Semiconductor International

Industry Observation

A Legend to Accompany the SIA's Lithography 'Roadmap'

Since Gordon Moore first penned his now famous "Moore's Law" showing the logarithmic decline in minimum feature size over time, industry pundits have loved to predict the future of lithography battles.

Early on, it seemed very clear that X-ray would take over, once optical lithography reached its 1 μm "barrier." But as this imaginary barrier slipped to 0.5 μm and then to 0.25 μm, predicting the death of optical lithography became a risky venture. What technology will dominate at 0.25 μm? At 0.18 μm? What factors will determine the outcome?

In November of 1992, the Semiconductor Industry Association (SIA) held its first Semiconductor Technology Workshop to ponder the future of the industry. The lithography working subgroup managed to capture a snapshot of industry opinion about the future of lithography, which they called a lithography "roadmap." Using Moore's Law to determine future requirements for resolution, overlay and field size, one or more technologies were chosen for each generation as the most likely candidates.

Reflecting the uncertainties of predicting more than two generations ahead, the roadmap for the 0.18 μm and 0.12 μm generations simply listed all possible lithography technologies. The trend predicted in their summary report is very disheartening: *a new lithography technology for each generation below 0.5 μm.*

Let's look at the past: Projection lithography was introduced to the industry just 20 years ago; steppers were introduced five years later. In 1973, minimum feature sizes of 8-10 μm were achieved with a broadband version of g-line. Through the 1980s, g-line steppers dominated the market. By 1993, the minimum feature at leading edge production fabs was 0.5 μm and for the first time i-line steppers outsold g-line. For nearly twenty years, and through a fifteen fold decrease in feature sizes, the basic technology for IC manufacturing remained the same: g-line projection lithography.

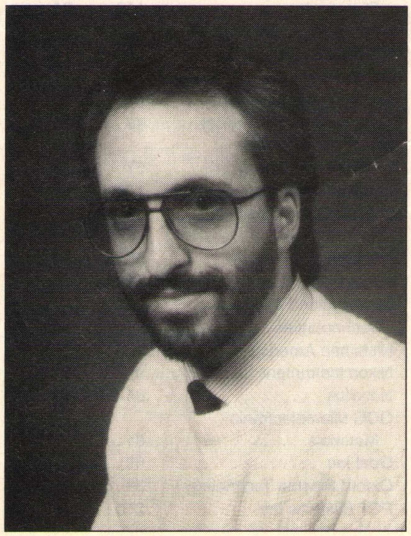
This remarkable improvement in capability came about, not through technology leaps, but through incremental improvements in lens quality and numerical aperture, photoresist performance, process and environmental control, stage and interferometry precision, and more *engineering* improvements.

The transition to i-line lithography was completed in 1993 for most leading-edge fabs, nine years after the first i-line stepper was introduced. Although the transition seemed easy enough, the industry was still very slow to adapt. The reason was quite simple. Manufacturing people hate change — and with good reason.

The competitive advantage that a manufacturing operation brings to the company is its processing technology, the methods built through experience that allow cost-effective production of the company's designs. A change in equipment or material results in a loss of some amount of the "experience base" that gives the company its advantage: the bigger the change the greater the loss.

As a result, manufacturing groups are naturally resistant to change that, in effect, throws away valuable company resources. The potential payoff must, of course, be greater than the loss of experience that will result, and must compensate for the risk involved before a change should be implemented.

"... companies must be prepared to quickly transfer not just technology, but *knowledge* from R&D to production."



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As has been said repeatedly in the many "twelve-step" programs to business success, companies that manage change successfully will survive. So how will the competing needs of improved resolution and current knowledge base be resolved? The answer lies in our ability to learn.

If the SIA roadmap is correct and a new generation of lithography process technology is required every few years over the next decade, companies must be prepared to quickly transfer not just technology, but *knowledge* from R&D to production. Operators and technicians, maintenance personnel, manufacturing and sustaining engineers, and management must be able to quickly replace their loss of experience with a current resist or stepper or track, with new information. Can this be accomplished without a catastrophic loss of productivity and thus company profit? It can, but not easily.

I believe that the industry will meet the challenges of 0.25 μm lithography, and then on to 0.18 μm, by making as few technology changes as the laws of nature will allow. Optical lithography will continue its dominance, not because it is superior to non-optical alternatives, or even because it has a lower cost-of-ownership, but because the value of the collective industry knowledge base on optical lithography is too great to discard. □