Mechanisms and dynamics of unipolar arcs in magnetized plasmas
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Mechanisms and dynamic of unipolar arcs

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Introduction

• Unipolar arc = arc between a plasma and a surface in contact with it [1]
• Main cause of wall erosion & impurity formation in fusion devices with metal PFCs [2,3]
• Impact of unipolar arcs on tungsten surfaces not well known [4]
• Many difficulties in the experimental investigations: spatial/temporal scales involved
• In this presentation: our first experimental results on the triggering of unipolar arcs
• Our aim: to provide more reliable input parameters & to assess the validity of models => better understanding of the mechanism/dynamic & consequences of unipolar arcs

Experimental device

• Experiments carried out in the ALINE device [5]
• Stainless steel cylindrical magnetized chamber
• 100cm long, 30cm in diameter
• Tunable RF plasma (10kHz-250Mhz, up to 600 W)
• Equipped with rotatable and biased manipulators by Cryoscan®
• Possibility of heat pulses (45W IR Laser)

Experimental conditions

<table>
<thead>
<tr>
<th>Gas</th>
<th>Active</th>
<th>Working pressure</th>
<th>Td (eV)</th>
<th>Magnetic Field</th>
<th>Vd (V)</th>
<th>I (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>He</td>
<td></td>
<td>30−100 mbar</td>
<td>0.3</td>
<td>up to 0.3 T</td>
<td>40−80</td>
<td>1−2.5</td>
</tr>
</tbody>
</table>

Examples of plasma density and potential profiles obtained in ALINE for different angles between the cathode and the magnetic field

Conclusions & Perspectives

• Versatile and well-diagnosed experiment for the investigation of unipolar arcs
• Various ways to trigger arcs on different surfaces: excitation by plasma pulse, laser pulse, biasing
• Experiments have just started: statistical investigation to come
• Modelling: 2D PIC code under development (see PB027, this conference)
• Participation to WEST C4 campaign for investigations in more fusion-relevant conditions
• Application to various PFC’s, including mirror cleaning applications with Univ. Basel.

References


Experimental set-up

-2 inches target samples mounted on rotatable manipulator
• Several kinds of target material (W, Mo, Ti, Al/Fe...)

Preparation of samples:

• Manual deposition of W micron-sized dust samples
• Microtexturation (FeAl40 and soft metals) by surface nitriding
• W, Mo... deposits in HiPIMS (possibility to trap various gases: Ar, He, D2)
• W fuzz, Ti nanoparticles (provided by Univ. Basel)

Post-mortem analysis:

• Unipolar arcs threshold
• Lifetime and dynamics
• Impurity and droplets rates
• Droplet velocities
• Input parameters for simulations [J. Moritz, PB027]

Experimental Results

• Only preliminary results, low statistics: 107 arcs
• Wide distribution of arc lifetime (best time resolution so far: 3.8 µs, 250 ns in close future)
• Influence of plasma & surface properties going to start after improvements in the set-up
• Preliminary observations suggest that dust rates are correlated with arc lifetime

References


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