Is the Chip Industry as Important as We Think? Depends on Whom You Ask

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For me, 2014 started with a focus on moving into my new office on my ranch that will allow me to do more higher-quality, uninterrupted work. After I finally finished moving in, I sat down to catch my breath and to contemplate the world I work in. Immediately these questions popped up:

Are we as leading-edge industry making a difference in the world?

Are my efforts to promote EUVL and help its transition into fabs making a positive difference?

Are we as scientists and technologists making the world a better place?"

This is not the first time I have pondered these questions. Not long ago, I responded with the following logic:

1. The world as we know it cannot continue to exist without the latest computer chips. Taking away all the leading-edge chips would set humanity back faster than almost anything else.
2. Lithography is the main driver for producing leading-edge computer chips.
3. I work on developing advanced lithography techniques - especially the most critical issue, EUV sources - so my work has to be important!
4. Our industry is the bedrock on which the new civilization stands.

Unfortunately, not everyone recognizes this. I shared my view with a friend who had just returned to Austin after many years in Hollywood. It turned out he took all the new and better chip-driven gadgets for granted. Yes, we use computers, he said, but all industries think highly of themselves. He told me Hollywood thinks it drives the world. Since then I have talked to more people and have gotten similar feedback: we get better gadgets every year and expect to pay less for them every Christmas. Business as usual, they say.

Still, I can't help thinking that we're special. Our leading-edge chip industry is driven by innovation and competition and not by regulation. Do you ever hear Congress debating legislation to make 14 nm node technologies available in 2014 so we can have faster computers for the next-generation X-box or IPad? Not a chance! Instead, our industry self-innovates by trying to outdo our competitors. Our only price and performance

guidelines come from competition– we deliver better products every year at lower cost, as driven by Moore's Law and consumer demand. Which other industry does this?

However, when we read media coverage about the leading-edge chip business, much of it circles around the extension of Moore's Law, when and if it will end, EUVL delays, source power, when we are going to have EUVL ready, etc. That is the end of the story. So how as an industry have we ended up here?

First of all, we are here because of how the chip industry conducts business. By trying to move to EUVL as next-generation lithography, we are changing more than one thing in the critical technology of lithography, which is very difficult to do and hence the delay. The current light sources are plasma-based and what industry has achieved for EUV sources is phenomenal. However, making high temperature devices (35K or more) for 24 x 7 operation is extremely difficult and we still have a way to go. To make faster progress, we need larger knowledge and innovation bases in research labs around the world, and we do not have them. Our industry now has at least half a dozen consortia, which are supposed to be working to generate a knowledge base to support solutions for difficult problems, such as those EUVL is facing today. However, their main focus has been on supporting suppliers in tool development, an important task to be sure - but no support has been given to EUV source research for a very long time, which is our number one issue. Last year major chip makers announced R&D support for EUVL via their investments, but did it go toward our number one issue of high power and metrology EUV sources? Work in other areas of EUVL is good, but sources are where we can expect the most benefit from R&D.

The second reason is how we share information in this industry. It is done by press releases, investor statements and mostly in formal large conferences – too large for any discussions or format to allow discussion or questioning of critical data. After many technical conferences, the presentations are not available for a while (if at all) or may appear in formal papers after a long time. This is why I organize biannual EUVL workshops that are small, allow discussions on the data provided, and make presentations available to all at no cost just a few days after the meetings end.

The third reason is the type of OEMs we have in our business. Some are leaders and risk-takers and as a result they win big and grow, like ASML. They "bet the farm" on EUVL and it is paying off for them. In the near future, there will be only one leading supplier for critical litho tools – ASML. As I say for any business, there are three critical elements – investment, core competency and risk. Some suppliers are not willing to take risks or make investments, but I believe that many lack the core competency for getting into EUVL as well. You can acquire knowhow by buyout, but not always. ASML via its network of R&D institutes and sub-suppliers has

built a vast network of competency that has supported its EUVL tool development. Such networks are not built in years, but over a decade.

History Repeats Itself - Rescuing Moore's Law

I would like to focus on the topic of light sources for lithography, which is of interest to many. If we look at the history of chip-making, we find that in the beginning of the current deep ultraviolet (DUV) based processing, around 1980, in order to stay on Moore's Law, IBM wanted to move to shorter wavelengths. At that time there was also a shortage of photons in shorter ultraviolet light, as we are seeing in the industry's transition to 13.5 nm wavelength to stay on Moore's Law. Then Grant Wilson and his colleague discovered chemically amplified resist, which allowed us to do more with fewer photons. We are at a similar place today: while many are looking for more photons, the solution may come not from that direction (higher source power) but from being able to do more with the photons we have. I believe that Prof. Wilson and his team, or someone else of that caliber, will once again come to rescue Moore's Law by showing us how to do more with less. I hope our industry is exploring this option well.

Nobel Prize and Computer Chip Industry

Coming back to the perception of our industry, let's talk about the Nobel prizes that have been given in chip-making. Although our industry can boast of a few Nobel prizes, there are not enough, considering its history of innovation and its contributions. Three have been awarded over the past 50 years - a 2000 Nobel prize in Physics to Jack S. Kilby for his part in the invention of the integrated circuit, a 1973 Nobel Prize in Physics to Leo Esaki and Ivar Giaever for their experimental discoveries regarding tunneling phenomena in semiconductors and superconductors, respectively, and a 1956 Nobel in Physics to William Bradford Shockley, John Bardeen and Walter Houser Brattain for their research in semiconductors and their discovery of the transistor effect. I certainly hope that there will be more in coming years.

Prof. Wilson's discovery of chemically amplified resist (CAR) has revolutionized modern computer chip-making. It stands among great discoveries and its implications have been vast – any leading-edge electronic device that you touch (IPhone or Kindle or laptop) has been made possible due to processing based using CAR - his invention. For what others inventions we can say this? For his work he has received many well deserved prizes, including the Japan Prize (similar to the Nobel) in 2013. I believe that his invention deserves recognition by the Nobel Committee for Chemistry. I certainly hope that leaders of our industry will write a

recommendation for him to the Nobel Committee and share with us on the role of his invention and contributions. I will be happy to publish them in this blog.