High Performance DUV Lasers for Lithographic and other Industrial Applications

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This paper describes progress in the development of KrF and ArF excimer lasers toward the ever more challenging requirements of the semiconductor microlithography industry. Also included will be recent developments with the XeF excimer laser used in the display industry and high power CO_2 lasers used in the production of 13.5 nm radiation for next generation microlithography tools.

Advances in excimer laser performance over the past two decades have been driven by the increasing requirements of the microlithography market. Parameters such as power, bandwidth, wavelength, beam size, beam divergence, and polarization have direct impact on the quality of pattern transfer. This talk will describe how the industry has taken on-wafer patterning performance parameters and transferred these into specific requirements for the imagining lens, the illuminator system, the beam transport system, and the laser light source. An overview of how these stringent requirements have been met using a two stage, MOPA, laser architecture will be given.

Beyond the typical beam quality metrics such as M^2, a multitude of laser parameters impact lithographic system performance. Not only the average value of these parameters, but also their variation over short and long time periods is of critical importance. The application of a two stage laser system separates critical functions between low power and high power. Parameters such as bandwidth and central wavelength (controlled to less than 0.1fm) are determined by the components inside the low power section. Parameters such as total power and pulse energy stability are substantially determined by components in the high power section. Beam size and beam divergence are affected by both low and high power sections. How this separation of functions has been accomplished will be described in detail.

Employing the knowledge gained in development of the microlithography ArF two stage laser, Cymer has developed a two stage XeF laser for use in the display industry for low temperature silicon crystallization. Unlike the ArF lithography laser, which is in the 100W class, the two stage XeF laser is in the 1000W class. This XeF laser is capable of producing 2000W of average power with near-diffraction limited divergence in one axis. The illumination requirements for this application require low divergence along one axis and high divergence along the other.

As an example of an application requiring traditional mode quality and tight focusing, the Laser Produced Plasma (LPP) Extreme Ultraviolet (EUV) light source at 13.5 nm employing a 50kW class CO_2 laser will be described. The requirements for this CO_2 laser are M^2 approaching 1, 50kW average power, and short pulse operation. It is the short pulse duration, 100ns-500ns, which makes this system unique among industrial CO_2 laser applications.

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