Investigations of plasma parameters and features of compression zone formation in MPC facility using the optical and spectroscopic methods of diagnostics


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**Motivation**

The experimental researches of high-energy compressive plasma streams, generated by magnetoplasma compressors (MPC), present considerable interest for fundamental and different practical applications [1]. Studies of dense magnetized plasmas of different gases are of importance for various scientific and technological applications:

- development of dense powerful plasma sources of ions and radiation in different wavelength ranges,
- generators of hot plasma and efficient fuelling techniques (plasmoids),
- testing of fusion reactor materials with high energy loads,
- surface modification by pulsed plasma processing,
- deposition of different coatings.

The plasma compression zone that formed in different pinching discharges is a source of intensive electron and ion beams, neutrons, hard X-ray and EUV radiation.

**The example of argon spectrum in wavelength range 4700 Å - 4900 Å with spectral line Ar II 4806 Å, chosen for plasma electron density estimation**

Stark broadening was calculated from full experimental widths taking into account instrumental and Doppler broadening [3, 4]. Plasma electron density was measured with good spatial and temporal resolution.

**High-speed imaging of plasma compression with exposition of 1 μs**

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<thead>
<tr>
<th>Discharge time (mks)</th>
<th>7 mks</th>
<th>10 mks</th>
<th>11 mks</th>
<th>14 mks</th>
<th>15 mks</th>
<th>23 mks</th>
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</thead>
<tbody>
<tr>
<td>1 Torr</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
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<tr>
<td>0.5 Torr</td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
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<tr>
<td>0.2 Torr</td>
<td><img src="image13.png" alt="Image" /></td>
<td><img src="image14.png" alt="Image" /></td>
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<td><img src="image16.png" alt="Image" /></td>
<td><img src="image17.png" alt="Image" /></td>
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**Temporal behavior of plasma density versus radial distance of chamber**

Conclusions

Spectral researches of plasma dynamics parameters, generated by MPC device, were performed. Temporal, radial and longitudinal distributions of plasma density were studied in plasma stream and compression zone for different initial pressures of residual working gas in vacuum chamber.

- The maximum of plasma electron density \( Ne = (3 \pm 5) \times 10^{17} \text{ cm}^{-3} \) is achieved for initial pressure \( P (Ar) = 1 \text{ Torr}. \) It was appeared near 1 cm from the end of outer electrode, at 7 ± 10 μs from discharge beginning. The average value of plasma density in plasma stream is about \( Ne = (2 \pm 5) \times 10^{17} \text{ cm}^{-3}. \)
- The average value of electron temperature in plasma stream is about \( Te = (5 \pm 7) \text{ eV}. \)

From the high-speed imaging seen that only \( P (Ar) = 1 \text{ Torr} \) has dense plasma formation, which appeared at 8 ± 9 μs and exist about the same time.

Plasma flow has good radial symmetry at all regimes.

The working regimes with pressures \( P (Ar) = 0.2 \text{ Torr} \) and \( P (Ar) = 0.5 \text{ Torr} \) has acceleration character of discharge evolution, and pressure \( P (Ar) = 1 \text{ Torr} \) has compressive regime with long existence of compression region and significant higher plasma parameters.

**References:**