

# EDITORIAL

## HOT-LOT EQUIVALENT OF TECHNOLOGY DEVELOPMENT—IMMERSION LITHOGRAPHY

In semiconductor production, there are superhigh-priority lots that are supposed to run nonstop. The total run time should be very close to the absolute processing time. In the last editorial, I elaborated on the JM<sup>3</sup> special section on immersion lithography being the journal equivalent of a wafer hot lot. This time, there is another hot-lot equivalent. It is in technology development. The subject matter is, again, immersion lithography.

Immersion lithography has been on the mind of many microlithographers, as early as the 1980s. There were sporadic reports on the subject. Most of them were content with reporting successful imaging in a fluid using either the interference scheme or a static lens. All of us thought that it would be employed after the lens numerical aperture (NA) in air is maximized, wavelength minimized, and resolution enhancement techniques pushed to an unbearable  $k_1$ . In 2002, the 157-nm technology was pursued with great urgency. Extreme UV was supported by strong company backing and consortia. Shorter wavelengths seemed inexhaustible. Immersion lithography was not considered necessary. Switkes and Rothschild found the courage to find suitable immersion fluids to extend 157-nm lithography, disregarding the mainstream thinking of succeeding 157-nm dry lithography with EUV lithography. I was less trusting of 157-nm technology and very concerned about EUV lithography. In a 2002 plenary presentation at the SPIE Microlithography Symposium, I listed immersion lithography as a possible alternative to 157-nm and EUV lithography. In July, in an invited paper at the Sematech organized 157-nm workshop, I found the courage to tell the 200+ attendees that 193-nm water immersion has a better chance to succeed and a greater potential to reach future technology nodes than 157-nm dry systems. The audience responded with enthusiasm, forgiveness, constructive concerns, and action. The hot lot started.

Sematech took the role of consolidating the constructive concerns and organizing researchers to address them, and hosted workshops to facilitate rapid sharing of discoveries and results. I took the role of analyzing the soundness of immersion imaging for the situation of hyper-NA and many associated effects such as polarization-dependent stray light and how to fit it into future technology nodes. Another role that I took was to motivate the exposure tool and resist vendors to develop

immersion systems. It was not easy. Much money has been spent on 157-nm lithography and spending is still going strong. Every company needs to recover its investment. One argument that I often used was, "The sooner you switch, the sooner bleeding stops."

This hot lot took an impressive period of 15 months to reach a crucial turning point. On October 7, 2003, a few of my colleagues and I had the privilege to witness history in the making. We saw the first images and the wafer that was scan exposed by immersion a few hours prior. In journalistic language, they say, "the ink had barely dried." Well, "the water had barely dried." On December 3, ASML announced they had taken the order for the first 1250i scanner from TSMC. In the Third Workshop on Immersion Lithography on January 27, 2004, and a lithography forum two days following, 193-nm immersion lithography was placed firmly on the roadmap for 65- and 45-nm half-pitch nodes by a large majority of semiconductor manufacturers. Now, the completion of a hot lot does not mean total success. The lot has to be tested for yield and qualified for robustness. Immersion lithography is entering the phase of getting ready to run innumerable wafers in production mode to shake out all possible problems it may face in such a rigorous test. Nonetheless, immersion lithography has leapfrogged over the two exotic technologies.

Before closing, let me get back to journalism. Starting in 2004, all figures submitted electronically in color to this journal will automatically be published in color online without charge, provided the figures meet the guidelines and requirements. This is the benefit of advances in technology. However, authors who wish to have their figures published in color in the printed journal will still be required to pay the associated costs. There is still some room for future advances.

Happy reading!

**Burn J. Lin**  
Editor-in-Chief

