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Nanotechnology: Understanding How Small Solutions Drive Big Innovation

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Thank you for inviting me to appear here today. It is a rare privilege to have the opportunity to comment to you on the importance of advanced nano-manufacturing and restoring U.S. competitiveness quickly to revitalize our most important economic engine of innovation.

I have had the opportunity to be involved in some of the most exciting developments of the digital revolution that have transformed our everyday lives. By way of background, I helped lead the teams that created and launched instant messaging, the cable modem, broadband, immersive imaging, the eBay drag and drop imaging system, and many other now-ubiquitous products. I now serve as Chairman and CEO of NanoMech, a leading nano-engineering and manufacturing company.

NanoMech is a highly innovative nano-manufacturing firm, based in Northwest Arkansas, down the street from the likes of Walmart and Tyson headquarters, with a portfolio of international award winning inventions and commercial products, including innovations in machining and advanced manufacturing, lubrication and energy, biomedical implant coatings, and strategic military applications. We feel we are poised for dramatic expansion of our manufacturing operations.

The former Chairman of the House Committee on Science and Technology, U.S.Rep. Bart Gordon, (TN), said "We stand at the threshold of an age in which materials and devices can be fashioned atom-by-atom to satisfy specified design requirements. Nanotechnology-based applications are arising that were not even imagined a decade ago. The range and potential application is broad and will have enormous consequences for electronics, energy transformation and storage, materials, and medicine and health, to name a few examples. Indeed, the scope of this technology is so broad as to leave virtually no product untouched."

This is even more true today. The United States is locked in a moon race with other major countries trying to take the lead in material science and bio nanoscale engineering research, development and commercialization in what is sure to be the next industrial revolution of progress. While these competitive countries lost out, to an extent, to the U.S. in the Information Technology revolution, they are determined to put enormous amounts of public and private capital to work to win this even more important race. Given the monopolistic efforts of China alone to control all of the world’s dwindling resources, the U.S. is now at a great risk in not having material

and rare earth metals that are core to our most important manufactured goods that are essential to our daily lives. Nanoscale engineering is our greatest hope in providing a way to do more with less in amazing and sustainable ways to keep America secure and the world leader in commerce, technology and defense. Speaking of defense, it is clear to most by now, that the country with the best UAV's wins, and no weaponization area more than UAV's will benefit from the tremendous advantages of nano-engineering and manufacturing. This of course is not to mention the huge gains realized in defense and national security in weapon systems deploying quantum leaps in super-advanced nano-engineered coatings, lubricants, fuels, energetics, faster processors, and battlefield gear.

Manufacturing Today

Over the past two years, I have had the opportunity to participate in the Council on Competitiveness U.S. Manufacturing Competitiveness Initiative, and The Office of the Comptroller General's Study on Nanotechnology. I take this opportunity to offer my perspective as an entrepreneur, innovator and nano-manufacturer. Much of manufacturing in the United States centers on higher value-added activities that require highly-skilled workers, unique knowledge from innovators or sophisticated infrastructure. Other U.S. manufacturers are in sectors that require proximity to end consumers due to transportation or other factors. Still other producers have unique quality-assurance relationships with larger firms or support America's defense base. A recent study by Deloitte and the Manufacturing Institute found that 5 percent of manufacturing jobs remain unfilled simply because people with the right skills are not available. That translates to 600,000 available U.S. jobs.

Not only are manufacturing and services interdependent, they are distributed globally. For most of the 20th century, "Made in America" meant just that: design, development, fabrication and associated transactions were performed in U.S. factories and offices by U.S. workers. Today, many goods are no longer designed, produced and sold within a single country. Instead, the activities needed to bring a product from concept to consumption are routinely performed in different countries. Many manufacturers believe that global competition has made them stronger, more productive and more competitive. Gains in productivity and output, however, are not translating into broader economic gains.

Furthermore, many U.S. states and localities do too little to attract manufacturing facilities, imposing complicated and time-consuming procedures on top of federal rules to site and build production facilities. The permitting process for a manufacturing facility in the United States might take months, if not years, whereas in some countries, the time required is merely a few weeks or less. Manufacturing also suffers from its public image. Many American's still think about manufacturing in terms of product fabrication—humming factories for the transformation of materials into new products, basically, "bending metal" in operations that are easily sent elsewhere. However, manufacturing today is part of a much more complex, high value-added and tightly integrated global web.

Consider, for example, NanoMech's very safe product platforms. We utilize convergent assembly so that we can nanoengineer tremendous improvements in many products, and through this process, what we ship is no longer at nanoscale, but vastly superior to conventionally manufactured products. We are developing cutting edge technology that enable dramatically more efficient industrial processes, and therefore, can save billions of dollars across several industries while dramatically increasing performance. At the nanoscale, we and other manufacturers, can reduce or eliminate harsh chemicals and materials and replace them with more environmentally sound and sustainable components. These include:

· **Lubricant Additives**: We have developed advanced nano-lubricant additives that dramatically reduce friction and thus wear to near zero in machines, and are able to deliver extraordinary energy savings as well as quantum leaps in performance. This work supports multiple industrial sectors including heavy machinery, agriculture, all forms of

transportation, aerospace, advanced machining, the flow of gas and oil, wind turbines, the military, and
others.

· **Machining and Coatings**: NanoMech has developed the world's first cubic boron nitride coating for manufacturing cutting tools allowing them to cut up to 1000% longer and in ways that allow the creation of better or new types of machines. It is not only an alternative for machining hardened steels but it enhances productivity by orders of magnitude. Through this innovation, the company has also developed strategic know how in ultra fast coating of nanoparticles for various applications such as machining, wear resistant surfaces, and anti-corrosion. We were awarded the R&D100, The Edison, and the SBIR Tibbetts Awards for this manufacturing advancement over the last year. At these awards ceremonies I couldn't help but notice that the majority of the award winners came out of the nanotechnology field.

· **Additives for Sustainable and Security Products**: NanoMech has developed additives for fabric, polymers, and wood-polymer composites for delivering sustainability and security. For example, NanoMech is currently providing an anti-microbial, fire-proof, anti-odor, anti-fungal and water-proof coating for armor vests and uniforms for public safety officers and the military that is much safer and causes no comfort change in the soft feel of the original material or cloth.

· **Metal Nanopowders**: Metals are a strategic commodity for the United States. Nanoparticles of metals allow us to deliver "more value for less usage." We have the ability to

produce large quantities of metal nanopowders including copper, nickel, and rare earths such as lithium, silver-indium alloy, aluminum, selenium and others. These materials are strategic and critical for multiple U.S. industries including energy, aerospace propulsion, electronics, and agriculture.

A broad array of government polices both foreign and domestic have important impacts on the innovation and production process, from research funding to taxes to market access. Presently, U.S. policies are not aligned with the full life-cycle perspective of innovation that includes production at scale. The policies, programs, strategies and business models that worked in the past are inadequate to secure America's future in the digital and nano age. Government, business, labor and academic leaders must rethink and retool the nation's business environment to seize arising opportunities and address several shortcomings. The leveling effects of globalization are diminishing the lost cost advantages offered in emerging economies and potentially opening the door to increased manufacturing in the United States.

Structural Changes in the Global Economy Create Opportunities and Challenges

The global migration toward free enterprise and open markets is driving growth in emerging economies. Several nations have rapidly developed into formidable manufacturing competitors. China's manufacturing output, for example, is now approaching that of the United States. As development spreads, a new consumer class is burgeoning around the world. About 1.8 billion people occupy the consumer class today. By 2030, this number could reach 5 billion, with 95 percent of the growth occurring in emerging and developing economies—creating large new demands for manufactured goods.

Global companies see significant sales and investment opportunities in emerging countries. U.S.-based operations must also compete with aggressive mercantilist policies from foreign governments. Many countries have put in place policies and financial incentives to attract investment, manufacturing facilities, foreign intellectual property and talent while protecting domestic business interests.

The digital and nanotechnology revolutions and the pace of technological change also profoundly impact the way that business and production are organized. Digital technologies have made many facets of the global economy nearly borderless. In an earlier era, the location of natural resources often determined where manufacturing would take place. In today's economy, knowledge, know-how, technology, creativity and capital are the most important resources for production, and they are highly mobile.

Put together, these trends—emerging manufacturing nations, growing consumer class, neo-mercantilist policies and revolutions in digital and nanotechnology—create a hyper-competitive manufacturing environment. Not surprisingly, firms are growing more sophisticated in their ability to react to these changes and, where possible, leverage them to their advantage in the marketplace.

Global firms are becoming more sophisticated and recalculating the total cost of production. Successful global firms rely on their ability to react rapidly to changes across the global marketplace. In the early stages of offshoring, inefficient manufacturing operations were often relocat-

ed from higher-cost economies to low-cost labor economies to maximize returns and ensure that products were price-competitive.

Talent is perhaps the most important driver for manufacturing competitiveness, especially in nanotechnology.

The United States needs highly-skilled workers to realize the productivity gains essential to remain globally competitive in the digital and nano age. Yet current and anticipated human capital deficiencies exist across the board. Not only are current openings for highly skilled workers challenging, manufacturing workers are retiring at a much faster rate than they are being replaced. The growing shortfalls represent a critical need for a wide range of skills across many occupational cuts, from the most rudimentary to the most sophisticated PhD level.

Another major focus continues to be graduating more students with advanced degrees in Science, Technology, Engineering and Mathematics (STEM) disciplines, as well as improving STEM literacy in general. Unfortunately, this re-engineering of our home grown workforce will take another 10 to 20 years. Current visa policies are reversing decades of openness to foreign scientific excellence. This is a major problem we face at NanoMech in hiring and retaining the best nanoscale trained engineers. Foreign nationals with advanced degrees from American institutions are returning to their countries of origin and pursuing employment opportunities unavailable to them in the U.S. With them, they take the skills and knowledge necessary to create next-generation goods and services, and reduce America’s competitive advantage while increasing that of the country to which they return. It almost seems as if after subsidizing the education of these bright and gifted individuals in the best University system in the world, we are, in effect, pushing the Einstein's and Wernher von Braun's to leave our Country. No one disputes

the need for safe-guards and assessment of foreign entrants. However, a system that is transparent and efficient and also offers fresh incentives for the best and brightest can offset current obstacles.

America Must Leverage its Edge in Innovation, Technology and Computing

America's technology and innovation capacity remains among the greatest in the world. In crucial fields like biotechnology, biomimicry, nanotechnology, materials science and computing, U.S. researchers and entrepreneurs define the leading edge. American universities and research laboratories are unparalleled, pushing the boundaries of knowledge in life, physical and social sciences. Despite the nation's budget woes, Congress has thus far been reluctant to impose drastic cuts to scientific research funding that is viewed correctly as an engine of economic growth. America remains the world's largest investor in R&D and is among the upper ranks in R&D investment as a share of GDP. At the same time, other nations are making rapid progress relative to the United States in the talent, investment and infrastructure needed to foster innovation. Furthermore, a number of policies and practices limit American innovation today. Licensing practices, export controls and immigration policy, for example, were designed for a different era. Removing those impediments could generate greater levels of innovation and commercialization from today's assets and investments. In addition, the United States had the most generous R&D credit of any nation in the 1980s, but today, 16 other nations have a more generous tax break for R&D, which means many U.S. firms are sending R&D overseas.

In 1960, the United States accounted for more than two-thirds of global R&D. Today, two-thirds of global R&D is performed somewhere other than the United States. Although a more prosper-

ous and innovative world is a welcome trend, the shift has significant implications for U.S. manufacturing and security interests. America has long been the global leader in creating new, high value-added goods and services. That lead will undoubtedly narrow and the greater issue will become whether Americans continue to develop and produce sufficient numbers of high-margin products to sustain and improve living standards.

America Also Must Better Leverage Its Entrepreneurial Enterprise

By combining innovation, entrepreneurism and risk capital, America has spawned more globally-recognized brands in more sectors than any other economy over the past several decades. The U.S. entrepreneurial enterprise is a critical advantage, since as much as one-third of the difference in economic performance among countries is attributed to the difference in their levels of entrepreneurial activity. Highly skilled entrepreneurs and business start-ups also create middle-skill jobs though the number of new businesses has declined significantly.

Consistent with other facets of the hyper-competitive manufacturing environment, many nations around the world—plus states and localities—are working to narrow the U.S. entrepreneurship advantage. They are creating tax incentives, sovereign wealth funds, skilled immigration incentives, regional innovation clusters and global collaboration forums with varying levels of success.

America must do more to enable entrepreneurs to take risks and to translate ideas into innovation. America is still leaving ideas on the table. On average, only one in ten U.S. patents is ever commercialized. Thousands of inventions lie dormant in the hands of universities, research centers and private companies. For those ideas that are pursued commercially, only seven out of

every 1,000 business plans receive funding. And even fewer are scaled to full production in the United States.

As I have noted, NanoMech develops “platform technologies” which can be customized for multiple industrial sectors. The world runs on machines, and machines run on lubricants. In the area of lubricant additives, that means we are developing specific formulations for transportation wind turbine gear boxes, aviation, marine, agriculture – if it has an engine, or any moving parts, it can benefit from our product. Collaborating with industrial end users too early in a product’s development often results in that product embodying a lower-risk, single, narrow application of the technology that ties up the underlying IP. This outcome precludes us from realizing the technology’s benefits for other key applications necessary to advance nanomanufacturing. The development timeline would also likely be much longer. In other words, if we engage with an industrial end-user too early, we will not be able to develop the technology for the many other sectors – which often include defense—that will reap substantial economic and energy benefits. Public funding for early development and testing at commercial production scale preserves our ability to market to multiple industrial sectors, which maximizes the impact of the technology.

Remember, the science underlying NanoMech’s products represents the best of the American R&D enterprise. When the resulting innovative products proliferate through the industrial base, the economic benefits are a return on the taxpayer’s investment. Furthermore, because NanoMech’s products are enabling technologies that will improve the energy efficiency of industrial

processes, we can actually help to restore competitive advantage to industries that have lost out to global competitors in the last few decades.

America Falls Short of Its Potential as a Market for Manufacturing Investment

The American nanotechnology marketplace also is competing against aggressive, coordinated and well-funded foreign efforts to attract manufacturing facilities. China is spending billions in building the Nanopolis in Suzhou to attract nano research and commercialization from around the globe into China, while RusNano is a $10 Billion dollar investment fund investing in major nanotechnology companies and venture capital companies in the United State's and other countries. America needs pro-growth fiscal and monetary policies that spur private sector nanotechnology investment, expanding R&D capacity, growing capital expenditures for nano-manufacturing at scale. These policies should be informed by these competing policies and cost structures overseas.

There are four primary stages of innovation and production where investment is needed:

• the technology creation stage, where the federal government plays a major role.

• technology transfer, where there is typically limited funding.

• the early commercialization stage, where angel investors and venture firms like to engage. •

the scale-up to full production stage.

Getting a new innovation to market often stumbles due to technology transfer functions with limited resources that struggle to connect researchers with limited business backgrounds to outside technologists, entrepreneurs and investors. The availability of government funds decreas-

es abruptly after the technology or knowledge is created because the government views subsequent investment as the domain of the private sector. This drop-off of investment occurs at the same time that the investment needs of a company or entrepreneur are growing to test, develop and begin commercializing the technology. This is the traditional valley of death referred to in the innovation process.

Often overlooked, however, is a second valley of death. A few of my colleagues from the Council on Competitiveness have suggested that this second valley emerges at roughly the point of scaling up production beyond $10 million to $100 million in revenue. Many firms are finding it more difficult to obtain scale-up capital in the United States than overseas. To capture the full fruits of the U.S. innovation ecosystem, the U.S. must bridge both valleys through deploying more into Public-Private Partnerships.

Conclusion

It is time for America to lead. Many question whether America has the resolve and resources to right its own ship, let alone lead a global recovery. I harbor no illusions about America's daunting economic challenges, but believe steadfastly that the challenges are solvable and that Americans and their leaders will summon the will to act decisively.

I do not want to manage a "State-run" company, but I do have to compete against them. America must coalesce around a new vision focused on innovation and leadership in high value-added, next-generation manufacturing. Public-Private Partnership business models have not been more important to U.S. GDP and knowledge job growth since World War II. For more than 200 years, the United States has prospered because it is the home for people from every nation

who are drawn to freedom, confident in their abilities to carve out a better life. That “can do” optimism for which America is known is more than a cliché; it is a deep-seated cultural belief reinforced by experience on battlefields and in boardrooms, in classrooms and laboratories...and on the factory floor. It remains within America’s ability to make its future.

We must capitalize immediately on our great University system, our National Labs, and tremendous agencies like the National Science Foundation, to be sure this unique and best in class innovation ecosystem, is organized in a way that promotes nanotechnology, tech transfer and commercialization in dramatic and laser focused ways so that we capture the best ideas into patents quickly, that are easily transferred into our capitalistic economy so that our Nation’s best ideas and inventions are never left stranded, but instead accelerated to market at the speed of innovation so that we build good jobs and improve the quality of life and security for our citizens faster and better than any other country on our planet. The America Way.

Thank You.