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Measuring the electron density in an Extreme Ultra-Violet generated plasma

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Introduction
Industries are continuously striving to reduce the size of computer chips in order to meet the demand of increasing computer speed and memory capacity. One way to miniaturize the chips is by reducing the wavelength used in lithography machines by using Extreme Ultra-Violet (EUV, 92 eV) light. Background gas in the lithography machine is partially ionized by the absorption of EUV photons. The study of this small low-density ($10^{15}$ m$^{-3}$) pulsed plasma is experimentally challenging.

Goal
Determine the temporally resolved electron density in an EUV generated plasma.

EUV plasma parameters
- Short (sub-μs) EUV pulse
- EUV transparent gasses (e.g. H$_2$ and He)
- Pressures < 1 Pa
- Low electron density ($10^{15}$ m$^{-3}$)
- A DC discharge is used as a simulation plasma to test the diagnostics

Microwave scattering
- Oscillating dipole moment in plasma due to MW [1]
- Scattered power has maximum @ $f_p$

Conclusion and Outlook
- No plasma effects visible in plasma scattering measurements
  - Dip in reflectivity @ $f_p$, $a < 0$
  - Peak in impedance @ $f_p$
  - Neither are observed

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The authors would like to thank Lex van Deursen for his help with the impedance measurements.

Reference cavity resonance spectroscopy
Measurement principle and set-up

Results of DC discharge in DC cavity
- Accuracy of frequency shift: 100 kHz
- Shift observed due to plasma
- Lower response

Preliminary spectrum EUV cavity
- Accuracy of frequency shift: <20 kHz
- Detection limit: $n_e < 10^{13}$ m$^{-3}$
- Response time: 15 ns
- Resonance frequencies correspond to theoretical values

References