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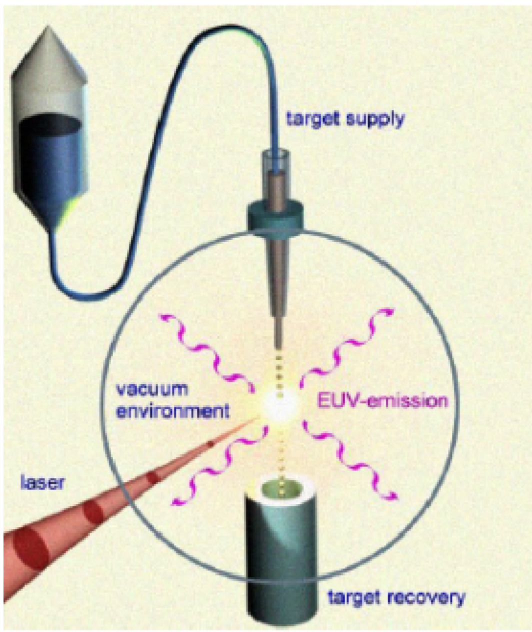
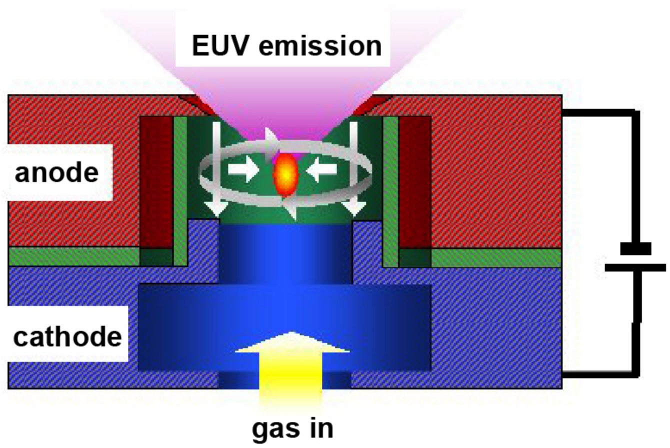
XTREME technologies GmbH

Rationale of Laser-assisted Discharge Plasma (LDP) Technology

EUV sources with high power performance have been under development for more than a decade. Historically, the investigation focused primarily on two technologies: laser-produced plasmas (LPP) and discharge-produced plasmas (DPP).



Traditional LPP Method



Traditional DPP Method

LPP Source

In an LPP source, the plasma is generated by a focused laser pulse hitting an appropriate target material. The target (mass-limited droplets emitted at a very high frequency) is designed to minimize the generation of debris.

A big advantage of this technology is the scalability of the output power, which is directly proportionally to the input power.

The complexity of tracking, targeting and synchronizing the laser pulses with the tin droplets, however, makes LPP sources highly unstable in terms of pulse-to-pulse and dose stabilities. Despite the simplicity of the concept, the challenges are many:

- Limited CO2 laser beam stability (further compounded by the amplification of the light reflected by the droplet themselves),
- Droplet dimensional uncertainty, due to the generation process itself,
- Droplet temporal and positional uncertainty,
- Difficulty in tracking and synchronizing droplets of uncertain trajectory with laser pulses,
- Poor CO2-to-EUV energy conversion efficiency,
- Reactive contamination of Tin,
- Fast deterioration of reflectivity of the complex and expensive collector mirror,
- Generation of highly volatile and reactive stannane (SnH4),
- Transport of tin contaminants towards the scanner through the IF aperture.

Process-wise, the compounded dose instability resulting from such multiple instabilities eventually translates into poor CD uniformity, resulting in loss of yield.

Finally, because of its proximity to the plasma and exposure to a high dosage of ions, neutral debris, electrons and debris, the collector mirror — the main mirror that collects EUV photons and focuses them towards the scanner — rapidly degrades, exhibiting a significant loss of reflectivity and far-field uniformity.

Despite efforts at mitigating degradation of the collector mirror, lifetimes for such very high precision multi-layer optics have yet to exceed only a few days of continuous operation.

Already one of the most expensive elements of the LPP system, the collector mirror is also difficult to maintain in a clean room environment. Any trace of contamination by tin (or any of its volatile and very reactive compounds) would dramatically affect an entire wafer production.

As such, the collector mirror is one of the primary components of COO in an LPP architecture.

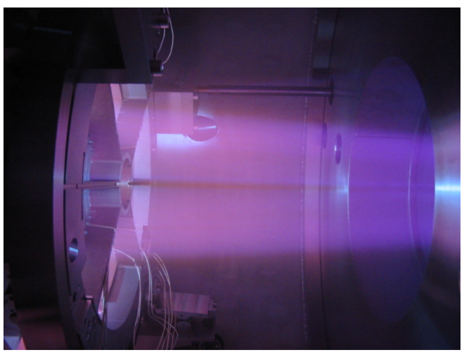
DPP Source

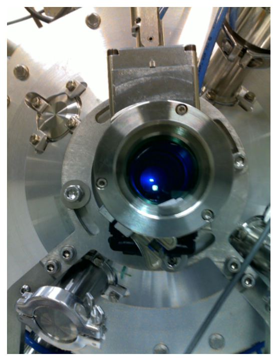
In a DPP source, on the other hand, the plasma is generated within an electrode system by an electrical discharge in the gas phase (Xenon).

The scalability of this technology to higher repetition rates, however, seems limited by the decay of the plasma. In addition, higher electrical input power leads to a higher thermal load on the electrodes, and cooling of the electrodes is limited by surface size.

However, DPP demonstrates high stability and achieves a high reliability.

LDP Source





Due to the inherent limitations of the traditional LPP and DPP technologies, since 2003 XTREME technologies has been engaged in developing a third alternative: Laser-assisted Discharge Plasma (LDP).

This hybrid technology combines the main advantages of the traditional LPP and DPP architectures: namely, power scalability and high stability. Additional advantages of LDP are:

- Pure photons (i.e., no tin contamination beyond the scanner interface), thus guaranteeing a long scanner lifetime,
- Clean photons (i.e., negligible DUV and IR spectral content), enabling imaging and overlay,
- Dose stability and repeatability (enabling CD uniformity),
- High duty cycles (enabling improved throughput), and
- Improved source uptime (enabling high-volume manufacturing).