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HEARING ON OVERSIGHT OF THE NATIONAL NANOTECHNOLOGY INITIATIVE AND PRIORITIES FOR THE FUTURE

THURSDAY, APRIL 14, 2011

House of Representatives,

Subcommittee on Research and Science Education

Committee on Science, Space, and Technology

Washington, D.C.

The Subcommittee met, pursuant to call, at 2:02 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Mo Brooks [Chairman of the Subcommittee] presiding.

Chairman BROOKS. The subcommittee will come to order. Good afternoon, everyone. Thank you. This is, as you can tell, this is my first time to chair a subcommittee. I am a freshman from the State of Alabama, Mo Brooks. I am going to be needing some assistance from staff and also Mr. Lipinski from the State of Illinois.

Welcome to today's hearing entitled Nanotechnology: Oversight of the National Nanotechnology Initiative and Priorities for the Future. In front of you are packets containing the written testimony, biographies, and truth in testimony disclosures for today's witness panel.

Before we get started not only is this the first meeting of the Research and Science Education Subcommittee for the 112th Congress, but it is also, as I stated earlier, my first hearing as chairman. It is an honor and a pleasure for me to chair the Research and Science Education Subcommittee for this Congress and is a position I do not take lightly.

As such, I look forward to working with you, Mr. Lipinski. I want you to know that I will endeavor to serve all members fairly and impartially, and I will work to ensure that the subcommittee on behalf of the American people performs its legislative oversight and investigative duties with due diligence with regards to matters within its jurisdiction throughout the 112th Congress.

It is imperative that we take seriously our charge to make sure that the agencies and programs under our jurisdiction are worthy of the public support.

I now recognize myself for an opening statement. First, let me thank each of our witnesses for joining us today, and in particular, I would like to give a special thank you to Dr. Clayton Teague. From what I understand tomorrow not only marks your eighth anniversary as director of the National Nanotechnology Coordination Office, but it will also be your last day in that role. I am sorry I will not have the opportunity to work with you in this capacity but would certainly like to thank you on behalf of the subcommittee for your dedication and service to this Nation. Thank you.

Then into my statement, nanotechnology represents a great deal of promise for the future of the U.S. economy, both in terms of leaps and bounds in the scientific knowledge base and in terms of potential products and employment opportunities as the technology continues to mature. Many believe it has the potential to be the next industrial revolution leading to significant social and economic impact. Nanotechnology is already prevalent in our lives. It is in sunscreens and cosmetics, batteries, stain-resistant clothing, eyeglasses, windshields, and sporting equipment. The development of nanomaterials that are stronger, lighter, and more durable may lead to better technology for items such as bulletproof vests and fuel efficient vehicles. Advances in nanomedicine to diagnose and treat diseases, as well as deliver drugs with fewer side effects, are literally just over the horizon. Many are already in clinical trials.

The National Nanotechnology Initiative or NNI is the United State's government's effort to coordinate the nanotechnology research and development activities of the Federal agencies. While nanotechnology is not a new scientific field, it remains an emerging technology. It is my understanding that neither this subcommittee, nor the full subcommittee for that matter, has held a hearing focused on the NNI since early 2008, primarily because the House passed an NNI Reauthorization Bill in both the 110th and 111th Congresses, only to see them die in the United States Senate. Regardless, much has happened in the past 3 years, including a new PCAST Assessment and the issuance of a strategic plan. This hearing today provides us with an opportunity to get feedback on those documents and have a discussion about national priorities for this technology.

In addition, we will also examine the President's fiscal year 2012 NNI budget supplement, which represents funding requests from the 15 federal agencies investing in nanotechnology. The request includes a more than an $11 million, excuse me. More than a $200 million increase or 11 percent from fiscal year 2010 enacted levels, including significant increases for environmental, health and safety areas, and nano-manufacturing. In these difficult budget times Congress needs to be sure that all federal investments will work to strengthen the economy, including our investments in nanotechnology.

I look forward to hearing the testimony to be presented today and to the beginning of what I hope is a fruitful discussion on U.S. nanotechnology investments and priorities.

And, again, thank you for joining us today.

[The statement of Mr. Brooks follows:]

*************** INSERT 1 ***************

Chairman BROOKS. And now the chair recognizes Mr. Lipinski for an opening statement.

Mr. LIPINSKI. Thank you, Chairman Brooks, and I want to congratulate you on being made the chair of this subcommittee. I served as chair of the subcommittee last year. It is a very--we do a lot of important work here. I really think that research and the--is critical, our scientific research is critical to the future of our country, and science education clearly also is critical to our future. So I am looking forward to working with you on the committee, and I think that we can get a lot of good things done, starting today with one of my favorite subjects of nanotechnology.

Not only are nanotech products and science fascinating in their own right, but investments in this area have already resulted in job creation in my state and across the Nation. I firmly believe the potential for return on a relatively modest federal investment is many times what we have already witnessed.

I am fond of saying and have said this countless times here in this committee, that at one point I drink the nanotech Kool-Aid to believe that it really is the next industrial revolution as the chairman had mentioned. And it may have been when I visited Chad Mirkin's lab at Northwestern University about 5 years ago. Mr. Moffitt knows it very well. I was amazed by what could be done to the scale of a single atom. In nanotechnology there is now a branch of engineering that simply did not exist 23 years ago when I was getting my degree in mechanical engineering at Northwestern.

By controlling individual atoms we are creating new materials, products, companies, and jobs. It is not just material sciences or semiconductors. Companies like Mr. Moffitt's Nanosphere, which emerged from Dr. Mirkin's lab 10 years ago, are succeeding because nanotechnology is helping us understand biology at the cellular level. We are now seeing applications that were not even imagined 11 years ago when the National Nanotechnology Initiative was first created.

The range of potential applications is broad. It will have enormous consequences for electronics, energy transformation and storage, materials, and medicine and health to name just a few.

The Science Committee recognized the problems of nanotechnology early on, holding our first hearing more than a decade ago to review federal activities in the field. The committee was subsequently instrumental in the development and enactment of a statute in 2003 that authorized the Interagency National Nanotechnology Initiative, the NNI. As the chairman said, we have passed three times in the House in

2008 a reauthorization of NNI, and we passed it in a bipartisan manner. Unfortunately, all three times they died in the Senate. Not the only things that did.

But I hope that working together, Chairman Brooks, we will have the opportunity to take up a reauthorization once again this Congress and maybe the fourth time will be the charm.

I do not think that the NNI requires major revisions, but I do think their opportunities have formalized some of the recommendations we have received in the last few years from PCAST international academies on how to strengthen the program even further without any additional costs.

Our bill has been about making smarter use of the money we are already spending, not necessarily about spending more. I welcome recommendations from our witnesses today on how we can continue to improve upon the existing program.

I am particularly excited about the Administration's Signature Initiative in sustainable nano-manufacturing, and I look forward to hearing how the agencies are responding to PCAST's recommendations to ensure that this initiative is successful, such as by developing coordinated milestones, promoting strong educational components, and creating public, private partnerships in nano-manufacturing.

I would like to spend my last couple minutes talking about something else. In our invitations to the witnesses we did not ask you to submit testimony specifically on energy health and safety or EHS research. That must be part of any comprehensive nanotechnology research strategy, but hopefully we can engage in some discussion on this topic during the Q&A.

It is important for the successful development of nanotechnology that potential downsides can be addressed from the beginning in a straightforward and open way. We know too well that negative public perceptions about the safety of technology can have serious consequences for its acceptance in youth.

I hope to hear from our industry witnesses about their thoughts on this issue, and it is certainly not the purpose of peer mongering. It is for purposes of really clearing up any misconceptions that are out there and making sure that nothing new that we are doing here in nanotechnology is going to have a negative impact on the environment's health or safety.

The NNI has always included activities for increasing the understanding of these aspects of nanotechnology, but I believe that EHS research did not receive sufficient attention or funding for many years. I am concerned about the lack of a well-designed executed EHS research program.

I look forward to hearing from Dr. Teague about the strategy that is, I understand is scheduled to be released in the coming days on EHS, and I am looking forward to hearing how it incorporates the comments of experts from both academia and industry.

And on that note I wanted to echo Chairman Brooks in thanking Dr. Teague for his work. He has been with NNI almost since the beginning, and I know that your expertise is going to be missed.

Once again, I am very happy we are having this hearing today, and I look forward to all the witness testimony and the Q&A, and I think you all for being here today and thank you for the extra time here this week.

Mr. Chairman, I yield back.

[The statement of Mr. Lipinski follows:]

*************** COMMITTEE INSERT ***************

Chairman BROOKS. Thank you, Mr. Lipinski. If there are members who wish to submit additional opening statements, your statements will be added to the record at this point.

Now, before I introduce the witnesses, I would like to yield a few minutes to the distinguished chairman of the Science, Space, and Technology Committee, Mr. Hall of Texas.

Chairman HALL. Thank you very much, Mr. Chairman. I appreciate your good work and your hard work and your long hours of work and your committee, and also I thank you for telling us about Clayton Teague and his history and the long service he has rendered. About 41 years ago I started in public service as a state senator and then 31 years ago I started up here, so we started out about the same time. You look a lot younger than I do, but we thank you.

And this is a very important committee, and this is, I think, nanotechnology and the priorities and the initiatives and everything for the future is very important. It is much more important than these empty chairs here indicate, but we are at an urgent time in this Congress now when we are trying to decide whether to pass a budget or CRs to put the government off and keep them from shutting down. A lot of people just want to let them shut down and forget about it, but I think with the leadership of this chairman and this committee you are onto the subject and issue that is very vital to us, and that offers a great, great service to us for the future.

Thank you, Mr. Chairman, for what you do, and thank you all for giving your time it takes to get here and to prepare for a hearing and to get back to your work. God bless you. Thank you.

[The statement of Mr. Hall follows:]

*************** COMMITTEE INSERT ***************

Chairman BROOKS. Thank you, Mr. Chairman.

At this time I would like to introduce our witness panel. Dr. Clayton Teague is Director of the National Nanotechnology Coordination Office for the National Nanotechnology Initiative, Dr. Jeffrey Welser is the Director of the Semiconductor Research Corporation's Nanoelectronics Research Initiative or NRI. The SRC conducts research on behalf of the semiconductor industry and the Semiconductor Industry Association or SA--SIA. Dr. Welser is on loan to the NRI from IBM.

Dr. Seth Rudnick is a medical doctor and Chairman of the Board of Directors for Liquidia Technologies, a nanotechnology company located in Research Triangle Park, North Carolina. I might have to ask you about whether you are for NC State, North Carolina, or Duke. I am a Duke guy, so be ready. That develops highly-precise particle-based vaccines and therapeutics for the prevention and treatment of human disease.

Dr. James Tour is a Professor of Chemistry, Computer Science, and Mechanical Engineering and Material Science at the Smalley Institute of Nanotechnology at Rice University, and Mr. William Moffitt is the President and Chief Executive Officer of Nanosphere, Inc., a nanotechnology-based healthcare company offering diagnostic testing technologies housed in Northbrook, Illinois.

As our witnesses should know, spoken testimony is limited to 5 minutes each, after which the members of the committee will have 5 minutes each to ask questions.

At this point we recognize our first witness, Dr. Clayton Teague, the Director of National Nanotechnology Coordination Office. As I do so, please, everyone should be aware that we are scheduled to have votes before long, and at some point we will have to recess for those votes to be taken, at which point we will resume thereafter.

So, Dr. Teague, the floor is yours.

STATEMENTS OF CLAYTON TEAGUE, DIRECTOR, NATIONAL NANOTECHNOLOGY COORDINATION OFFICE; JEFFREY WELSER, DIRECTOR, NANOELECTRONICS RESEARCH INITIATIVE, SEMICONDUCTOR RESEARCH CORPORATION AND SEMICONDUCTOR INDUSTRY ALLIANCE; SETH RUDNICK, CHAIRMAN, BOARD OF DIRECTORS, LIQUIDIA TECHNOLOGIES; JAMES TOUR, PROFESSOR OF CHEMISTRY, COMPUTER SCIENCE, AND MECHANICAL ENGINEERING AND MATERIALS SCIENCE, RICE UNIVERSITY; AND WILLIAM MOFFITT, PRESIDENT AND CHIEF EXECUTIVE OFFICER, NANOSPHERE, INC.

STATEMENT OF CLAYTON TEAGUE

Mr. TEAGUE. Chairman Hall and Chairman Brooks, Ranking Member Lipinski, first of all, thank you for your kind words about my service. It is very much appreciated. It has been my distinct privilege and honor to serve as the NNCO director.

It is also my distinct privilege to be here with you today to discuss the NNI and the contributions of Federal agencies to sustaining U.S. leadership in nanoscale science, engineering and technology.

For more than a decade, the NNI has set the pace around the globe for enabling ground-breaking interdisciplinary research, innovation, and infrastructure development in the scientifically and economically powerful domain of nanotechnology. As the primary interagency program for coordinating federal research and development in this field, the NNI has catalyzed remarkable advances in electronics, medicine, energy, manufacturing, and many other areas. Integrated with these R&D efforts to advance nanotechnology has been world-leading research by NNI member agencies to understand and address the environmental, health, and safety aspects of nanotechnology.

Starting in 2001, the NNI has developed into an engine of innovation that has drawn 25 federal agencies into fruitful collaboration resulting in their investing a cumulative total of over $14 billion in this fast-moving area. The NNI Strategic Plan, which was delivered to you in February, provides a description of how the NNI adds value to all participating agencies.

I want to note at least two things about the plan's inclusion of two new subjects. First, specific objectives for each of the plan's four goals, a first for this strategic plan, and second, three important signature initiatives for interagency focus and alignment of resources.

Agencies are proposing about $300 million in the 2012 budget drawn from their agency budgets for these signature initiatives in order to accelerate progress in areas of national importance.

The President's 2012 budget provides $2.1 billion for the NNI. These investments will advance our understanding of phenomena and nanoscale and enhance many of the things that Chairman Brooks just laid out for us; our ability to engineer nanoscale devices and systems to address areas such as renewable energy, next generation electronics, and sustainable manufacturing.

Let me briefly show you a few examples, and if the slide would come up, of how nanotechnology is revolutionary. One is carbon nanotubes. You can think of them as super-thin sheets of carbon, just one atom thick, rolled into microscopic tubes or straws. They are extremely strong and lightweight and are showing great potential in important structural and electronic applications.

Shown here is an application of carbon nanotube-based materials, the second--go back to the first one, please, to build a large, lightweight, 52-foot long boat that can travel 2.5 miles per gallon. Comparably-sized conventional boats can travel only one-fifth of that distance per gallon of fuel.

In the next slide and in the sample being passed among the committee, you can see a test sample using similar nanomaterials for potential use in bullet-proof vests that have a high resistance to penetration, yet are far lighter than any other currently-available material. Note that in this case a test shot of a high-speed, nine millimeter metal jacketed bullet did not penetrate this sample that is only 1 millimeter thick.

A third example comes from the medical domain where nanotechnology is showing great promise for disease diagnosis, cancer treatment, and drug delivery. This slide shows a novel nanotechnology-based method for revealing the amount of artery-choking plaque inside a blood vessel. Red and yellow represent higher levels of plaque. Low levels are represented in blue and green.

The before and after images illustrate the efficacy of not only the medical treatment but also the imaging tool. Such imaging tools can enable faster and cheaper development of life-saving drugs.

Multiple sources have now come to the conclusion that these and other nanotechnology-enabled products will be valued at up to $3 trillion by the end of the decade with major ramifications for jobs. A study funded by the National Science Foundation projects that 6 million nanotechnology workers will be needed worldwide by 2020, with 2 million of those jobs in the United States.

The United States is, however, not the only country to recognize the potential of nanotechnology. At least 60 countries now have national nanotechnology strategies with the European Union 27 countries outspending the United States. Perhaps more important the spending increases in some countries such as Russia, China, and South Korea are considerably greater than here in the United States.

A recent analysis of the number of nanotechnology patents, publications, and citations show that our leadership is being strongly challenged. This could put our national security at risk since technological superiority is a foundation of our national security strategy.

I see us now at a crossroads. With continued support of the NNI the U.S. will play a major role in what is unfolding as the next economic and technological revolution. Without it the United States could fall behind in this extremely important race.

So while the U.S. is currently a global leader in this area of technology, it is crucial that our place--pace of investment be maintained.

I would like to conclude on a personal note. I have interacted with this committee since 2003, through five Congresses and two different Administrations. As I leave this post I want to sincerely thank this committee for all its strong leadership, commitment, and support of federal investments in nanotechnology that you have provided throughout this period.

I will be pleased to answer any questions you may have, and thank you.

[The statement of Mr. Teague follows:]

*************** INSERT 2 ***************

Chairman BROOKS. Thank you, Dr. Teague.

Our next witness is Dr. Jeffrey Welser.

STATEMENT OF JEFFREY WELSER

Mr. WELSER. Good afternoon. Thank you for inviting me today and for your continued commitment to advancing science and technology, especially as we struggle with difficult fiscal challenges.

Semiconductor chips are in everything from computers and smart phones to medical devices and LED lights. They are making the world around us smarter and more efficient. They are also economically vital to the Nation. In 2010, U.S. semiconductor companies generated over $140 billion in sales, representing nearly half the worldwide market and making semiconductors the Nation's largest export industry.

Our industry directly employs over 180,000 workers in the U.S. and another six million American jobs are made possibly semiconductors. Studies show that semiconductors and the information technologies they enable represent 3 percent of the economy but drive 25 percent of the economic growth.

Remarkable success in the semiconductor industry is due to continuously technological advances built upon robust research and development. U.S. semiconductor companies invest on average 17 percent of revenues in product-related research and development, among the highest of any industry.

Just as critical, however, is long-term fundamental science research, which is largely performed at universities funded by the Federal Government. The university research supplies the knowledge from which all companies benefit and which no one company can afford alone. Publicly-funded long-term research and privately-funded product-related research are different, yet complimentary.

We are now in the cusp of an exciting new era enabled by nanotechnology. The National Nanotechnology Initiative has played a key role over the past decade in accelerating progress in many scientific disciplines. In the coming decade the NNI should be called upon and authorized to maintain U.S. leadership by continuing the broad discovery work while coordinating federal efforts in areas of promise both for scientific breakthroughs and large economic impact. One of these areas, nanoelectronics, is key to the future of the semiconductor industry.

We are quickly approaching the fundamental limits of current semiconductor technology. We need to find entirely new devices to continue advancing technology, and this will require new discoveries in the fundamental science that NNI supports.

Hence, maintaining funding in nanoelectronics research has never been more important for the economy, for high-paying jobs, and for the Nation's ability to innovate and compete globally. The nation that is first to discover and develop the necessary nanotechnologies, that is the next switch, will lead the nanoelectronics era just as the U.S. has led the microelectronics era for the past 50 years. Countries around the world recognize this and are investing accordingly. Continued U.S. leadership is far from assured.

To attack this challenge the SIA and SRC form the Nanotechnology Research Initiative, a public-private program that funds research at universities in partnership with federal and state agencies. NRI supports goal-oriented, fundamental research across many scientific fields and strives to harvest the results quickly. Two federal agencies, NIST and NSF, are key partners in NRI. Robust budgets of these agencies and other research agencies that support nanoelectronics are critical.

Beyond the research breakthroughs, funding university scientific research educates our technology workforce. A pipeline of science and engineering graduates is critical to keeping and growing the businesses that will rebuild the economy. Indeed, several states are supporting NRI as nanoelectronics offers an opportunity to grow a new industry around their university base.

I have a few recommendations for strengthening the NNI and ensuring U.S. leadership in nanoelectronics. First, Congress should reauthorize the NNI and in particular support the Signature Initiative on Nanoelectronics for 2020 and beyond. Congress should adequately fund the participating agencies and ensure they prioritize nanotechnology research when facing difficult budget choices.

Second, NNI agencies should coordinate and leverage investments of industry consortia and states to get the most out of every dollar spent.

Third, in other areas of nanotechnology research topics with broad, long-term economic potential should have priority. We also encourage NNI agencies to form additional public-private initiatives like the NRI.

I want to close with this point. NNI funding of nanoelectronic research produces the new ideas, as well as the talented scientists and engineers critical for driving America's innovation economy and for solving society's biggest challenge in medicine, security, and energy. The nanoelectronics industry will be in the U.S. only if we choose to support the research necessary to discover these new technologies first.

Success will only come from the combination of the best science from the universities, the mission focus of the industrial and government labs, and consistent funding from the government for the fundamental science and from industry for translating these breakthroughs into new products.

In the 5 minutes I have been talking to you the semiconductor industry made over 600 trillion transistors. Silicon Valley grew from innovation built on federal research. What companies will populate the new Nanoelectronics Valley? The question is not whether this place will exist but where it will be.

I thank you and look forward to answering your questions.

[The statement of Mr. Welser follows:]

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Chairman BROOKS. Thank you, Dr. Welser.

Next we have Dr. Seth Rudnick.

STATEMENT OF SETH RUDNICK

Dr. RUDNICK. Mr. Brooks, Mr. Lipinski, thank you very much for allowing me the opportunity to address the committee and talk about nanotechnology and as you can guess as a physician I am going to direct most of my discussion to medicine.

You have heard that substantial funds have been addressed to many different agencies which have, in turn, affected many different companies and products around the United States and the world. It is a huge and growing part of our economy, and I am going to talk about that little red corner that is medicine.

And in nanotechnology medicine has transformational impact, and by that I mean the ability to change the way we address disease, the way we treat disease, the way we diagnose it, and the way we prevent it. Therapeutics that ran from targeted delivery of drugs, to cancer, to avoiding particular toxicities of drugs by changing the way they traffic through the body, all of that has been already proven by new nanotechnology drugs, some of which are actually on the market today. Ultimately our goal is always to increase safety in efficacy, and nanotechnology is a lever, a very important lever in doing that.

There are other areas, including the prevention of disease, that I think are equally well addressed, vaccines being a primary example of that. Nanoparticles are synthetic carriers. They allow particular areas of the body to be inoculated with antigens and adjuvants, potent ways of getting the body to recognize a particular viral or bacterial disease and treat it. This is a next generation of biotechnology. It is, again, already in the clinic and, in fact, my company, Liquidia, has had its first safe clinical trial completed late last year.

We believe that not only will we be able to be safer and more effective, but the ease of manufacturing using technologies that, in fact, derived from microelectronics are an important part of driving the costs down such that vaccines will be far more useful to the third world and not just the first world.

You will hear more about diagnostics and imaging from one of the other speakers, but the ability to rapidly detect new disease, to multiplex, to look at large numbers of population markers, and to identify the risk of disease early is something that is critical to medicine and is being transformed by nanotechnology.

The reason that nanotechnology has become so useful in medicine is because the scale of nanotechnology is now addressing biologically-relevant sizes. In the 1970s nanotechnology, which is microelectronics at that point, was addressing scale at the red blood cell size. Today we are already down to the molecular size, and we have passed through bacterial and viral sizes during this last 2 decades.

By being able to address and traffic those areas we now understand mechanisms of disease that were heretofore untouchable. But not only did we need to address these, we needed to be able to manufacture something that could address these at the proper scale, and that ability to take the etching off a semiconductor plate, put it onto a film, and manufacture at the scale that a newspaper press operates at or a photo film press operates at, which is many thousands of feet per hour, has led to Liquidia's manufacturing. And again, I was going to use the hundreds of trillions analogy, but that one piece of film that is in the lower right corner actually represents hundreds of trillions of vaccine particles that can be used that are treating disease.

I would like to tell you that we, in fact, now have the ability to address almost every size and shape based on the microelectronics etching of particles down to 30 nanometers, 40 nanometers, right at the edge of what microelectronics can etch. This is a representation of a series of shapes that we use in research or in treatment or in diagnostics. You can see that many of these shapes actually incorporate multiple colors, and those represent different drugs or different adjuvants or different antigens that are being administered for a particular disease.

We can change the softness or hardness, the modulus or the porosity. We can change how particles actually float into the lung. You can see over in the right-hand side of that slide particles that look just like pollen. All of this is enabled by technology that has actually originated out of the NNI.

There is one regulatory agency that is quite used to handling nanotechnology. You may be aware that the Food and Drug Administration has approved drugs in this field, has looked at diagnostics in this field, and has had an incredibly-positive interaction with not only our company but many companies in trying to move this technology forward, and as an example, the recent clinical trial that we completed was done in a year and a half from concept to first therapeutic intervention. I think the FDA has shown its ability to handle the technologic challenges of nanotechnology and done so in a very positive fashion with industry.

I would like to thank all of the agencies out of NNI that have contributed to the University of North Carolina. To answer your question I am a heel, but we appreciate greatly the opportunity to speak here today and to have--answer questions as they arise.

[The statement of Dr. Rudnick follows:]

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Chairman BROOKS. Thank you, Dr. Rudnick. Better luck to both of us next year.

Up next we have Dr. James Tour. Dr. Tour.

STATEMENT OF JAMES TOUR

Mr. TOUR. Thank you. I have the good fortune of being able to teach in the departments of chemistry, the department of mechanical engineering and material science, and also computer science because nanotechnology bridges across all of those areas. I have over 400 research publications and 50 patents on diverse nanotechnology products, ranging from high performance materials to ultra small electronic devices, targeted chemotherapy delivery agents, and nanomachines.

Today I will underscore the threat of foreign competition, the need for continued support to basic nanotechnology, and continued support for transitions into nano-manufacturing to ensure U.S. jobs and preeminent global competitiveness.

Nanotechnology is about the study of the very small, a range between the molecular size and the cellular size. Some examples from my own lab are on the slide. A light-powered nano-car is in the lower left box. Thirty thousand of these cars can fit on the diameter of a human hair. They are for manufacturing in the future, 50 years from now, where we will do bottom-up manufacturing.

For example, if we want to make the table, we go down, we find a big tree, we cut it down, and we make a table. That is not the way we will be manufacturing 50 years from now, but we will be able to build bottom up, just like nature's enzymes do it. Machines bringing in molecules for direct construction of the table.

We need to work now to be the leaders in 2060, but nanotechnology is also upon us today. The top middle box shows an oil well blowout preventor that are eight times tougher than the typical ones because they have carbon nanotubes in them. I founded a company in Houston that now makes these toughened rubber materials so that nano-manufacturing is with us today.

I am the son of immigrants who came to the U.S. right after World War II. My parents instilled in their children a love for this country. My father used to tell us that the U.S. was the greatest country in the world, and I still believe he is correct.

I say to tell you what is now at risk. With governing bodies rightly seeking to trim budgets, there is consideration of deep cuts in basic research for nanotechnology. Some are unaware that nano-manufacturing is about to spawn entirely new segments that will rise from the current 150,000 American jobs to 800,000 jobs by 2015. The U.S. has benefited from the best brains in the world coming to our shores for the past many years. People's intellects are our best asset, and by God's grace we have been the recipients of the world's top brains. Those brains have caused us to win the nuclear race, the space race, and the Cold War. U.S. higher education and research is the apple of America's eye and the envy of the world.

Alarmingly, however, foreign competition is now on our shores, successfully wooing the best and brightest away with assurances of funding for basic research and support for transitions to manufacturing. In the past 14 months I have been invited to Singapore with a second trip planned this summer, and I have had more than a dozen visits from Singaporean representatives interested, including twice from the Economic Development Board of Singapore, interested in building me a lab in Singapore, funding my lab there, and having some of the new nanotechnology companies founded there with their capital backing and a much lower tax burden than offered in the U.S.

I have also been approached by Russian, Chinese, and Japanese officials. Welcome to my world of global competition.

American researchers are industrious and self-driven. We have been trained that way. If we cannot get our science funding and transition into the--in the U.S., we will go abroad, and top researchers will not wait for a decade for recovery. The brain drain has already begun, and it will continue at an alarming pace within the next 1 to 3 years if access to research and development funds become sparse.

If American researchers start going abroad, the impact of the brain drain would be devastating to near and long-term economic development in the U.S. Federal funding for nanotechnology beyond the discovery phase is also needed to spawn the transitions from the laboratory to the manufacturing stage. This can be done using a competitive grants process that keeps the government from choosing its favorites and permits competition through grants applications analogous to the competitive SBIR and STTR Programs.

In closing, let me underscore we are not finished with basic research and translational development in nanotechnology. The programs must continue. Foreign competition is at our doorsteps to capitalize upon and divert the country's lead in nanotechnology that will underpin the manufacturing of this century.

And I want to thank you for your service to this country, and I would be honored to answer any questions.

[The statement of Mr. Tour follows:]

*************** INSERT 5 ***************

Chairman BROOKS. Thank you, Dr. Tour.

We have received a notice of votes, and this is our game plan. Mr. Moffitt, if you are comfortable that you can make your remarks in 5 minutes, I have been informed that we have got a series of two votes, and as soon as your remarks conclude, we will go into a recess. We will vote, and then we will resume the hearing 10 minutes after the beginning of the last vote.

STATEMENT OF WILLIAM MOFFITT

Mr. MOFFITT. Thank you, Mr. Chairman. I am comfortable that I can do that in 5 minutes or less. So thank you, Chairman Brooks, Ranking Member Lipinski, and distinguished members of the committee.

I am here today to speak with you about your health. Your health, the public health, and the health of our economy, all underwritten by nanotechnology.

I appreciate the opportunity to testify before this committee and to stress upon you the importance of the National Nanotechnology Initiative and how crucial that has been to the success and the commercial success of my company. I am the President and Chief Executive Officer of Nanosphere, Incorporated. I am also a member of the NanoBusiness Commercialization Association on whose behalf I testify as well. In full disclosure, I am a former science teacher and a Duke Blue Devil.

Nanosphere is an 11-year-old company formed about the same time as the origination of the National Nanotechnology Initiative. We are a company that manufactures, develops, and markets an advanced molecular diagnostics platform for testing both in human health or infectious diseases, pharmacogenetics or personalized medicine, if you will, and in the area of ultra-sensitive protein testing for the earliest detection of advanced diseases such as cardiovascular disease and cancer. We also manufacture a bio-security system that detects the slightest trace of bio-terrorist threat agents in water and is field deployable around the globe, anywhere that it is needed, one a moment's notice.

It is the extraordinary properties of nano-particle technology that enable us to achieve these breakthroughs in human genetic testing, pharmacogenetics, and ultra-sensitive protein testing. We created life-saving tests for tens of dollars. It could be sold for tens of dollars as opposed to the hundreds and thousands of dollars we hear today about genetic tests. All of this is in the format of a system that can be moved right to the patient's side, can be installed in the average community hospital or any medical setting, and be used when and where the physician needs results to these crucial tests.

I want to spend a second and acquaint you with a couple of these. One of these is a test that is based on an established bio-marker. A bio-marker is the fingerprint of a disease. It is the earliest telltale sign of heart disease. It has been used to diagnose heart attacks in emergency rooms for 25 or 30 years. Through nanotechnology we have found two new uses for this tried and true marker.

One is the earliest detection of early-onset cardiovascular disease, and the other just discovered in the last 6 months is the use of this same marker to be able to monitor the progress of chronic heart failure patients and adjust their therapy more appropriately, therefore, improving their health and also reducing re-hospitalization, re-hospital admissions for them. So all of these lifesaving technologies can be brought right to the bedside in the hospital, if you will, by virtue of nanotechnology.

We also have the ability to test for septic shock, the bacteria and the organisms that cause sepsis, not in 3 days as would take today, but in 2 hours, therefore, moving a critical diagnosis farther much faster so that the appropriate therapy can be started earlier. This also have implications for exposure of antibiotics to the rest of the organisms in the world and resistant strains that are continuing to be a problem for public health.

I could go on and on with the things that we have done, but let me tell you this would not exist if it had not been for the National Nanotechnology Initiative. The efforts that have funded those agencies and the coordination there have helped tremendously in funding our company. The leverage in our company has been tremendous. Five or $6 million in federal grant aid was put into Nanosphere, which has augmented that with another $200 million plus in private and public equity financing. A 40 to one leverage ratio for the government dollar invested.

This has been a success story so far, and we believe it will continue to be one. We would not have crossed that Valley of Death, if you will, had it not been for the National Nanotechnology Initiative and government funding, which supports the transition of core science into commercializable technologies.

This company has created jobs. We are small but growing. We are 115 strong today, but in years to come we will be hundreds, and we will be thousands in size, and these are high-tech jobs. Eighty-five percent of our employees have college degrees or advanced degrees. The average salary in our company is over $85,000, and that is if you take the top level off.

So we are creating the kinds of jobs that underwrite the economy in this country. Our greatest challenge is employees, workers. I think we all are aware of the crisis we face in stem education, the crisis in this country, and we cannot underscore that enough.

Let me by-- let me close, I know I am going over here, by simply saying that we also realize and recognize that the competition we get from foreign investments and nanotechnology, they are closing the gap on us rapidly. We cannot stress that enough.

Thank you, again, for the opportunity to speak, and I look forward to answering your questions.

[The statement of Mr. Moffitt follows:]

*************** INSERT 6 ***************

Chairman BROOKS. Thank you, Mr. Moffitt. Based on our conversations with Mr. Lipinski, the Ranking Member, and myself, we are going to recess. I would anticipate we will be back somewhere in the neighborhood of 15 to 25 minutes. It is a series of two votes. The members should be back 10 minutes after the last vote starts to be cast.

We are in recess.

[Recess.]

Chairman BROOKS. My wife is a math teacher. She would have loved to have had that kind of response using a gavel.

Well, I thank the panel for their testimony. Reminding members that committee rules limit questioning to 5 minutes. The chair will at this point open the round of questions, and the chair recognizes himself for 5 minutes.

Before I begin my 5 minutes, though, I have the consent of the minority to go ahead and resume. From what I understand Congressman Lipinski is on the way back and should be with us shortly.

The first question for Dr. Welser, in your testimony you state that nanoelectronics can contribute to deficit reduction in three ways; increasing jobs, wages, and expanding the tax base, lowering the cost of computing to the government, and increasing economic productivity, and as you can imagine in the context of the battle that we are now in in Washington, we have unsustainable budget deficits, we have basically three approaches or a combination of those three that we can use. One is to cut spending dramatically, one is to increase taxes dramatically, or a third way is to grow the economy, which naturally will generate additional revenue.

So if you would, can you please expand on these ideas? How can Congress build on these concepts?

Mr. WELSER. Yeah. Thank you very much for the question. I think that obviously the most important factor that the nanoelectronics provides is the ability to grow the economy, and it is not just the chip industry but everything else that gets enabled around it.

One of the reasons the exponential increase in revenues has occurred at the semiconductor chip level is because when something gets smaller, it doesn't just get faster. We can make whole new products, so you have smart phones or GPS or embedded sensors or, you know, drug delivery systems in the body, all enabled, new markets and industries enabled by increasing the scale of nanoelectronics.

So I think that is the number one thing that happens, and then the jobs, of course, that go with that continue to then grow the economy as well.

On the other side, for productivity and efficiency, if you look at the cost of computing over time, the I-pad that we have today has the computing power of basically a super computer from the late '90s, so if you would try to do the kind of calculations and things that we want to do with the super computer then, you can now do it by buying an I-pad.

So there is a huge increase in productivity that you get for your dollars and computation. I think these two are probably the main ways that we can contribute, but obviously, I think just having more electronic capability also ends up assisting people in their jobs in all sorts of fields.

Chairman BROOKS. And on the chance that any of the other witnesses would also like to address that question, you are free to.

Seeing none, Dr. Tour, your testimony discusses the importance of federal investments in nano-manufacturing and public-private partnerships. In addition, you state that the continued federal commitment to basic research at universities and companies helps to mitigate the investment risk for those looking to enter the marketplace.

Certainly you are aware of the budget and deficit decisions facing Congress. In looking at the fiscal year 2012 budget and what is already an finite pot for federal investment and will likely be even smaller the next year, which area do you believe is more important for federal investment; basic research or nano-manufacturing, and if your answer is both, which it may very well be, then where in this field do you recommend we find the savings that we absolutely must find in order to enhance our expenditures in other areas?

Mr. TOUR. Well, if the number is X number of dollars would be committee, a portion of that X should go to both. So there should be a portion of X in the transition in nano-manufacturing, but we have got to have the basic research, because basic research is not done, but we have got to be able to have the funds also to transition them. And there are mechanisms to do that, SBIR, STTR grants, which are already in place, these sort of mechanisms to do that. But if we just take X and we take a portion and we put it into both.

Chairman BROOKS. And this question is for, first for Dr. Teague, but if anyone else wants to chime in afterwards, feel free.

Dr. Teague, I believe it was your testimony that related to us what other nations were spending on nanotechnology research and development, basic research, things of that nature. In your judgment how much does the United States need to commit to this field in order to remain competitive?

Mr. TEAGUE. I wish I had an immediate answer to that. I can tell you that we have looked at the amount of funding that is going into nanotechnology R&D by other countries. Probably the one that currently is in the lead is the overall European Union and the member states of the European Union. Rough estimates are that in 2010, they will be investing something like $2.6 billion in nanotechnology R&D. This is 1 year of their new framework that they are investing.

So I think that they are certainly the leaders in the world as of major economy in investing in nanotechnology R&D. The other countries are coming up very strong. It is really quite difficult to estimate how much funding is really in place in places like Korea, Japan, and China because one of the biggest reasons it is difficult to estimate how much they are investing is typically they don't publish a lot of numbers in terms of the labor costs of what--when you see estimates of funding. You will see mainly what they invest in equipment, new research, and things of that nature. So the numbers that you often see for China, Korea, and Japan, they often do not reflect labor, because that is assumed that it is just there.

So if we wanted to keep competitive with the European Union, which I think is frankly one of the fastest-moving economies in the world, our estimate this year with the request for 2012 is 2.1 billion. European Union already had in 2010, 2.6 billion. That would be the comparison that I would look at, and I think, my judgment is when you start looking at publications, publication citations, and things of that nature the fastest-growing countries there are probably--is probably China. If you look at the graphs of our publications and our publication citations, and you look at those of China, ours is leveling off some, and theirs are growing exponentially.

So those are the two countries that I would really look at as very, very competitive if I were trying to make an estimate. I would hesitate to give you a hard number, but I would look at those two comparisons very carefully.

Chairman BROOKS. Does anyone else wish to share an opinion or a judgment concerning how much you believe we should be investing in nanotechnology in order to be competitive?

Mr. TOUR. I think in light of the current budget and where we are, we certainly don't want to decrease what we have been coming in at. I think that that would be devastating to the progress of nanotechnology to suffer with any decrease.

Chairman BROOKS. Thank you. Now I recognize Ranking Member, Mr. Lipinski.

Mr. LIPINSKI. Thank you, Mr. Chairman. Mr. Moffitt, I want to commend you on the remarkable success of Nanosphere in just 11 years, and I noted in your testimony you talked about receiving 5 to $6 million in government grant funding, I believe, in those 11 years, which was a leverage of an additional $200 million in private and public equity financing, giving a 40 to one investment ratio.

I just wanted to ask all of our panelists, throw this out there, the--what type of--what has been your experience with leveraging grant money in order to have further--getting private investment into business?

Anyone want to--Dr. Rudnick.

Dr. RUDNICK. So I think it is of great interest from the perspective of international health that the Gates Foundation invested $10 million in Liquidia this past month, and they did so because of the drive to be able to supply populations of the world that can't have vaccines today with new and more importantly improved vaccines.

I think the ability to get that Gates money to be stemmed directly back to the initiative and the funding that came through NIST and other agencies to Liquidia over this last 5 years, I think it is imperative to have that kind of leverage and to continue to have that kind of leverage, at least in healthcare.

Mr. LIPINSKI. Anyone else? Dr. Tour.

Mr. TOUR. What I have seen with the companies that I have started, it is, for example, with Nano Composites, it has been around 7 years, the company. The company was just, a large part of it was bought by a major party now, and it has been about eight to one ratio, but, again, this is 7 years. I heard you mention with Mr. Moffitt 11 years, and this is part of the problem with nanotechnology. It doesn't come immediately. This transition takes time, and without the government standing behind us to bear this, it is very hard to get the investment that will ultimately come, and for us it was 7 years before a major player come in. Seven or 8 years.

Mr. LIPINSKI. Mr. Moffitt.

Mr. MOFFITT. Thank you for the kind comments. You know, I think I would remiss if I didn't point out to the committee while there is a 40 to one leverage in the money that has been invested into Nanosphere, the ultimate return on investment here is the cost savings that we get in our public health system and the costs that we eliminate or reduce in our--in the healthcare system in this country, and indeed, ultimately, others will benefit around the world.

But I can even point already to some examples of where our products are sitting in a position to be able to cut hospital readmissions simply by better treatment of the patient when they are in the first place, or pharmacogenetics, the term we use in this industry, personalize medicine, the ability to ensure that the drug that is being given to the patient is, in fact, the right drug, one that is not going to be harmful to them or one that is going to be effective for them.

And there are already examples there of where a simple genetic test before somebody goes on the drug Coumadin, a blood thinner, Warfarin-based material, if you will, and there were about six million people in this country that are on it, and it has a significant adverse side effect in the first few days on a certain percentage of that population. A study that was done 2 years ago by a Mayo Clinic in Medco, showed that you could reduce hospital admissions by 30 percent after taking that drug if you simply performed this simple, little, inexpensive genetic test before dosing it.

So I think the long-term payback here is much, much greater than 40 to one.

Mr. LIPINSKI. Thank you, and I want to through out one more quick question here.

Mr. Moffitt, you stated we face stiff competition from China, Germany, Korea, Japan, and others who have strategically found ways to decrease the gap from invention to commercialization, and that is a big issue that we face, not just in nanotechnology but in other technologies and other research that we are conducting here.

What are some of the best practices, just whoever wants to comment, some best practices we can take from other countries to refine our NNI?

Mr. MOFFITT. I think one of the best practices I have seen has been the formation of, I guess our term in this country would be centers of excellence, but I would call it more like arteries or pipelines, centers that are charged not only with the basic research but moving it onto translational development of products that are focused on specific industries, such as healthcare and perhaps even more focused on specific niches in healthcare.

For example, the nano-cancer centers that have been funded in this country. I think more of that kind of effort where we not only just fund the basic research, but we fund the ultimate development and application of it, focused on core problems in our country.

Mr. LIPINSKI. Anyone else want to comment on that?

Mr. WELSER. Just make a brief comment from the nanoelectronics side. When we were setting up the NRI, one of the things that determined where we were putting some of these centers was the willingness of the states to putting in money, not just for the research and infrastructure of the universities but your neighboring innovation parks, incubator labs, that could then take results that come out and rapidly try to put them into products, which is particularly important when you are doing basic research because it doesn't always impact the industry or the area you thought it was going to. So certainly our companies are very rapidly picking up the results that come out that can affect us on the nanoelectronics side, but you can have other collateral results in sensors or communication areas that perhaps startups would want to go after instead.

So I think having that kind of environment around universities makes a big difference.

Mr. LIPINSKI. Thank you. Anyone else? Okay.

Thank you very much. I yield back, Mr. Chairman.

Chairman BROOKS. Thank you, Mr. Lipinski.

Next we have Congressman Harris from Maryland.

Mr. HARRIS. Thank you very much, Mr. Chairman, and thanks to all the members of the panel for being patient with us to go and make those votes and come back and let me just--and this is a fascinating topic because obviously a lot has changed in medicine since I went to medical school, Dr. Rudnick and Mr. Moffitt. The--but I have to ask, the first question is at some point you have to move the basic science. At some point industry will be ready to pick this up, and for instance, in the electronics industry, I mean, you know, I know the balance sheet of some of the large semiconductor companies. I mean, why aren't they--there are so many benefits to them of doing this, why does the government have to fund any of that anymore?

I mean, at some point you have to push, you know, you cut the umbilical cord, and you know, industry should do this, and maybe Dr. Welser and Dr. Rudnick, I mean, at what point do we--can we cut the umbilical cord on these things?

Mr. WELSER. Well, we certainly do pick up the research in the R&D. As you heard, we put about 17 percent of our revenue into product-related R&D, and if you look back over time, certain areas that we used to rely on university research and breakthroughs to go through we no longer rely on that. We do it ourselves.

My area of research and my Ph.D. in the early '90s was strain silicon, and that was a lot of very fundamental research on materials. We didn't understand how to use it, and now it is in our production lines, and we are constantly making improvements on it, and we don't fund research in that back in the universities for a large extent or ask the government to do it either, because it is an area that we can now handle on our own.

I think the reason that the government needs to be involved still at the basic level for even something like nanoelectronics is we constantly need to move to the next device, the next material, and that requires screening huge number of potential materials and ideas and structures that maybe aren't even in the materials that we use today.

So that requires an investment that no company on its own can afford to do, and although we ourselves in industry put about $60 million a year into industrial, into university research on this, that is not enough to go after all the different materials that are possible. We have to focus those dollars on those things that we think can have the most promise going forward.

Dr. RUDNICK. On the medical front I think it is interesting to look at what happened at Liquidia. About 5 years ago the company was started. It was started with an idea that a little piece of film could have these nano-sized pores etched into it, and literally you could rub another piece of film over it, fill those pores, get drug substance out that was appropriately sized and shaped.

To take that from that concept that started the company and developed manufacturing that now can literally produce hundreds of thousands of feet of film per month filled with particles was about $25 million and about 4 years.

If the government hadn't stepped in and supplied some of the money through NIST to get that manufacturing ramped up, I doubt that venture capital would have been attracted to it. It would have been too early, too difficult, and there was no other place to go and get that level of resource to move it along except for that NIST funding for nano-manufacturing.

Mr. HARRIS. I have just a follow up on that but now that industry I think is going to realize the value of this, you know, again, at some point, and I don't know. I mean, it could be a broad enough field that we should just always spend the same amount of money and look into different areas, but, you know, with regards to screening products, you know, the pharmaceutical industry which also has a pretty good balance sheet, I mean, they do the screening of their drugs on their own. I mean, they do the same thing. They screen hundreds and hundreds of chemical compounds to find the one that is the next blockbuster drug.

So, you know, that is the only question I have, and very briefly, because Mr. Moffitt, you actually suggested that, I think in one of your answers that we should go actually beyond basic science and actually fund some of these things and get it further out, but I would say that--is that correct? Is that kind of what you had suggested, because to me it, you know, the appropriate role of the government is to do something that no private individual would do, and to be honest with you, I had a little reticence. You know, the trouble with academic research, I love it, I did it, is that it is public domain. I mean, the Chinese have the access to the academic research that we fund, to be honest with you, which is different when industry does it, and it becomes something that is intellectual property that stays here in the United States.

So, Mr. Moffitt, if you could just follow up on that?

Mr. MOFFITT. It is a comment about crossing what I think everyone refers to as the Valley of Death. Once the basic core academic research is done, how do you translate that into something? If the folks doing the basic research don't have a vision and idea for what this could become, then there needs to be a vehicle for making that happen.

I think the venture capital community in this country is very efficient at picking the winners from the losers, and they are ready to put the, you know, significant, at-risk capital to work in the earliest stages, but there is a gap between those two. And what I refer to there, and I think it is a best practice that is occurring in some of our competitors around the world, competitive countries around the world, is they are finding a way to close that gap up, and they are doing it with either partnerships, private and public, or additional funding from government resources.

Again, targeted to very specific problems that are there. But--so it is all about getting the technology to the point where industry, the venture capital community can recognize the pathway forward from there. And then I think at those points they are happy to take it forward.

Mr. HARRIS. And if I could just, Mr. Chairman, just briefly follow up, just very briefly, observation is that some of the states, Maryland included, have said that is fine, but we could provide some of that venture capital to do that bridging to conventional venture capital, the difference being is when it becomes successful Maryland is making back some money, because we are actually bridging the venture capital.

Mr. MOFFITT. And there are good examples of that. Maryland is one state. There are other states where there are programs in place to help connect that link, if you will, and the payback is in the economies of those states.

Mr. HARRIS. Well, not only payback in the economy but also a true physical dollar payback.

Mr. MOFFITT. Sure. Return on investment.

Mr. HARRIS. Thank you, and I don't know, Chairman, Dr. Tour I think wants to follow up a little, and then I will yield back the balance.

Mr. TOUR. Could I make one comment?

Mr. HARRIS. Please.

Mr. TOUR. The reason why we need to pay students to do research is because we have to pay them. Students line up at medical schools and law schools to pay their way through. They don't do that with science. They haven't done that with science for 50 years. We do that as a Nation because we feel it is valuable to train students in science and engineering. We pay them because we have to.

I will give you an example. We were doing pure basic science, didn't know where it was going, graphene oxide. As soon as we saw the way it plugged filters, then we talked with our friends in the oil industry in Houston and starts going down hole to make cleaner drilling holes so that we get less infiltration.

So it is the basic science that has to be done to spawn the new ideas that are then going to be transitioned, and it is not all in the public domain. I have 50 patents all through the university. So that--because of the Bi Dole Act is given to the university. The university then has the power to license that out, and I agree with you. We first file the patent, then, boom, we publish the paper. So we do both.

Chairman BROOKS. Thank you. The chair next recognizes Congressman Clarke from Michigan.

Mr. CLARKE. Thank you, Mr. Chair. I want to pick up on the line of questioning especially those issues raised by the good gentleman from Maryland, but I just want to preface my questions that I do not have an ideological agenda or position I am trying to push right now through this questioning.

I am going to ask you the questions for one reason. I would like to know the answers, and anyone can respond, but I am from metro Detroit. I am acutely aware of the fact that we need to create more jobs, and we got to do it faster. So how can we accelerate the commercialization of nanotechnology, and what do you think would be the most, not necessarily proper role but effective role for us to invest our tax dollars in this process?

And the reason why I ask this, especially in light of Dr. Tour's written testimony and verbal here, that outlined the strong global competition for U.S. researchers, that truly concerns me, on top of the fact that, you know, you have a lot of foreign students who are graduating from our great research universities, one of which is in the area that I represent, Wayne State University, yes, I am plugging them. And then those graduates end up going back home and not staying, you know, in the U.S. We want to try to keep them here, but that is a matter of immigration policy.

But still also for the same objective so that we can be truly competitive, and I want us to be number one in this area of commercialization, creating jobs in nanotechnology.

That is the end of my speech in essence. My question is genuine, though. How do we best leverage federal tax dollars to create more jobs in nanotechnology and create them quicker?

Dr. RUDNICK. May I start to answer that question? I don't know that I can fully answer it.

Chairman BROOKS. I think he left it up to any of the five who want to jump at the mike first.

Dr. RUDNICK. One thing that I think can be extremely helpful is for the government to recognize that there are positive and negative influences that they exert, and the setting of standards for the development of nanotechnology I think is a critical area, and whether you call them environmental and health standards or you call them manufacturing standards or whatever you choose to put behind them, the government can through the National Nanotechnology

Initiative help to set positive standards to frame the types of examination that nanotechnology particles, for example, will have to make sure that there are standards available to people if they need to test and investigate.

And that is something that if it doesn't happen, if the national standards are not set and enforced in a reasonable and functional, the way the FDA practically does it for drug products, I think there is always the risk that things will slow down, and I would hate to see that happen, and so that is just one perspective and one small corner.

The idea of having foundries that can manufacture these particles for anyone to use and test and know that they are getting the same thing time after time, I think is a very useful NNI response.

Mr. WELSER. I would also like to add I think there is value to having these for the public-private partnerships. The NRI in particular when we started it was sort of an experiment for the industry in that this was research that was really quite far out for us, something that we normally didn't get involved with, but we saw the urgent need with this transition coming up in the industry to start doing some funding on it, and we found that even though we were funding chemists, physicists, material scientists doing very basic work, having the industrial assignees working with them, we could identify ideas much more quickly that looked that they might actually solve a problem we would have or look like it could actually go do something different.

So rather than having that be just a pure science result, we could more rapidly say, well, let's take the science, learn the science, and also think about how you would apply it.

Mr. CLARKE. This is at the basic research level?

Mr. WELSER. Very basic research level.

Mr. CLARKE. Okay.

Mr. WELSER. So, for example, graphing material, there was a physicist down at U.T. Austin who had come up with an idea for making room temperature excitons, I am sorry, made excitons, great idea, didn't mean a whole lot. We asked him, well, could it ever be done at room temperature, he never even though of that, went and looked at it and said, actually, it could. It could be one of the first room temperature excitons. It is a great science result. If it is true, it actually could make a device that would be a thousand times less energy than our current CMOS transistors. So obviously of clear interest to us.

So we are hoping that that kind of interaction, even at the early stages, can identify things that we could move more rapidly.

Mr. TOUR. I think that money is always a great incentive, and if we want to push these out faster, one of the things that we could do is to say, when I am speaking to an industrial entity to say, look what I have got, if you start to invest in this to do this transition of this nano-material into your business, there are certain laws that would give you different tax structure during this phase that are particularly enhancive to, would particularly enhance this system, this particular type of research.

And whether it be 15 cents that the U.S. Government would put in on the dollar that the company would put in or if it would be some other type of incentive in this way.

Mr. CLARKE. Dr. Tour, I know my time is up, this is very important. Is there a way that you could get me some bullet points of these types of proposed incentives that could work at different stages of the process?

Mr. TOUR. Absolutely.

Mr. CLARKE. I really appreciate it, and I am Hansen Clarke from Detroit.

Mr. TOUR. Okay.

Mr. CLARKE. Thank you.

Mr. TEAGUE. May I add a few comments from the federal program, please? Yes. All right. I just wanted to point out that within the new NNI Strategic Plan that there are two aspects of it that I think move in the direction that several of the Congressmen has spoken about.

One is the three signature initiatives that I talked about. These signature initiatives are really aimed at moving maybe towards slightly the next stage but still being in basic research, but they are really aimed to focus upon a number of common areas that are seen as being of high economic importance and national importance, and trying to align the resources of all the 25 federal agencies, at least those that have interest in those signature initiatives, to move towards the direction of maybe not, certainly not commercialization, but certainly to try to make the next stage, moving towards the application areas and to some degree trying to move the technology that came out of exploratory research into some of the next stages that Dr. Welser and some of the other ones have spoken about.

That is their principle aim is to align the resources of those interested federal agencies toward common thrust areas and toward common targets that identified and all the agencies that are working, agencies working on it have agreed.

The second thing that I would point out is that within the EHS Research Strategy the principle goal of that EHS Research Strategy is to both look at simultaneously the safety as far as human health is concerned and as far as the environment is concerned, but also to make sure that the commercialization of things are not limited and are actually boosted by this trying to focus on environmental health and safety aspects of nanomaterials.

Many people have said that one of the potential greatest barriers to commercialization of nanotechnology products is concern about the environmental health and safety. So I think that this focus by the agencies, particularly those in the regulatory community, to focus on both the safety aspects of it as well as the advancement of the technology and the commercialization of the technology, it is really quite an important move by the agencies to assist and to aid commercialization and technology advancement.

So I would encourage you to really take some look hard at all three of the signature initiatives and to the new EHS Research Strategy once you have it in your hands.

Chairman BROOKS. Before we get to our next member, Congressman Tonko, I am going to add that we have a little bit of time for additional questions, so should any member want to ask some more, just let me know, and we will have a second round.

With that we have Congressman Tonko of New York.

Mr. TONKO. Thank you, Chairman, and thank you and our ranker for what I think is a very important discussion. Let me thank our panel for the guidance that you are providing.

I represent the capital region of New York, which is the third fastest growing hub of science and tech jobs, high-tech jobs, a lot of it driven by the investment we have made in nanoscience. So I totally respect the impact that it can have favorably on our economy.

Dr. Welser, in your testimony you mentioned that the NRI research is extremely in early stage, and like most scientific researches it is unlikely to become part of a commercial product for 10 years or more. Is there any concern that that 10-year delay in a commercial product will have a negative impact on the semiconductor industry?

Mr. WELSER. Yes, certainly. I think that we are after this right now because we know in about 10 years we will have no other alternatives, but there is a long way to go in the next 10 years. Just making the current technology we are constantly struggling to make things smaller and smaller, and that is really, of course, what scaling has all been about.

And particularly in the patterning side of things, this is--there are some huge roadblocks ahead. We have been using what they call 193 nanometer light for quite awhile. We really need to move to smaller wavelengths. We are making features now in the order of 30 nanometer, so EUV, extended UV is a major focus right now of work within industry consortia and with government partners. Semi Tech in your area, of course, is a leader on this as well, and that--the solutions are not there yet. It is not only just making it work, but there is still materials work that needs to be done, understanding how to get light sources that can work, and on top of that we also think ultimately we need to think about patterning with other methods and combining that with things like directed self-assembly or other mechanisms.

So there is a long way to go just to make sure our current technology continues forward.

Mr. TONKO. And what role, I mean, what can we best do to move the EUV concepts along? I mean, it seems as though it is going to be a very pricy investment, but they obviously should be a partnership with the government I would hope.

Mr. WELSER. I absolutely agree. I think that, particularly if you consider the competition out there, you know, the other countries already, of course, are striving to get more and more of the FABs over there. Very fortunately, of course, Global Foundries has recently chosen to put a FAB in the U.S., which is, I think points to the fact that all of our companies really would like to have FABs in the U.S. if the business environment is right and if we can be close to hubs where the R&D is going on.

So having a partnership with the government for this incredibly expensive development that needs to go on and research on the basic materials that are there is the only way we will remain competitive with the other countries that are putting that money in.

Mr. TONKO. It frightens me that whoever gets that investment as a nation will be controlling the job count out there, and while everyone is bulking up with investment, we are talking about de-funding, which is a frightening thought.

Dr. Teague, do you agree with those recommendations made by Dr. Welser, and could you also incorporate your comments on the signature initiative in terms of how it could help us pull us into the right direction here toward that effort?

Mr. TEAGUE. I definitely agree with Dr. Welser's comments on the need for that, and I think that if you look at, particularly the signature initiative on nanoelectronics for 2020 and beyond, these are, I think, quite well aligned with some of the directions and the emphasis and the needs that are needed for advancing these next electronics.

I might just point out that we have four thrust areas within the Nanoelectronics Signature Initiative, and I think that they are quite well aligned with a lot of the directions that the Nanoelectronics Research Initiative by the SRC and the electronics industry is taking.

If I may just read those, and he might, Dr. Welser might comment on them, the first one of the thrust areas is exploring new and alternative state variables, architectures, and modes of operation for computing. I know this--I am quite confident this is very parallel to what the NRI is doing.

Merging nanoelectronics with nanophotonics and exploring carbon-based nanoelectronics, exploring nanoscale processes and phenomena for quantum information systems, and national nanoelectronics research and manufacturing infrastructure network that is university based in their overall infrastructure.

We currently are trying to, as I say, align the activities of the main agencies which are concerned with this, the National Science Foundation, the National--NIST, DOE, and DOD in these areas.

The next step that I think will be taken with the signature initiatives is to start interacting more with private industry for a possible public-private partnerships but mainly to try to make sure that what the agencies are doing, what they are funding is aligned with, to some degree, what is happening out in industry.

Mr. TONKO. I note that I am running out of time, but if you could get back to me personally or to the committee about how to grow the public drive, the general public, to push nanoscience. So many times that is what is needed in our culture. You have other cultures that are pushing investment in science and technology. We seem to be kind of strayed on entertainment and sports cultures and are lulled, we are somewhat lethargic about investing in science and technology. If any of you as panelists here could advise us on how we can engage the public to drive the advocacy for investment in this area, I would love to hear that.

Mr. TEAGUE. I couldn't agree with you more on that. After working with it, as I indicate, for the past period that I have been, the engagement of the public and mounting their interest in the nanotechnology, both in terms of its potential and in terms of the knowledge of it, efforts are being made to make it be a safe technology right from the start is something that I think we truly need to make sure the public fully understands and hopefully accepts rather than being potentially afraid of it.

Mr. TONKO. Uh-huh. Well, as a kid I saw that general passion of the Nation to be the first to land a person on the moon. I would love to see that sort of passion again for nanoscience.

Thank you, Mr. Chair.

Chairman BROOKS. Thank you, Mr. Tonko.

I have got three questions. The first one is to Dr. Teague, the second one would be all witnesses, and the third one would be for you all to digest and get back to us on.

Dr. Teague, what continues to be the primary concerns about the environmental health and safety impacts of nanotechnology?

Mr. TEAGUE. I think in terms of the general concern, if you are talking about the general concern sometimes of the public or the particular genuine concerns that are held by the scientific community, people that are involved in toxicology and the health aspects of nanotechnology, as well as the potential hazards that might it be posing for the environment, much of it is still remaining lack of knowledge of how some of the nanomaterials may potentially cause harm to human health and to the environment.

The investments by the National Nanotechnology Initiative member agencies, and I am pleased to say that we have had joining this year the Food and Drug Administration, as well as the Consumer Product Safety Commission in investing some in R&D for nanotechnology.

Our focus and I would say they have been pretty measured, as well as targeted, and trying to answer these questions and to come up with increased knowledge about the potential hazards of nanomaterials is the greatest concern. There has been much growth, much effort in this direction. I think the NNI and the NNI member agencies are making great progress. Our investments in the United States are far beyond any other country in the world, including the entire European Union, in this area, trying to understand it.

We have for the entire period of the NNI led the world in trying to understand these potential hazards of nanomaterials.

The--and I think the EHS strategy lays out a wonderful path forward in terms of how we will try to address this. The--all the agencies that have worked on the EHS strategy has really been laying out a great program to achieve the goals of making it safe and also being able to advance the technology of nano.

They call it their risk management research framework, and this overall framework of trying to take account simultaneously of safety concerns as well as those that are needed for advancing the technology is, I think, an excellent path that they have laid out. It has been developed with huge inputs from the entire community. We have had four different workshops over the past year to get great input from the experts in the field of toxicologists to help especially the fields that might be concerned about environmentalists, to lay out this path.

And so I hope that we can address this particular concern.

Chairman BROOKS. This one is for all the witnesses. Are current federal and private research efforts adequate to address concerns about environmental health and safety impacts of nanotechnology, and why does the Federal Government need to increase spending of EHS activities in the White House budget fiscal year 2012 by 36 percent over fiscal year 2010 which was 44 percent over fiscal year 2011 continuing resolution?

And that is for whomever of you may wish to address that issue as to why the need is so great for increased funding on

EHS activities.

Mr. TOUR. I don't agree that we need that increase. I would rather see that increase be put into the basic research because as basic researchers we are already doing a lot of the EHS. When we are studying nanoparticle toxicity in our animal models for therapeutics, we are already gathering a lot of that data. I have been in companies that are thinking about incorporating nano, and they already have a lot of the testing that they are doing as part of their normal regulatory work that they are doing.

So I am not sure that there needs to be that increase.

Chairman BROOKS. Anyone else have any judgment to share?

Mr. MOFFITT. I am not an expert. I can't speak to the increase itself and the detail of the budget, but I would say this. I do think it would be irresponsible of us in our--in this industry to continue to develop these products without understanding the long-term downstream implications of them and the impacts on these materials that we are making.

And I think if I think about Congressman Tonko's question about how to engage the public, I think this is an example of how we help engage the public, which is by reassuring them that these materials are not dangerous or, in fact, getting the answers if they are and how to handle them.

Chairman BROOKS. Any other insight?

Mr. TEAGUE. May I just add a few comments on that in response?

Certainly the percentage of increase is from the continuing resolution in 2011, and from the actual amounts expended in 2010. I think your--I wouldn't question your figures on that, but I would make sure that everybody is understanding that these increases still bring the total investment by all the NNI agencies and the environmental health and safety research still remains at something like 5 percent of the overall NNI investment.

This seems to be quite, as I say, that--and even that level has been very carefully looked at through a lot of consultation across the federal agencies, through all the input that I mentioned through workshops outside, through PCAST recommendations, through recommendations from the National Academy of Sciences.

So the current investments and these increases still by many people in the field think that that is too small, but I think because of the careful consideration of inputs from a broad range of stakeholders and from, as I say, PCAST and the Academy of Sciences, those increases are really quite justified in consideration of the hazards which many people think need to be addressed and better understood.

Chairman BROOKS. Dr. Welser, excuse me, Welser or Dr. Rudnick, do you all have an opinion you wish to share? If not, that is okay.

Mr. WELSER. I think I would like to reinforce the two opinions to the left in the following fashion. I think that I can't judge the overall amount and the value of that amount, but I can say that there is a great deal of work that is already going on in terms of safety of these particle-like products, and it is being done as part of the medical development of them, and not sharing that information across agencies would be a mistake.

And I think that has been one of the great strengths of NNI which is the sharing of information across agencies has been strong. I would hope that however the budget is constructed and however the workshops are constructed going forward that that continues to be the case.

Chairman BROOKS. Thank you. If we provide each of you with a copy of the text of House Resolution 554, the NNI Reauthorization Bill from the last Congress, would you please provide us with feedback for the record? Share with us your insight on the verbiage that is used and the scope of that legislation?

All right. We will do that.

Next, Mr. Lipinski, Ranking Member, do you have some follow-up questions?

Mr. LIPINSKI. Thank you, Mr. Chairman, and one area that I was going to go down, and you did a good job covering in the--in your questions there, and I certainly just want to echo the sentiments that we have heard from some of our witnesses about the importance of environmental health and safety research and the need to be investing in that.

The question I had about computer chips, our current chips are 32 nanometers. The next generation, maybe next year or maybe sooner, 22 nanometers. As we approach 10 nanometers, everything changes, quantum mechanics.

I want to ask Dr. Teague and Dr. Welser what is being done for research as to what we do next given the importance of rising computational power, and is there anything more that needs to be done, anything more that the--can be done by the Federal Government in helping industry, you know, deal with this issue?

Mr. WELSER. So I will start if you don't mind since this is exactly where the NRI is focused. I think we all realize that while we see a roadmap around 10 nanometers, and no one wants to predict exactly whether it is 10 or 8 or 5, but, you know, somewhere in along that line, but the current devices, we know that in the next 10 years the reason the NRI is looking out beyond that is because we know it needs to be completely different at that point.

At that point it doesn't become about shrinking anymore but actually about finding a different device, which probably means different materials, certainly means different physics needs to be involved because we understand the limits that we are reaching with our current physics, and it is actually all about energy and power it turns out. The problem isn't necessarily that you couldn't go maybe slightly smaller, but the energy these things utilize, the power density on the chip is just too large at that point. So finding physics that can reduce that energy is huge.

So all the things I am listing there and you heard the five areas that the NNI has also targeted all are about finding basic new physics and materials to carry this forward, and I think that it is so critical to do it early because although we can take it eventually to industry and actually do something with it that makes it into a product, we have to have a firm basis that has already been done at the research lab level before we can really take that in.

Mr. LIPINSKI. Dr. Teague.

Mr. TEAGUE. I am not sure that I can add a lot to what Dr. Welser said. I am not an expert by any means on quantum information systems. What I do hear much and I read much about the great promise that people see in moving to quantum information, computing quantum information, communication systems, and overall quantum logic devices.

For many people these seem to be the long, long range of what people hope to do. As we run upon the barriers of quantum mechanic tunneling at the distances that we are talking about, 10 nanometers and below, much of the classical way that we have looked at building electronic devices, electronic computing systems, we will run into barriers that we cannot overcome because we have run into the ends as far as the basic physics of those kind of systems.

Even there as indicated by these five different ways in which the agencies have laid out their path forward on nanoelectronics for our 2020 and beyond, that is one of the paths that is to be followed and to try to pull together all of the--and align the efforts of the agencies along those directions.

The other one is the one that I think the NNR, NRI, and as well as the agencies are going to be pursuing is looking at other state variables other than electronic charge. This seems to be one of the paths that is looking at, looks a lot promising. For instance, spin systems, using spin as the state variable rather than the electronic charge is one option that people are looking at. I am not an expert in this field and would hesitate to say that that is one of the more promising ones. There are a lot of others. I think Dr. Welser could maybe speak much more knowledgably about that, so I would be interested in his thoughts on that.

Mr. WELSER. Well, I am not going to pick a winner here today. If we knew that, we would go after it, but I will say the spintronics in the area of carbon electronics clearly show huge advantage.

I realize one other part of your question was what--are we doing enough? What more could we be doing? I think one of the things that does concern me is because of the fact we have been very careful in terms of where we focus this, we are looking at just the main transistor switch right now, and that is, of course, the building block that the entire chip industry is built on, but going along with that, if we move to spin or if we move to something completely different, you need to figure out how you are going to interconnect that, how you are going to build memory devices that go with that, the architectures and circuits that go along.

One of the important things about the signature initiative is it pulls together people who think about circuits and architecture and memory devices with the people who do transistors and then the people who do physics and chemistry, and in getting those people altogether and a critical amass of funding to enable them to do their research in their areas is something that I think is crucial to actually finding a technology and rapidly moving it in rather than waiting until we find the perfect device and then suddenly say, wait, now we got to figure a circuit that is going to be used.

So I think that is a real value to these signature initiatives in these areas.

Mr. LIPINSKI. Thank you.

Mr. TEAGUE. Just one last comment on that. Dr. Welser mentioned the spin and also with new carbon-based electronics. The one thing that I think that is very, very much overlapping between what the government agencies are doing, hopefully there is great communication with industry, but all of them are looking at how do the architectures, the basic overall architecture of the computer change as you move into these new systems.

Much, much thought to be given to how do you completely restructure the electronics, reconstruct the entire way that logic is done in--as you do computing.

Another one that should be considered is the coupling between nanoelectronics and nanophotonics. Light-based aspects of the computing architectures are also beginning to play a major role in even current computing systems.

Mr. LIPINSKI. Very good. Thank you.

Chairman BROOKS. Well, there go those bells again.

I thank the witnesses for their valuable testimony and members for their questions. The members of the subcommittee may have additional questions for the witnesses, and we will ask you to respond to those in writing. The record will remain open for 2 weeks for additional comments from the members.

The witnesses are excused, and this hearing is now adjourned.

[Whereupon, at 4:09 p.m., the Subcommittee was adjourned.]

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