Gasdynamic ECR Tandem Ion Source for Negative Hydrogen Ion Production

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SMIS-37 gasdynamic high-current ion source

- Frequency 37.5 GHz
- Power up to 100 kW
- Pulse duration 1 ms
- Trap magnetic field up to 5 T
- Unique plasma parameters
  \( N_e > 10^{13} \, \text{cm}^{-3}, \tau \approx 5 \div 50 \, \mu\text{s}, \, T_e \approx 50 \div 300 \, \text{eV} \)
- High current density \( (j \approx 100 \div 800 \, \text{mA/cm}^2) \)
- Low emittance values

SMIS-37 gasdynamic high-current ion source
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\[ H_2 + e^- (< 100 \text{ eV}) \rightarrow H_2^* + e^- \]

\[ H_2^* + e^- (\sim 1 \text{ eV}) \rightarrow H + H^- \]
Extraction system

<table>
<thead>
<tr>
<th>Plasma electrode, mm</th>
<th>Puller, mm</th>
<th>Δr, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>11</td>
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Previous experiments

- The dependences of the current of negative hydrogen ions $\text{H}^-$ were measured at constant gas injection into the first chamber on various parameters.
- Despite the obvious non-optimality of the experimental conditions in the experiment it was possible to achieve values of the current amplitude of the anions up to 2 mA (and negative ion current density to several mA/cm$^2$).
- We made up optimization of gas injection scheme.
Focus of recent experiments

- Experiment with only pulsed gas injection into second chamber
- Plasma chamber heating in order to remove water
- Residual gas analysis
- The use of various extraction systems
Optimal parameters search
Optimal parameters search

![Graph showing charge vs. temporal delay between gas inlet and the leading edge of microwave impulse, ms, with curves for $O_2^-$ and $H^-$ labeled.](image)
Optimal parameters search

The temporal delay between the gas pulse and the leading edge of the microwave pulse, $mc$
Gas set after cleaning the chambers
Intermediate results

- After all the improvements were made, it was found with the help of the analyzer that the $\text{H}^-/\text{O}_2^-$ ratio is 2/3 for plasma electrode aperture of 5 mm.

- Electron current to negative ion current ratio was about 80.
Plasma electrode aperture = 1 mm

Sample negative ions \( \approx 80 \) mA/cm\(^2\) !!!
Checking the optimum
Plasma electrode aperture = 3 mm
Results
Conclusions

✓ We measured dependencies of the negative ion current on various parameters with different extraction systems

✓ We achieved the negative ion current density on the level of 80 mA/cm² through 1 mm plasma electrode
Thank you for attention!

Q & A