Highly Efficient Nanoparticles Generator


Methods, systems, and apparatus for generating flux-specific bursts of nanoparticles for various applications

Extreme ultraviolet lithography (EUVL) is one of the candidates for the next generation lithography (NGL) for the production of silicon-based computer chips. 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. EUVL is designed for printing microchips whose minimum feature size is 30nm or smaller. To achieve such a small feature size, EUVL utilizes a shorter wavelength of radiation at 13.5 nm, significantly shorter than prior art lithography technologies. In the roadmap for the development of EUVL, the provision of a source of sufficient power is identified as the principal problem area. There are two primary types of sources being developed, those depending in electrical discharge plasma, and those that use a laser plasma source. Both approaches must be capable of long term operation and debris-free, meaning protected from the effects of particulate emission and plasma ions emanating from the source. Both laser plasmas and discharge plasmas can produce high velocity particulate projectiles that will damage the expensive, precision coated EUV collection mirrors that are in direct line-of-sight of the source. Therefore, there is a need for a debris-free, high power short wavelength light source. Several techniques have been devised to achieve this, such as the use of Xenon-based plasmas. Although the use of Xenon mitigates the debris problem to some extent, the principal drawback is its low conversion efficiency into EUV light. Conversion efficiency (CE) is the ratio of energy radiated by the EUV source, low CE has adverse implications for both discharge plasma and laser plasma sources. For the laser plasma it means the use of a laser system having a power beyond known technical capabilities and possibly prohibitively expensive. For discharge plasma sources, the low CE poses extreme problems with heat removal from the source and very large electrical power requirements.

Technical Details

The present invention uses a modest, low power laser to transform a small droplet of material into a cloud of nano-droplets or nanoparticles. This novel nanoparticle generator will improve significantly the efficiency of both laser plasma and discharge plasma sources for lithography. By using this mist of nano-droplets as the source material for the plasma in both these types of sources, high conversion efficiency (CE) of laser/discharge plasma energy to 13.5nm EUV emission can be easily obtained. Moreover, the nano-droplet number and density can be adjusted so that all the nano-droplets are completely ionized in the plasma. Meaning that, not only will the source be most efficient, but also there will be no particulate debris, which would tend to damage the optical components such as mirrors surrounding the plasma source. This innovative nano-particle generator will be of great
importance to the development of intense EUV sources for lithography, precision metrology, and advanced microscopy.

Benefits

- Achieves high conversion efficiency (CE), resulting in low cost architecture
- Produces significantly less heat while having lower electrical power requirements, resulting in a highly efficient source
- Nano-droplet number and density can be adjusted so that all the nano-droplets are completely ionized in the plasma, therefore debris emission is minimized, eliminating excess material
- Increased reflectivity lifetime of the mirror, increases the EUVL light source lifetime, eliminating the need for costly and cumbersome replacements

Applications

- Development of high-power short wavelength incoherent light sources:
  - EUV lithography
  - Precision metrology
  - Advanced microscopy

Additional Technology Numbers: 31269

Technology #30250


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