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Executive Briefing: Getting Direct On Litho

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One-on-one with David Lam about next-generation lithography, where he's placing his bets, and what's changing in the VCI world.

Semiconductor Engineering sat down and talked with David Lam, principal of the David Lam Group, an investment and advisory firm. Lam is also the chairman of Multibeam, a multi-beam equipment startup for direct-write lithography and other applications. He founded Lam Research in 1980 and left as an employee in 1985. He served on Lam Research's board for five years after that.

SE: Multibeam is developing what it calls Complementary E-Beam Lithography (CEBL). What is that?

Lam: In a nutshell, it is using e-beam direct-write to focus on patterning the critical layers only. By that, I mean patterning the gate layers, metal layers, contacts and vias using e-beam direct-write. All of the other layers will be patterned by traditional optical lithography. CEBL could be used to pattern line-cuts in critical layers to complement optical lithography. The critical layers are difficult to pattern with optical. And, of course, they are the most costly because of multiple patterning.

SE: Doesn't CEBL require uni-directional or 1D layouts?

Lam: Traditionally, the design is two-dimensional. This can be very complicated to print on the mask as well as on the wafer. The world has moved to so-called 1D designs. Intel has been doing that since 2007. They lead the pack and the others are following. The memory folks have already been doing that for several generations. The memory guys have an advantage because the cell structures are very regular. The logic guys took a longer time to adopt that. But there is no other way to do it. In this methodology, the layout can be separately split into line patterns and cut patterns. The optical guys can do both today. They don't need EUV or e-beam. The only problem is that the cost is mounting due to multiple patterning. E-beam lithography is a strong candidate to pattern the cuts of optically printed lines. Again, that's a limited application, but it is very critical.

SE: There are several options on the next-generation lithography (NGL) roadmap, such as EUV, multi-beam and nanoimprint. How do you see NGL?

Lam: As you know, ASML is a powerhouse. They are successful and I respect them. When it comes to what we call patterning line cuts and holes, the issue is primarily cost or cost-of-ownership. In fact, at the end of the day, it's who can provide the most cost-effective solution to pattern the critical layers. But our technology can complement EUV as well as optical.

SE: What about directed self-assembly (DSA)?

Lam: DSA may have an application in hole shrinking. But then, there are other methods already available for hole shrinking. They are much less expensive and can do the job. So for DSA, I'm not sure I see a compelling advantage over the current methods.

SE: Hasn't the industry dismissed direct-write e-beam?

Lam: Far from it.

SE: E-beam direct-write has been around for decades. Why has it never moved into mainstream chip production?

Lam: In the early days, we had an e-beam writing system. That's often called ML2 or maskless lithography. Then, in recent times, ML2 has evolved into MPPW or massively parallel pixel writing. ML2 is writing one pixel at a time and that's why it's so slow. With MPPW, the thought is if you can write a lot of pixels at the same time with a huge number of beams, you can gain an advantage in terms of throughput. Indeed, it has improved the throughput, but it has created other problems. The system has one source or column. That is a huge amount of data coming in at a very high rate. If you do a few wafers per hour, let's say five to 10, your data transfer rates are in the order of 10 terabytes per second. That's unachievable today. So you can have these beams writing at the same time, but the data transfer rate is an enormous bottleneck. On top of that, all pixel writing is historically very slow.

SE: You talk about Tennant's Law. What is that?

Lam: Tennant's Law essentially captures in a single equation the difficulties of e-beam direct-writing getting into the mainstream. Tennant's Law can be represented by $T=k\ R$ to the fifth power. T is throughput, k is a constant and R is resolution. Tennant's Law shows that throughput for direct-write lithography deteriorates rapidly with improving resolution. When feature size improves by 50%, throughput drops to 3%. That's why e-beam direct-write has so many problems and never got into mainstream production.

SE: What's different about Multibeam's architecture? Why will it succeed when others have not?

Lam: In other systems, the key thing is the column is too big. We have to make it smaller. We have to make it as small as a marking pen. That's five or six inches tall and about 20 millimeters in diameter. Now, you can put them in an array to cover the entire wafer. For 300mm wafers, you need about 100 columns. These are mini-columns. So, the columns are small, and multiple miniature columns can be assembled in an array, covering an entire wafer. Each column has an electron source, deflection/blanking components and focusing lens. Each column has only one beam. The beam does not split.

SE: What about throughput?

Lam: All beams in a module write independently and in parallel. A single module is capable of five wafers per hour, which is good for low volume production and chip development. When you go 450mm, you need a few more. If or when 450mm comes along, our approach will have the same throughput for 300mm and 450mm. The reason is our architecture allows us

to cover the whole wafer surface. The amount of data rates that will come through the column is very normal and there is no bottleneck.

SE: When do you plan to ship a system based on the technology?
Lam: We have customers and we have partners. We are on a roadmap to develop commercial products. We are not ready to talk about the details.

SE: Why start a lithography company like Multibeam in the first place? That's a tough business.
Lam: Today, 70% of the total cost in a fab goes into lithography. When I started Lam Research, that number was only 25%. When I looked at the 70% number, I said this is not sustainable. This has to be a major concern for anyone running a fab. So, where do you go if you want to attack this problem? You would attack lithography.

SE: Multibeam has a different strategy than others, right?
Lam: In the early days, I thought that e-beam direct-write was going to be an NGL. Then, I realized that this was not possible. If we tried to invent something new to replace something old, that would be difficult. I came to the conclusion that we would have to be a complementary solution, not a disruptive solution.

SE: You are also active in the venture capital world, right?
Lam: I have been involved in venture capital. I had two companies sold in the last two months. I like to call myself a mentor capitalist as opposed to a venture capitalist. For example, investors will introduce me to a company. The company is well funded, but the investors will say we need someone like you to help work with the management. When I was at Lam Research, I wish I had that kind of mentor to help me make fewer mistakes.

SE: Any advice for startups looking for VC?
Lam: There are two different kinds of VCs. One is the traditional VC. They set up funds to invest in multiple small companies and multiple fields. Then, there is the corporate VC or strategic venture capitalist. They don't want to lose money, of course. For strategic reasons, they are investing in technology that will be used in their business. In some cases, the traditional VCs are chasing the next big thing. They are chasing social media and things like that. Because of that, there is a new and meaningful role for corporate strategic investors. There are also challenges. You need to have a lot of trust in that investor. You need to look at each individual strategic investor and evaluate them for yourself. Realistically, however, a semiconductor equipment company perhaps should not rely on traditional venture capital to support them. The traditional VC is more interested in other emerging areas.

SE: How do you see the foundry model evolving? And what about Intel's efforts in the foundry business?
Lam: Now, the IDM is picking up the foundry model. The foundry is picking up the IDM model in a sense. They are actually

merging the two concepts. Take Intel. For foundry customers, Intel has signed up Cisco and Altera. These are not small guys trying to come up with new gadgets. So I see Intel working with more established companies.

SE: Any thoughts on the state of the semiconductor equipment industry?
Lam: Consolidation will continue to happen. For an equipment company in general, the small companies tend to be more innovative. They are able to go outside the box. Big companies would do well to look for those small companies to find a way to work with them.

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