Research on Novel Materials Holds Key to Extending Immersion Lithography

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The future of 193 nm immersion (193i) lithography will be driven by the demonstration of a high-index lens material, invention of a third generation immersion fluid, and development of a high-index photoresist, Sematech-sponsored scientists reported at last week's SPIE Advanced Lithography Symposium.

These technology initiatives, all being spearheaded by SEMATECH through R&D agreements spanning three continents, were detailed in four papers and associated meetings during SPIE. Presenters reported steady progress in preparing key materials for extending 193i past the 45 nm technology generation, where it will first be employed. These results also will allow Sematech members and the semiconductor industry to make critical decisions regarding the ability to assess the extensibility of 193i by the end of 2007.

Emerging as a promising 193i lens material is lutetium aluminum garnet (LuAG), a crystalline mineral first identified in 2005 through Sematech-supported research at the National Institute of Standards and Technology. LuAG is attractive to lithographers because of its high refractive index of 2.14, compared to 1.56 for fused silica lenses currently used in semiconductor exposure tools. The higher index can be used to produce a larger numerical aperture (NA), which in turn can help utilize 193 nm light to define microcircuits much narrower than the wavelength.

Consequently, Sematech has launched a joint development agreement

with Germany's Schott Lithotec to develop mid-sized, projection-quality LuAG lens elements with a diameter of 80 mm. These prototypes will establish the framework to test the feasibility of full-scale LuAG lenses, which will need to be around 150 mm in diameter for high-volume manufacturing.

The project's goal is to produce a LuAG lens in 2009 to support beta exposure tools that could become available in 2010. At a Sematech-sponsored materials review, all three major exposure tool-makers reported that the crystal's drawback of moderate intrinsic birefringence, which distorts light waves, could be corrected for manufacturing. Schott representative Dr. Lutz Parthier predicted that his company would produce a production-worthy lens-blank by 2009. "All available test results don't reveal any technical showstoppers" to this goal, he said.

Analysis of second- and third-generation immersion fluids likewise produced a set of hopes and challenges. Several companies have revealed hydrocarbon based fluids having a refractive index between than 1.6 and 1.7. However, such fluids darken under laser irradiation, and leave residue on the lens surface. Also, ways must be found to prevent advanced fluids—which typically are viscous—from leaving behind microscopic droplets during removal.

Sematech is addressing these issues through support of research groups at MIT Lincoln Laboratory and at the University of Wisconsin. In addition, through three universities, Sematech is pursuing approaches to third generation fluids—based on nanocomposites, carbon-ring organics and hetero-compounds—with refractive indexes above 1.8.

Separately, Sematech sponsored research at the University of Queensland in Australia has recently developed a sulfur-based platform to demonstrate the first imaging with a resist index of 1.76. High-index resist offers the possibility of extending 193i even further, and

developing a broader process window as well.

“We need to make the technology for these future generations available in the next 10 ½ months—that’s our mission,” said Bryan Rice, manager of Sematech’s 193i program. “We need to offer a choice of technologies to semiconductor manufacturers.”

Source: Sematech