

# Development of a Compact Capillary Discharge for Actinic EUV Metrology Applications

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Conventional EUV lasers in pinched capillary-discharge configurations for neon-like argon ions at 46.9 nm have mostly employed fairly inefficient excitation schemes using very high supply voltages ( $\geq 100$  kV) and very large stored energies (several 100 J). This resulted in quite low pulse conversion efficiencies of  $\sim 10^{-7}$ , or even less. In view of potential actinic metrology applications for the nitrogen recombination transition at the shorter wavelength of 13.4 nm, we discuss the development of a novel, highly compact capillary-discharge design with hollow-cathode trigger, automatic pre-ionization and integrated excitation-pulse compression.

We examine a low-inductance configuration with a single switch in an LC-inversion discharge scheme using ceramic capacitors of currently 16 nF total capacitance that is operated at peak currents of several kA using bipolar supply voltages below 20 kV at pressures of a few Pa, corresponding to the left side of the Paschen curve. High-voltage probes and a Rogowski coil are attached for waveform analysis. Based on detailed computer modeling of the plasma evolution in discharges of capillaries with 3 mm inner diameter, the failure to observe the predicted lasing action on the Balmer- $\alpha$  line of  $N^{6+}$  at 13.38 nm in the attempts of several other research groups was previously attributed to the detrimental influence of ablated capillary material [1].

With a hollow-cathode electrode and end-on differential pumping on the opposite capillary side in our configuration, we have used a translucent capillary with very smooth inner surface and fairly large inner diameter ( $\frac{1}{4}$  inch) to minimize wall ablation. This configuration also permits side-on observation of pinched visible light emissions. We report on initial tests with recorded voltage waveforms in different switching schemes and few-ns light emission periods in single-pulse operation with dry air.

[1] M. Vrbova, P. Vrba, A. Jancarek, M. Nevrkla, N. A. Bobrova, P.V. Sasorov, Phys. Plasmas **26**, 2019, 083108.