Effective Laser Plasma Source for Extreme Ultraviolet Lithography Using Water Droplet Target System

Lithography is used to print highly complex circuits onto microchips. In order to keep pace with the demand for the printing of ever smaller features, lithography tool manufacturers have found it necessary to gradually reduce the wavelength of the light used for imaging. Previously known as soft x-ray projection lithography (SXPL), extreme ultraviolet lithography (EUVL) uses a wavelength of 13.5 nm, significantly shorter than prior art lithography techniques, such as optical lithography, allowing the traditional scaling of chip feature sizes to continue. For EUV projection lithography there is a need for a high repetition-rate laser plasma source that can radiate at specific wavelengths in the EUV part of the spectrum and capable of operating at approximately 1200 Hz. This type of source should comprise a compact high repetition-rate laser and a renewable target system capable of operating for prolonged periods of time, in order to make the irradiation system cost effective. Target sources for laser plasma soft-x-ray projection lithography have encompassed several systems such as tape driven targets and solid targets and frozen gases which all have inherent problems. Tape driven targets are limited mass targets that are difficult to construct, prone to breakage and produce low velocity debris that can damage the other components such as the mirrors in the laser output system. Furthermore, using and replacing the tapes is generally cumbersome and costly. Solid targets sources inherently can produce various ballistic particles types that can emanate from the plasma in various directions, degrading the surface quality or the operating performance by over coating the optical elements in the laser output system. Frozen gasses such as Krypton, Xenon, and Argon not only require exorbitant containment costs, but also these gasses are quite expensive. Moreover, all previous embodiments of frozen gas targets have continuous large-mass pellets targets which produce particulate debris.

Technical Details

The present invention provides an inexpensive, high repetition rate sequencing water target source for laser plasma EUV projection lithography. This laser plasma target source for lithographic applications can operate continuously for an extended operational period, extending beyond that currently

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needed for an operating lithographic tool. This innovative target system also prevents ions from hitting the collector mirror or associated components of the lithographic system by using a repeller electric field structure. This debris shield in form of a repeller field reduces the sputter speed by nearly one order of magnitude, resulting in a cost-effective source. This novel target source system produces nondamaging debris, and it can be incorporated into well-known EUV lithography systems for the production of advanced wafer chips.

Benefits

• Able to operate continuously for an extended operational period, extending beyond that currently needed for an operating lithographic tool, proving to have a significant increase in the operational lifetime in comparison to prior art
• Reduced debris due to the mass limited target and due to an innovative debris shield in form of a repeller field, which further reduces the sputter speed by nearly one order of magnitude resulting in a cost effective source

Applications

• Source for EUV lithography

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