long haul, I don't think that we should be as concerned about losing, as some people fear, with the IT. I don't think this is a fad. I think the ability to build things from the very small is going to be the way we do things from now on. So I think that is the key difference in describing the two.

Chairman BURGESS. Dr. Feng.

Dr. FENG. Mr. Chairman, the IT revolution or bubble of the '90's really was built on a concept that was not built on a good business plan concept. People, especially venture capitalists, for example, were literally throwing money into the IT sector. Many, many infrastructure was created on a promise that it will have investment return much, much greater than it showed. And, of course, eventually since it was not based on good business plan, it faltered and collapsed.

Nanotechnology, on the other hand, requires information—it requires a knowledge barrier which is a lot higher than the IT knowledge barrier. It requires people to really try to understand the science behind it, it requires people to understand the manufacturing behind it, it requires people to understand the business behind it, and they are still struggling at the moment in all that. So I think that it has a much longer period of maturation than the IT did. The IT literally grew overnight and became billions and bil-

lions of dollars of activity that nanotechnology is slowly growing into.

I therefore believe that the fact that, as was mentioned earlier, nanotechnology will have impact in the health sciences, will have impact in the military strength of our nation, will have business implications and all that. It will be a much more robust and healthy industry in the years to come for our nation.

Chairman BURGESS. Dr. Elsenbaumer.

Dr. ELSENBAUMER. Yes. What I'd like to add to the comments that have already been made is that nanotechnology as it develops is going to obviously take a much slower time frame. It's going to be a little slower to develop, a much longer term time frame than what we recognized in the information technology era. A lot of these technologies are going to be directed at real needs in nanotech, and there will be continual feedback from the marketplace into the development process, and for that reason I think you'll see a much longer and much more robust sustained development of this technology for many, many years and decades to come.

Chairman BURGESS. Mr. Gintz.

Mr. GINTZ. I'd like to offer an alternative opinion. If you look at the history of industrialization in this country in the past 100 years, it took about 75 years for the car companies to become commodities. It took the radio and television industry about 35 years to become commodities, and it's taken the IT industry about 20 years to become a commodity. So I think it's all about velocity, and velocity is predicated on the kind of people that we have working in the field, and the more people that we have from other cultures that come here to learn about our processes, the faster they're going to be able to take those processes that they've learned to other countries. We've certainly seen this in North Texas in the semiconductor industry, specifically in Taiwan and Korea. So I think it's all becoming very interconnected, and we run the risk of having to stake out some territory that will enable us to defend from an economic and from a jobs perspective specific areas of the technology that we're going to want to own in this country.

I think in the past 25 years economic development has kind of been the story of O. We started out with the info era, which was predicated primarily in the Northeast because you had a very good collection of economic and educational resources working on it. Then the next wave was the bio revolution and that was also predicated on the same kind of ingredients. With nano, we really are not closed to where that technology can develop, and so I think in those parts of the country, and in fact those parts of the world, where you take private and government capital, you take a very viable educational process, people who are open to technology transfer, that's going to be fertile ground for the development of the technology, and so I think that unlike maybe what other people believe with regards to the velocity of how quickly nanotechnology could transfer, it could transfer very quickly given that mix.

Chairman BURGESS. Dr. Randall.

Dr. RANDALL. Say what you will about the boom and bust economics of the IT revolution. The benefits of it are still with us, and in fact Internet commerce continues to grow. And in fact I would argue that the IT revolution, even if the economics of it was a little

herky jerky, has really positioned us to move forward in nanotechnology. In fact, a few people find it a little strange that Jim Von Ehr, who mainly made his money through a software company, got interested in nanotechnology. He understands, and I agree with him completely, that software and information control, largely developed by the IT boom, is going to be absolutely essential in developing nanotechnology. If you'll look at just in the, say, the human genome project, the amount of information that's generated there and will be generated ever more quickly with nanotechnology being applied to that problem, generating the information is one thing, dealing with it is entirely different. And so all of the infrastructure that we've put in place for information sharing, data mining and handling large amounts of data is going to be absolutely essential in making progress in this area. And as to the question are we well positioned in the North Texas area to contribute and benefit from the nanotechnology boom, I think absolutely, and I think it's going to be a long and sustained economic growth for this region and this country.

Chairman BURGESS. Thank you. Mr. Hall.

Mr. HALL. Mr. Chairman, thank you again, and I'm really pleased you had the opportunity of selecting the panel that you've brought us a good mix of academic researchers and industry representatives. I think that's wholesome, and I think that will be very good information to put out to the rest of the Subcommittees, the Committee and to the Congress in general. I might ask Dr. Randall if you attended the signing, did the President keep his economy cutback going by not giving out pens?

Dr. RANDALL. I believe, although I did not personally attend, it was actually, I was speaking for Jim who did attend, and I believe he actually did give away some federal dollars in pens.

Mr. HALL. Well, to a guy like Jim Von Ehr I'd give him all the pens I have because that's the ideal type contractor that we like to see that puts themselves into it, and that's the future with their funds, and I thank you for doing a good job of representing him here today. I wish he could have been here.

Dr. RANDALL. Well, thank you, sir. I will pass along your comments to him. He'll appreciate those.

Mr. HALL. Most of you mentioned federal funding and of course President Bush has just announced a new thrust, the National Nanotechnology Initiative, and the National Academy of Sciences has already conducted some reviews on this, as you all well know. First they establish a board, some type of an advisory board. You have to have that, it seems like, always. Then a strategic plan, which makes sense, and then interagency coordination, ask for that, and we have that here today. If they have it as much as they carry out the program as Chairman Burgess has in setting up this hearing, why we'll have input from everybody, from every side, and that's what we need. And then to promote interdisciplinary nanotechnology R&D. Those are some of the things, and you've mentioned funds being put in and the federal funds that you have to have for programs like this to get it off and going, just like the space program. One day that will be a competitive program by the private sector as it should be.

I think in addition to setting funding goals, though, this bill, as you read it closely, the bill puts in place mechanisms for planning and coordinating an interagency research program and it includes a lot of expert outside advice, and that's what we're doing here today is getting that to go to the people that will make the program work and ensure its relevance to emerging technological opportunities and to industry. In other words, don't oversell or don't undersell nanotechnology, and I guess that's what the Congress is crying out to you now.

You have to have funding and I think—and by the way, the President's just announced a new thrust to the moon, and I don't know how far off that is, but I think—I certainly congratulate him for going back and thinking in those terms, because who knows, the next war might be fought from space, but certainly in all the thrust that we have from the Science Committee and into the space thrust, we need to be first because there's so much fallout, medical fallout, national defense fallout. It's like President Reagan's effort for Star Wars. We probably never did accomplish that, but the Russians didn't know we didn't and there was a fallout on the way there. Those are things that meetings like this spawn, and I thank you all for being a part of it.

I guess my question is to any of you, what's your impression as to how the United States ranks internationally in the commercialization of innovations on nanotechnology? Have you had a chance to survey that? Do you have some opinions on that? Are there particular subfields in the technology in which other countries are more advanced than we are? Are we behind? Do we have to catch up like John F. Kennedy said at a certain time we were going to put a man on the moon? Not today, you'd have to say we're going to put a person on the moon, I guess. But are we behind either in applications or in research accomplishments in nanotechnology or have any of us really got off and started and underway? Is that a question that any—Mr. Gintz? And don't ever say small for anything in Texas, because we don't agree with that. We think everything's huge in Texas, and we think of all small industry, 98 percent of industry is small industry here and everywhere.

Mr. GINTZ. When I've gone abroad people's impression of Texas is it's a whole other country. The assessment that we've made is the Germans in particular have made some pretty interesting advancements in basic materials science, which has, of course, always been their strength.

Mr. HALL. Yes.

Mr. GINTZ. I don't think outside of materials science, though, there's any particular area of nanotechnology that we're behind. I think that we have some very specific areas that we're working in, especially with regards to electronics, that we're clearly ahead. It's difficult, for example, for the Japanese to understand exactly the nature of what we're doing because of the structure of some of our collaborations between research universities and private companies. But I think most people today are probably concerned about the proximity of the competition from overseas. The gap is narrowing because there are dedicated groups of people in Singapore, in Europe, in Japan that are working in nanotechnology that are

probably approaching the same scale of effort that we're seeing in the United States, but because so much of the technology—of the scientific discoveries were here, we have a three- to five-year head start.

Mr. HALL. I have no time left but does anybody want to take 15 or 20 or 30 seconds? Go ahead, Dr. Reidy.

Dr. REIDY. Congressman, I think the way I would address this is I would concur with what my colleague just said that the Germans are doing some very interesting things in nanotechnology of materials science.

Mr. HALL. Like what?

Dr. REIDY. Well, I mean, for example, the highly porous materials, while originally developed in the '30's by scientists at Stanford, the more recent revolution began in the '80's in Germany. These are the materials called aerogels, which are highly porous, and I just attended a conference on that so I can speak on this. And the Germans and the Austrians and some of the other European countries are doing very well, and these are highly—very, very small structures that have very selective things they can do in the environment, pick up toxic chemicals, things like that. But to be fair, I think Americans, because we have a tremendous base of instrumentation, and believe it or not that really gives us a huge advantage over other countries who are starting, is that all three universities represented here are well stocked and much better stocked, for example, than many universities, most universities in China.

So we have the competitive edge, I think, to maintain our lead and so again the key issue is, and I put a figure in my testimony where it takes materials, it takes instrumentation and it takes students to do research on the academic level, and if you shortcut any of them, you slow things down, and I think the Nanotechnology Initiative gives us the opportunity to keep that pace up. So I would assert that we are in the lead in most of the fields, but that cannot be—those cannot be laurels we rest on.

Dr. RANDALL. If I could interject just for ten seconds, you made a very good point about instrumentation and while currently we do enjoy a big advantage there, let me point out that in Europe and particularly in Japan a lot of the high-tech instrumentation is being produced in these countries. This is a key advantage that we own and are losing. Manufacturing tools are seeping out of this country, and it's something that we really need to work at bringing back, not only for nanotechnology but for high technology in general.

Mr. HALL. Of course, initiatives are going to grow as we fund it and as we put a proper budget in there for it, and I think the President started it out with \$464 million in Fiscal Year 2001 and it's grown up to \$849 million. That's an awful lot of money in Rockwell, Texas, but that doesn't seem like an awful lot of money as we move a thrust as important as nanotechnology that can mean leadership for this country. I think, Mr. Chairman, that we ought to take the word back that we're going to need a lot more funds than we've put into this as this thing grows, and I depend on you to sell that because you're the majority party up there.

[Laughter.]

Chairman BURGESS. We'll put it on the list.

Mr. HALL. Okay. I yield back the time I don't have.

Chairman BURGESS. Thank you, Mr. Hall. I wanted to kind of combine a couple of concepts. We've talked about some of the grand vision things and coupling to the energy of the Apollo mission in the '60's, balancing our long-term interests with short-term expectations, and part of that would be a concern of overselling the expectations on nanotechnology. And, certainly, while we do, and Mr. Hall and I take this very seriously and we will be selling the good news of nanotechnology, there's also, and I think we heard this when we talked about the ethical considerations that we were putting into the bill, there's a dark side of the force as well, and I have not read the book, I must confess. There's apparently a movie coming out next year called "Prey" where there's a convergence of computers, biotechnology and nanotechnology to create intelligent nanotech particles that take over people's lives and bodies. So could you just address that? How do we balance the expectations—overbuilding our expectations with the short-term results we're likely to achieve? And then, two, yes, we do want to sell the good news on nanotechnology, but how do we counterbalance the—someone brought up the issue of the genetic engineering in foodstuffs in Europe and how that perhaps wasn't approached as carefully as it might have been, and there's been some fallout from that. So how do we address that as well? And open that to any member of the panel.

Dr. RANDALL. I'd like to address at least part of that. I love Michael Crichton, I think he writes great science fiction, and he does touch on a fear that people have about new technologies. This isn't a new phenomenon. And in fact nanotechnology brings with it a lot of power in the technology, and I don't believe there's any such thing as a good technology or a bad technology. It has uses that can be for good and for bad, and serious debates have been touched off about what is the ways, the ethical implications, the social implications of nanotechnology, and what are the impacts of a particular material? We're very excited about, at Zyvex, carbon nanotubes, but the health implications of those are not well understood. There's a great program down at Rice that's starting to look into those health risks, potential health risks with new nanomaterials.

And so I think it's a debate that's a healthy one, that should be ongoing. There's always going to be some reactionary results there, but in fact I think that plays a good role in starting the debate and looking very carefully as we develop new technologies. We need to make sure that they're going to be safe technologies and that they're going to be used in ways, as best we can control through policy and good economics, in beneficial ways.

Chairman BURGESS. Anyone else like to address that, particularly in the sort of sense of balancing the expectations, the short-term results versus the long-term expectations?

Dr. FENG. Mr. Chairman, I fully agree with what was just said. I think it is very important for universities not to oversell nanotechnology and not to oversell, generally, any kind of research that they're doing. Universities must take a long-term view about the research that they're trying to do for the benefit of mankind,

for the increase of lives and so on and so forth. On the other hand, nanotechnology is posing a very, very critical challenge to universities at the moment that we must try to meet as soon as possible. It is one of the first times where a research program within universities has immediate interest from the media, from the public and so on so intensively, and from the government, of course. And so, therefore, I think that universities must conduct continuous public lectures to the public and let them understand what are the issues that are involved at the moment. Universities should not close their doors to the public and do this research in-house and only communicate with other academia. Therefore, events such as this, and similar to this, should be conducted on a continuous basis so that the public feels that they are not being blocked out.

Chairman BURGESS. Yes, Dr. Reidy.

Dr. REIDY. Dr. Feng's an excellent representative and has spoken very well for the scientific community on nanotechnology and the public in the past, and I'm sure will continue to do so. I think one issue that he brought up that I want to hammer down is I had an advisor once tell me that as a scientist the only thing you have is your credibility, and that really—he was speaking with regard to our colleagues. What's even more important is the public has very little understanding for what we do and how important our credibility is, and they have very little patience for a scientist who says one thing and can't produce, and it is incumbent on us to produce what we say we can produce. And I think one of the things I listened very carefully to all the things that were said today, all of us were very measured in how we described what nanotechnology is doing, and we speculate what it can be, but no one's reaching beyond the football field here. We're all staying within our realm, and I think having representatives on universities who are willing to speak toward books and movies like "Prey" immediately and not pooh-pooh the idea that it's just a fear but discuss it, these sort of forums are critical. And one of the things that I spoke of earlier, it is critical that the public appreciate what we're doing and support it, because in the long term if they don't, they're going to vote against people who are in support of it.

Chairman BURGESS. Dr. Elsenbaumer, did you have anything to add?

Dr. ELSENBAUMER. I just wanted to expound a little bit more on the public awareness factor. I think as we as scientists, and also those of us in private industry, need to partner and make sure that we are able to communicate adequately to the general public what these technologies mean and what they mean to them in common terms and easily understandable terms. And we need to do this, I think, on a continual basis as these technologies get developed. It's, I think, also critical that the private sector be part of this process, because they are the ones that have the measure, they are the ones that will actually be implementing these technologies into our lives. And so as these things get—as our technologies advance, as new products and processes and devices get developed, the private sector can help with understanding how these are going to change or implement or impact on people's lives. So I think both academia and the private sector have a responsibility here.

Chairman BURGESS. Thank you. Mr. Hall.

Mr. HALL. Dr. Elsenbaumer, I certainly agree with you, and we need to have it in language that everybody understands. So often we have men and women like you that come before us up there and I have to say, and it irritates them sometimes, "Now tell me what you said in American where I can understand it." Even my associate, Charles Cook, here who's been with me, believe it or not, since I was in the Texas Senate 40 years ago, a graduate of TCU, University of Texas and a guy that knows something about just about everything, but I asked him with the good scientific mind that he has, I asked him what was nanotechnology and his answer was it's the science of manipulating and characterizing matter at the atomic and molecular level. I could ask 19 more questions about that and still not know what the heck nanotechnology is. But you know and we know, let me tell you, this program is going to grow and it's going to grow fast, and we've got to really have some cooperation, as the President requested, in those four things that he set out there between industry and educators.

For example, electrophoresis in space at one time was the equipment that, you know, that Johnson and Johnson and McDonald Douglas and NASA put together to gather components in a weightless environment as they circle the Earth to come back here to study to try to find a cure for cancer, diabetes and other dreaded diseases. And after the *Challenger*—who's from Penn State? Yes. We got to looking for that equipment and we found it at Penn State, and nobody knows how it got there, and it was old equipment by that time, and we now have bioreactors that are up there that we hope will be productive. So it's going to go pretty fast.

Dr. Feng, I can give you some good hope on the visa situation. There's some technology answers to letting the right people in and keeping the wrong people out, and they're working on that up there. You know, the Immigration Act used to be written by a couple of names: Simpson and Mazzoli, Alan Simpson from Wyoming and Mazzoli from Kentucky. What the heck did they know about immigration? You know, up there insulated by about ten states, I guess, and we're here on the border.

Chairman BURGESS. They actually have a northern border up there.

Mr. HALL. Yes, they have a northern border too but I don't count that.

[Laughter.]

I'm very pro-Mexico, and I'm not very pro-Canada. But they say down in Mexico and on the Rio Grande there one time under the Simpson-Mazzoli Act we just passed that there was a group standing there that had just crossed the river with their hands up and said the act was so loose they said, "No, no, drop your left hand and repeat after me."

[Laughter.]

So that might have been the way that they were going to solve the problem, but that doesn't solve it. We have a lot to do and I certainly want to encourage your witnesses to share the views of the federal effort to advance nanotechnology and how we can make it more effective.

And I think it's 20 minutes until 11, the Chairman said we're going to stop at 11, and I don't have any more real questions, but

I would like, Mr. Chairman, if we might have the right to maybe write to these gentlemen and seek information in the future if we need it to update the report that Dr. Burgess will make to the United States Congress. And I yield back my time and I thank you very much.

Chairman BURGESS. Without objection, so ordered.

Dr. RANDALL. Please, we would be honored to answer any questions that you might send to us at Zyvex and do our best to illuminate you as best we can.

Chairman BURGESS. Let me just touch on one other concern before this wraps up today, and that's the issue of the liability climate in this country, and we're currently struggling with trying to somehow come to some sense on the asbestos litigation crisis in the country and how it's negatively impacted the manufacturing sector in this country. Dr. Randall, you brought up the issue of the nanotubes and carbon tubes and the biologic effects on the human body, a lot of which are unknown. What would be your vision? Obviously, we want to protect the public interest and yet at the same time we don't want to drive the technology offshore by a pernicious legal climate. So how do you see those two roles progressing?

Dr. RANDALL. It's certainly a difficult balancing act between trying to encourage progress and trying to maintain the health and safety of the American public. I think that activities such as this one, where we have an open forum to discuss the issues, are a good way to start. I do believe that to some extent some of the attempts to control the size of the awards that are made in some cases I think to some extent that's gotten a little out of control in this country. We tend to be a litigious society, and I think some control in that place would be a good thing. But I certainly have to recognize and understand that there are risks out there and that people want to feel protected, and so it's a difficult act to try to figure out what the right balance is. I would like to see us swing a little more toward reducing the level of liabilities, reducing the enormous size of some of the settlements that we've seen recently.

Chairman BURGESS. Yes, Dr. Feng.

Dr. FENG. Yes, Mr. Chairman. Certainly, this country is evolving so rapidly in terms of litigations and political correctness and so on. In fact, yesterday I just learned that I no longer can refer to Before Christ, B.C., anymore as an era. It now has to be B.C.E., which stands for Before Common Era. So all that is changing so rapidly. It's actually coming out of Washington, so you probably should know this.

Chairman BURGESS. No.

[Laughter.]

Mr. HALL. Probably out of the leadership.

[Laughter.]

Chairman BURGESS. No.

Dr. FENG. The asbestos and the nanotube are actually excellent examples of how we have progressed as a nation. Asbestos was obviously used when it was introduced into the Nation for a specific purpose, to do insulations and so on. And, of course, at that time no one knew that it was a health hazard, and years later we found out that that was true. However, nanotechnology, of course, we don't know it now, but we are already worrying about it. So I be-

lieve that the fact that we are talking about it almost from day one, scientists that are working in this issue, thinking about it, talking to the health people, talking to the medical people, working closely with them, we will very quickly come to an understanding as to its implications on human health. Asbestos was used, and in fact introduced to the whole Nation, without having any kind of such discussions, and by the time it was realized it was already too late, it was all over the Nation. So I think that I'm quite optimistic that we are much more mature as a nation in dealing with this issue today.

Chairman BURGESS. Yes, Dr. Reidy.

Dr. REIDY. I would concur with Dr. Feng. As a one-time asbestos inspector, I can speak both to the logic and the illogic of some of the actions, especially the litigious nature, of asbestos. For example, at one postal service facility in Washington, one of the plenums was covered in asbestos and was repeatedly being hit by mail carts and launching asbestos in the air. I would consider that a major hazard. On the other hand, this was treated with the same concern as a small amount of asbestos in a closet in the far reaches of the same facility.

I think Dr. Feng's exactly right. We are at the point now that both the arrogance of the way we do things has diminished considerably. We are sensitive to the public. And also, in agreement with what he said, I think we are beginning to do this at the very onset of our issues. Now, I heard—someone mentioned the Rice Nanoscience Institute. Vicki Colvin, the Director there, recently spoke to some of the fear issues that were going on, and she spoke that she spends a great deal of her time today answering questions about some of the fear issues that the public has. And this is a tremendous responsibility that we all have. I mean when someone from the press comes up to us, this is not something that we need to sneer at. I think rapid response and knowledge about our own topic area is critical.

I would not, however, and it's been suggested by some of the people who are very concerned, that there should be sort of FDA approval of a lot of these products. The fact is we're not going to know what a lot of these things do for a long time anyway and risk is going to occur. I think there's a rationality to some of these things, for example, some of these nanoparticles that I mentioned earlier being looked at as fuel additives. These materials are incredibly inert and have been inert for a long time and we walk around with them. They exist in road salts and things like that. The fact is that we can't expect the worst from nanotechnology. We have to expect rational sort of studies, and I think so long as the Nanotechnology Initiative has some room for funding for this sort of thing, these sort of companion pieces between universities and researchers will work well to allay a lot of the public fears.

Mr. HALL. You addressed the word, "fear," you pitched that in there. I think it's something that we really ought to consider and talk about and maybe put to rest, because Frank Roosevelt said 60-something years ago that the only thing we had to fear was fear itself, and today we're a nation at fear. We're fearful they're going to hit the Golden Gate Bridge, one of our other huge facilities, and you know the hard truth is we've spent a lot of money protecting

this country and they haven't hit us since that time. And the Doctor and I, as we go to the Capitol and go to our offices we have to show our IDs, and we know people up there, they know us, but we have to get in our own office. They look under our car with mirrors, they have the dogs sniff around. They're careful with us.

Chairman BURGESS. They don't do that to me.

Mr. HALL. They just do it to us Democrats, I guess.

[Laughter.]

But we do, we go through a tough mission to get in to our own offices there, and if they're that careful with us, you can know how careful they are at the airports. One thing we have to be thankful for is it's working, and we may have an incident before any of us get home today, but up to this time it's working. And let me just thank, I want to make two thanks, and, Doc, I want to thank you for this hearing and for the way you came to Congress. You didn't come to Congress as a novice. You hit there working and he was accepted as a partner in the thrust that we had up there. He's a very fine Member of Congress, highly respected, and I want to also give thanks to Gene McDermott, Cecil Green and Eric Johnson, three of the great men in American history and those that they spawned from them. We are in a building that they provided for the University of North Texas. I handled the bill as a senator in the Texas Senate when we created the University of Texas at Dallas. They were very generous in giving all the area that they gave there. Great Americans like that step forward when we really need them, and I want to certainly always remember their gifts and their dream.

And just in closing, I was very close to Eric Johnson. I had such high regard for him. And I asked him about TI and how they formed it, and he said, one Sunday morning he was driving out and he had just cut a trade, he had signed a deal, a letter of intent to acquire Texas Instruments. He was driving out one Sunday morning to see what he'd bought and he was trying to get out there and get back to go to church with Margaret, with his wife, and on the way out he turned on the radio and the Japanese were bombing Pearl Harbor. I said, "Well, Mayor, as a matter of being a great engineer, you're really super but as a matter of timing, by God, you're perfect." And, of course, TI had just gone like that. And we have a great country and great opportunity, and this is going to require a lot of cooperation and a lot of work.

And let me also congratulate Dr. Burgess. He's done a good job with the men and women in Congress who allocate funds. His area and the State of Texas were very gifted through his efforts, and there's others of course who have helped, in acquiring funds in nanotechnology trusts. If you'll just check the books and records, we weren't passed by when they allocated out the funds, and that's the name of the game. They say money ain't everything, but it sure keeps you in touch with your kids. Well, let me tell you, it also keeps you in touch with the folks you represent, and the Doctor is doing a great job of that. I congratulate him. And all this kidding about Republicans and Democrats, I'm the only Democrat in Congress that endorsed, worked for, supported the President and I am still proud I did. So I'm not that hard on Republicans, actually. Thank you.

Chairman BURGESS. Thank you, Mr. Hall, for being here. I guess we probably will wrap this up at this point. Someone made the point about not wanting to throw nanotechnology over the fence. I think what we've seen here this morning is a good example—we're taking fences down. We've got private enterprise, we've got public institutions and what really excites me is we've got collaboration between our three centers of excellence of nanotechnology in the Metroplex. And going forward I think that's really what's going to make the difference for us here in North Texas and being the leader, making the type of world class institutions we want to make, utilizing this technology going forward.

I would just say, as we wrap up, if any of you have any follow-up thoughts that you wish to send to myself or the Committee, please feel free to do so. I want to put things in generational context. Ralph Hall was a contemporary of Eric Johnson, and I went to high school and graduated with his granddaughter. Thank you.

[Laughter.]

[Applause.]

[Whereupon, at 10:50 a.m., the Committee was adjourned.]