EUV Lithography: Separating Fact from Fiction

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Optical lithography is the preferred technology for semiconductor manufacturing due to its high resolution, tight overlay, and exceptional areal throughput, all at a cost which allows a positive economic return for the IC maker. Immersion DUV lithography using the ArF excimer laser source at 193nm is the standard for leading edge manufacturing but is limited to approximately 40nm half pitch resolution. Multiple patterning allows devices to be made down to 20nm using self-aligned double patterning (SADP) and down to 10nm with SAQP. However, the additional masks, etch, and deposition steps have increased the cost, complexity, and cycle time of the patterning process, threatening the economic basis of further feature size reduction. Extreme Ultraviolet (EUV) lithography has been developed to succeed immersion as the main patterning technology, offering a new wavelength (13.5nm) at which to practice optical lithography.

The technology has been slower to come to market than originally forecast, due mainly to low source power resulting in insufficient dose to achieve high productivity. This delay has been highly visible and widely analyzed. Much progress has been made. Through steady improvements made to the laser produced plasma (LPP) source and to transmission through the optical train, EUVL is now able to deliver more than 1000 wafers per day, with a clear target of 1500 wpd in 2016. Resolution to 16nm half pitch and overlay to less than 2.5nm mixed machines is achieved.

Remaining challenges in the development of reflective masks and resists for EUVL come to focus. Mask infrastructure development for blanks, writing, inspection, and repair pose formidable difficulties both technically and economically. Again, substantial progress is reported. Blank and multilayer deposition defect density has been reduced steadily. A clean process for EUV transparent pellicles to be mounted and removed has been developed. Resists with sufficient resolution and line edge roughness are required at a dose which allows EUVL to be competitive with multiple patterning. Steady progress in both chemically amplified and inorganic resists is reported.

System availability is a main area for improvement. The scanner body has many common elements with the production immersion tools, with the notable exception of additional vacuum systems. The scanner exhibits high reliability. The LPP source, on the other hand, has various failure mechanisms which have contributed to less than successful overall availability. However, careful reliability engineering should allow us to improve system performance to targets of 70% availability by year end and 85% by the end of 2016.