Ernst-Moritz-Arndt University of
Greifswald

Master Thesis

Kinetic effects in RF discharges

Author:
Philipp Hacker

Supervisor:
Prof. Dr. Ralf Schneider

*A thesis submitted in fulfillment of the requirements
for the degree of Master of Science - Physics*

in the research group of

Computational Sciences,
Institute of Physics

July 13, 2017

Declaration of Authorship

I hereby certify that this thesis has been composed by me and is based on my own work, unless stated otherwise. No other person's work has been used without due acknowledgement in this thesis. All references and verbatim extracts have been quoted, and iall sources of information, including graphs and data sets, have been specifically acknowledged.

.....
Signature of author
Greifswald; July 13, 2017

Contents

1 Physical properties of low temperature RF plasma **1**
1.1 Basics . . . 1
1.2 Capacitively coupled radio frequency plasma . . . 1
1.2.1 Sheath physics and wall interaction . . . 1
1.2.2 Self bias voltage . . . 1
1.2.3 Dielectric displacement current . . . 1
1.3 Negative ion physics . . . 1
1.3.1 Anion creation and distribution . . . 1
1.3.2 Dynamics and collisions . . . 1
1.4 Particle-In-Cell simulations with Monte Carlo-Colissions . . . 1
1.4.1 Principles . . . 1
1.4.2 2d3v PIC . . . 1
1.4.3 Monte Carlo-Collisions . . . 1

2 Simulation of capacitively coupled discharges **3**
2.1 Experimental setup . . . 3
2.2 Secondary ion emission . . . 3

3 Anion energy distributions in ccrf oxygen discharges **5**

4 Local electrostratic field solver **7**
4.1 Diagnostics of current and charge . . . 7
4.2 Field calculation . . . 7
4.3 Comparison with Poisson-based solvers . . . 7

5 Conclusion **9**

Physical properties of low temperature RF plasma

1.1 Basics

1.2 Capacitively coupled radio frequency plasma

1.2.1 Sheath physics and wall interaction

1.2.2 Self bias voltage

1.2.3 Dielectric displacement current

1.3 Negative ion physics

1.3.1 Anion creation and distribution

1.3.2 Dynamics and collisions

1.4 Particle-In-Cell simulations with Monte Carlo-Colissions

1.4.1 Principles

1.4.2 2d3v PIC

1.4.3 Monte Carlo-Collisions

Simulation of capacitively coupled discharges

2.1 Experimental setup

2.2 Secondary ion emission

Anion energy distributions in ccrf oxygen discharges

Local electrostratic field solver

4.1 Diagnostics of current and charge

4.2 Field calculation

4.3 Comparison with Poisson-based solvers

Conclusion

"Without encroaching upon grounds appertaining to the theologian and the philosopher, the domain of natural sciences is surely broad enough to satisfy the wildest ambition of its devotees. [...] The work may be hard, and the discipline severe; but the interest never fails, and great is the privilege of achievement. "

John William Strutt, 3rd Baron Rayleigh, 1884
Address to the British Association in Montreal