From Modeling to Manufacturing, Engineer Applies Innovations in Silicon

The most recent recognition of Mark Pinto’s impact on semiconductor manufacturing came in December 2008 when he won the J.J. Ebers Award from the Electron Devices Society of the IEEE. The award recognized his “contributions to widely applied semiconductor technology simulation tools.”

But Pinto’s job as chief technology officer of the iconic Silicon Valley company Applied Materials, includes thinking well beyond traditional electronics. With a broad view of nanotechnology and silicon-based manufacturing, he has helped the company venture into environmental markets as well. Pinto (PhD 1990 EE, MS 1983 EE) recently took some time to look back—and forward—and with us.

What are simulation tools and why are they important?

It is impossible to design the individual transistors and the integrated circuit process without some kind of computer assistance. There are billions of transistors on some chips, so it’s very complex, and also because the physics of the process are so complicated that you can’t just use an equation to figure out at what temperature to put the chip in the furnace or how many atoms of a material to deposit. You have to do some very sophisticated modeling and calculation.

Some of the early work in this area dates back to the mid-1960s. People started to use computers to design transistors, and the first successful effort was at Stanford, by my advisor, Bob Dutton. It was called SUPREM, for Stanford University Process Engineering Models, and it was the first well

known computer program for doing this kind of work. And when he did that it was a very limited application. It told you what the material looked like in one dimension, so if you made a cut in the silicon wafer it would tell you where all the atoms were. It didn’t really tell you how to design a complicated transistor, but it was a first step.

Your work here was on software called PISCES-II?

While an undergraduate at Rensselaer Polytechnic Institute I became interested in this simulation research. It combined a lot of things that I like to do, and I felt I could have an impact. I found that Dutton was a world leader in this, so I ended up going to Stanford and I met him.

I was eager to do some problems that were interesting in industry. Bob warned me that it was a pretty ambitious agenda for a student to take on, but he would support me. We ended up going down this route to develop a simulator that could basically be general purpose: useful for many, many applications.

The best thing was working with other students—not just the students I collaborated with on Pisces but also the other students who used the program to do their own thesis work. It helped them to do their work, and it helped me to make the program better. I looked at many types of examples that helped build the capability of the simulator.

Where did you work after graduate school?

I decided to go to Bell Laboratories. At the time, it was a preeminent institution. If you went to Bell Laboratories and distinguished yourself there, you were better qualified to do almost anything in our industry. Also, one of the future uses at the time of semiconductor technology was telecommunications. Seeing what could happen with fiber optics and wireless, I felt that a communications company would be an exciting place.

When did you join Applied Materials?

I joined Applied Materials in 2004 after working at Bell Laboratories and various offspring. What excited me about Applied was that they had grown to be such an important part of the Moore’s Law food chain—an absolutely essential part to enable Moore’s Law. Another aspect was the applications of nanotechnology, using that word very broadly to mean engineered materials on the atomic scale. There were great new applications that might emerge, and Applied could be a big part of them.

My job is not just a technical job, but rather it’s a combination of technology and new business development. That combination has been very exciting in terms of my satisfaction, but also having an impact. It’s not just about doing things in the lab and providing technology to product units, but also being accountable for turning it into a business. That has been the foundation of what we’ve been doing in solar, for instance.

What have been some of the most interesting and rewarding things that you’ve had the chance to do?

My first month at Applied and I was given responsibility for the display group, which was kind of a stepchild, if you will, outside of the mainstream silicon business. I went over to see what they were building and the equipment size of what they were building was just so enormous. Those TVs that you go to Fry’s to buy—40” or 46”—that piece of glass is actually cut from a piece
of glass the size of a garage door. Instead of building circuits on a little 12-inch wafer, they do it on a garage-door sized piece of glass. And yet, the control of the materials across that piece is extraordinary. It’s still on the nanoscale. I was just amazed by this. The reason they are doing that is to drive down cost. The bigger piece you can do this processing on, the less it costs to build the TVs.

This large-scale process opened up a whole new set of applications that we could go after, such as solar panels. Building on that capability, we now build a set of different products. We’ve made some acquisitions, and we’ve gotten into some other areas, such as architectural glass coating. You can coat the glass with different layers to make it more heat-resistant, so it can keep air conditioning costs down, or make it more cold-resistant so you can keep heating costs down. The layers have to be done to a very high precision over a big piece of glass that’s going to be cut and mounted into windows.

When I joined, what the chairman, the new CEO, and the board had in mind was for me to go looking for different areas of business. To then find such capabilities beyond the traditional semiconductor wafer business that we could actually work from was very exciting.

Tell us a little bit about the solar business.

When I joined in 2004 we looked at solar and said, this is a great opportunity for Applied. In the long term, this is the technology that people are going to use, but what’s going to enable it is reducing cost. It is not popularly recognized that cost is a key element in chips. When Gordon Moore wrote his original paper, the reason he argued for integration was cost. An example I like to use is the iPod. If you use the average cost of a transistor in 1976 and you take the number of transistors inside an iPod, the iPod would have cost one billion dollars. Also, it would be the size of a building. Cost per transistor is one of the key drivers of semiconductor technology.

In solar, it is really the key element. If you go back twenty years, Jimmy Carter had projected that the U.S. would be twenty percent solar in electricity by the year 2000. He also put solar water heaters on the White House. But it never took off due to the cost. The equivalent cost of electricity from solar in 1980—the difference between the retail electricity price to the consumer and buying and actually putting up a solar panel—was more than ten times. It was over a dollar a kilowatt hour to generate it from solar. So it just wasn’t competitive.

Now, because of many research and development, manufacturing, and other investments in places like Japan and Germany, in many parts of the world solar is cheaper than the ways to generate peak electricity. If we have opportunities to further lower the cost above and beyond that, it’ll make sense in more and more places.

What then happened from 2004 to today was climate change policy became much more of an issue. Now we are really in a good position in terms of having something to offer and a market that has huge demand. Today, electricity generated by solar is less than 0.1 percent of the electricity worldwide, so we have a huge opportunity for growth. China and India want to use more electricity, so it’s a great opportunity for Applied to provide technology to help solve this problem. Electrification of transportation, with renewable generation from solar power, is another possible trend.

Along the way we’ve talked about Moore’s Law. What is your take on how much longer it’s going to continue?

I think we are now certainly in a period where it has gotten tougher and it’s not progressing the same way it had, say five years ago or certainly ten years ago. Some products have slowed down in their use of Moore’s Law and new technology. The ones that have made the most use of it are memory technologies, especially flash memory. For that kind of technology we still see a fairly good time horizon of at least another ten years of the same kind of progress.

The bigger challenge has been the non-memory applications, the microprocessors, in the PC or in the cell phone. It’s just so difficult to design that they haven’t been able to absorb and utilize the new technologies as fast as in the past. I think we see a good ten years of maybe going at a slightly slower rate, but certainly still progressing. Beyond that, there are efforts in the universities to try and knock down some of the fundamental barriers. In the past we’ve been able to do it.