Mechanisms and dynamics of unipolar arcs in magnetized plasmas
Chabha Djerroud, F. Brochard, Jérôme Moritz, Jordan Ledig, Eric Faudot, Grégory Marcos, Martin Julien, Ludovic de Poucques

To cite this version:

HAL Id: hal-02372071
https://hal.univ-lorraine.fr/hal-02372071
Submitted on 20 Nov 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Mechanisms and dynamic of unipolar arcs

Institut Jean Lamour, 2 allée André Guinier, BP50840 F-54011 Nancy Cedex France
Chabha.djerroud@univ-lorraine.fr

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 biasable manipulators by Cryoscan ®
- Possibility of heat pulses (45W IR Laser)

Experimental conditions

- Gas: Ar, He, D)
- Working pressure: 10^-7 - 10^-1 mbar
- Plasma densities: 10^11 - 10^17 m^-3
- Magnetic field: up to 0.1 T
- λp (mm): 0.03 - 0.3
- i (mm): 0.03
- t (µm): 1 - 3
- λ(TV)/&: 0.02

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

Typical plasma parameters in ALINE

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.

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, D)
- W fuzz, Ti nanoparticles (provided by Univ. Basel)

Post-mortem analysis:

- sample Degradation/Erosion (SEM, profilometry, FIB)

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

Steroscopic imaging of a unipolar arc on a W sample with pre-deposited W dust

References


Video

Post-mortem analysis of AUG PFCs, showing unipolar arc traces and droplets [3]