Silicon technology: From micro to nano, and why federal investment matters

By Kathleen Kingscott
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Let me begin by expressing my thanks for the privilege and opportunity to address you today.

I would like to provide you with an industry-based perspective of nanotechnology in order to help you understand why we at IBM view nanotechnology to be so important.

What is nanotechnology? For some, nanotechnology is narrowly defined as a technology in which structures are assembled in a "bottom up" manner by placing the individual atoms into desired positions. But for many others, nanotechnology is used to refer to any technology which incorporates structures which generally are of nanometer dimensions, regardless of how those structures were created. I shall use this second definition. It is important to understand what a nanometer is. If you were to take four atoms and line them up in a row (something that we can do these days) the row of atoms would be about a nanometer long. You should also understand that while science research at the nanometer scale is a real and burgeoning endeavor, nano*technology* is largely a vision of possible future technologies.

Nanotechnology is coming. It is premature to say just when and in what form nanotechnology will take hold. We cannot predict the industries in which it will have its first impact. But the signals are clear enough: over the last decade there has been remarkable progress made in laboratories all around the world. The motivation is clear enough: nanotechnology holds tremendous promise for how it would impact our lives. Let me give you just one example from the computer industry. If we could store and access information on a nanometer length scale, it would be feasible for me to have a device which would give me near instant access to every piece of text ever written. It could store every sound of my life and many images as well. Nanostructured materials hold the promise of being stronger and lighter than conventional materials. This would have innumerable beneficial impacts from more fuel efficient and safer airplanes and cars, for example. Nanostructured materials will become ubiquitous.

Why is nanotechnology important? History teaches us that each time man has extended his ability to structure matter, whether it be to shape an ax from rock or a microprocessor from silicon, the benefits are extraordinary and enduring. Nanotech is the next frontier.

Why does IBM invest in nanotechnology research? The steady advance of semiconductor and data storage technologies has been the road along which the entire computer industry marches. For

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example, semiconductors have had an unprecedented impact on the economy because the industry has provided its customers with exponential increases in performance while dramatically reducing the cost. The impact on our society, economy and security has been enormous. The essential ingredient in these advances has been to shrink the size of the structures that do the work. In the coming decade, we will begin running into a major obstacle on this road: there will come a point where devices which work on today's principles will no longer work. They will have become too small. To prepare for this future, IBM's Research Division has been actively working to build a foundation of knowledge, devices and intellectual property which will allow the continued shrinking of our technologies and as a consequence, the onward march of our industry. The new devices will have nanometer-scale dimensions. They may well work on very different principles from today's technologies. They represent an enormous business opportunity.

Why is IBM concerned about the federal government's role? Simply put, the job has got to get done and there is no way we can get the job done on our own. An economically viable and multi-industry era of nanotechnology will require a large knowledge base from which to grow, and a university-based infrastructure which produces well trained people. The federal government is the primary source of funds for university-based fundamental research. This research is the base from which new technologies are derived. This is NOT research that will get done in the private sector. The information technology industry does have a major R&D responsibility and it is investing heavily in R&D. However, competitive pressures cause the bulk of that investment to be short-term, and overwhelmingly devoted to the D side of R&D. Very few companies are able to invest in research that may not pay off for ten years or more. Despite this, the information technology sector has more than doubled its annual R&D investment over the past decade to its current level of about $30B. However, industrial R&D cannot replace government investment in long-term fundamental research. Federal and private research are largely complementary, not overlapping, activities.

Why should the people of the United States vigorously support nanotechnology research? The answer is *Technology Leadership* and the benefits that flow from it. If there is a lesson about technology that the twentieth century has taught us, it is that technology leadership has a huge and beneficial impact on the welfare of our society and national security. One need only look at our current economic prosperity or at how few lives have been lost in our recent military campaigns to have ample evidence of this truth. Stepping up our national investment in nanotechnology will do much to help insure our technological preeminence in the century that lies ahead of us. As investments go, it is a wise one.

These remarks are largely based on a presentation given to the U.S. Senate Science and Technology Caucus by Don Eigler, IBM Fellow, of IBM's Research Division, Almaden, CA.