

Plasma accumulation effects in Extreme Ultra-Violet generated plasmas

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Plasma accumulation effects in Extreme Ultra-Violet generated plasma

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Introduction

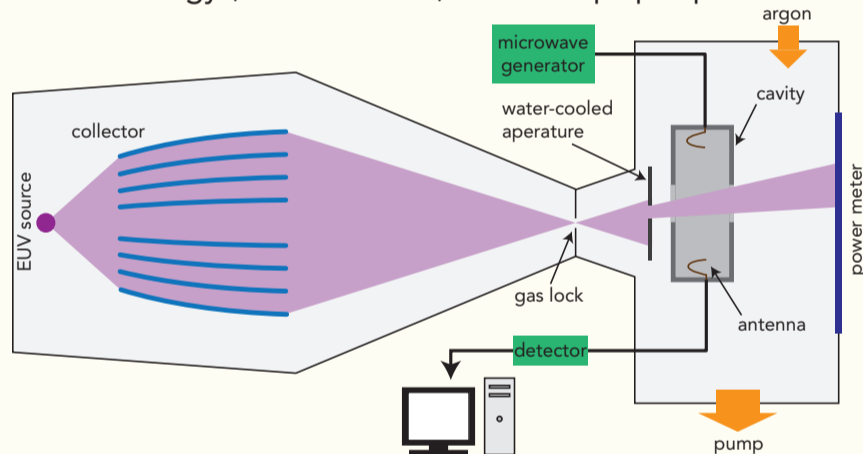
In order to meet the demand of increasing computer speed and memory capacity, industries are striving to reduce the size of computer chips. This miniaturization can be achieved by reducing the wavelength in lithography machines to Extreme Ultra-Violet (EUV, 92 eV). The low-pressure (around 1 Pa) transparent background gas (e.g. H₂ and He) in the lithography machine is partially ionized by the absorption of EUV photons. The study of these low-density (10¹⁵ m⁻³) pulsed plasmas is interesting and experimentally challenging.

Goal

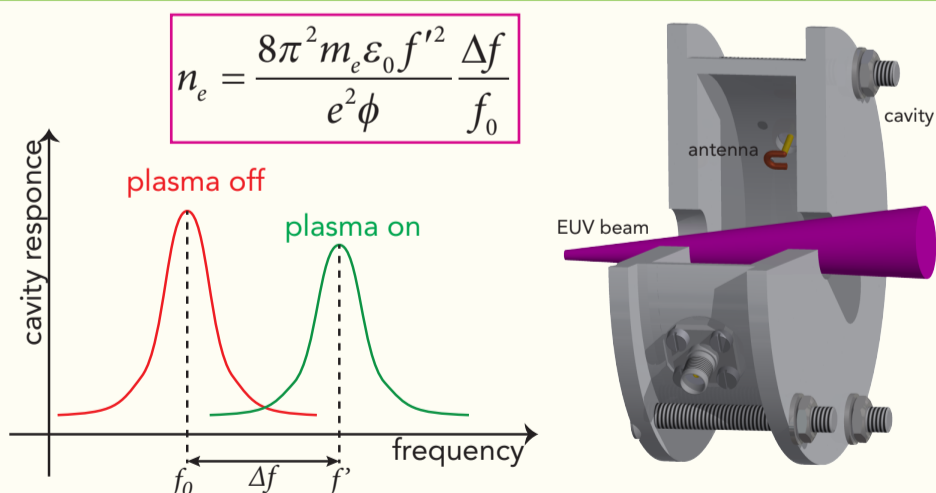
Study the accumulation of electron density in EUV induced plasmas.

Experimental set-up

- Tin-based LDP source
- Short (sub-μs) EUV pulse
- Frequency:
 - 10 kHz with 50% duty cycle (50 Hz)
 - 500 Hz with 100% duty cycle
- Inband energy (13.5 nm ± 2%) about 12 μJ per pulse



Microwave cavity resonance spectroscopy

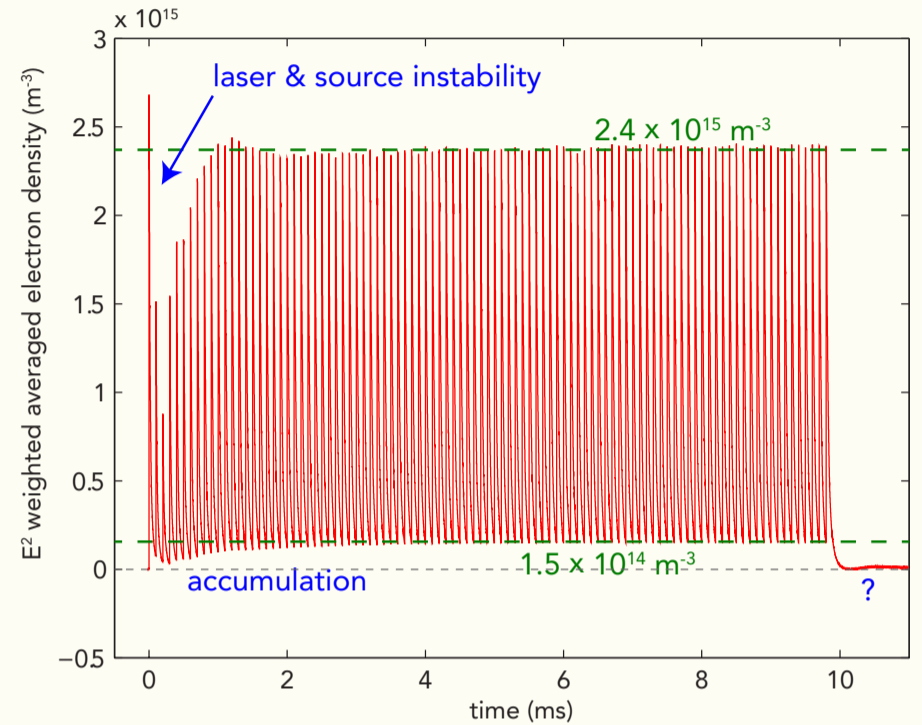


Conclusions & Outlook

- Plasma accumulation visible at high frequencies
- Accumulation predictable from low frequency measurement
- Repeat experiments in hydrogen
- Perform optical emission spectroscopy experiments

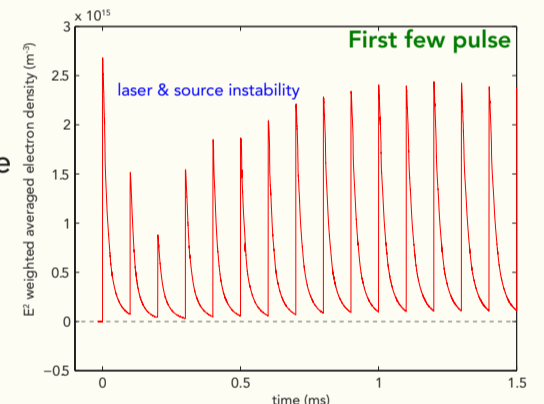
Plasma accumulation

10 kHz measurement



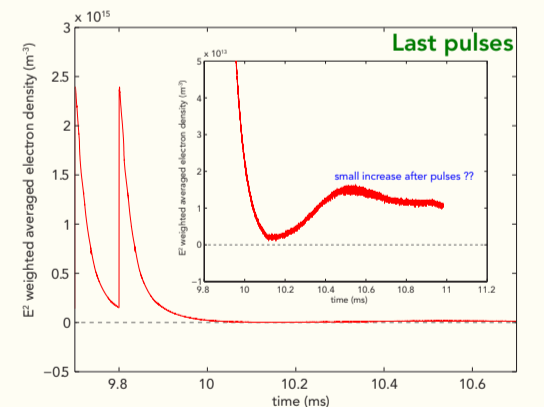
First pulses

- Laser instability during first pulses
- After 15 pulses steady-state
- Accumulation visible
 - $n_e = 1.5 \times 10^{14} \text{ m}^{-3}$



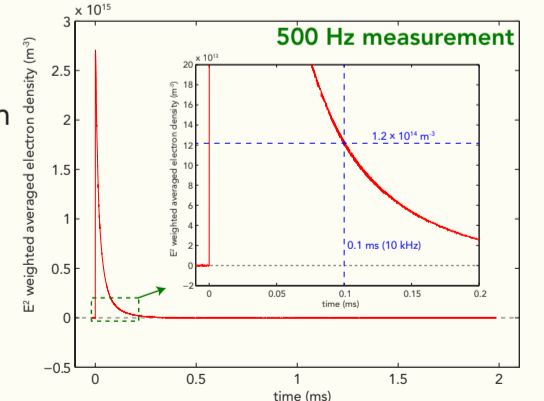
Last pulses

- Decay in tens of microseconds
- Minimum visible
 - No cavity heating effect
 - Reason yet unknown



500 Hz measurement

- Density at 0.1 ms comparable to accumulation at 10 kHz
- Accumulation density predictable



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