CSC-RUB PhD Project Proposal

Title: Large area thrusters from magnetized high performance plasmas

Sector of research: Dr. rer. nat.

Degree awarded: Physics

Keywords: Thrusters, Stochastic heating, Magnetic field topology, Modelling, Spectroscopy

Supervisors of PhD project:

Prof. Dr. Achim von Keudell, Chair for Experimental Physics II ''Reactive Plasmas'',
Faculty for Physics and Astronomy

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Prof. Dr. Rainer Grauer, Theoretical Physics I, RUB

Research focus of supervisor:

Research area of Prof. von Keudell are non equilibrium reactive plasmas at low, atmospheric and high pressures. Emphasis is on real time diagnostics using laser spectroscopy, emission spectroscopy, probe methods and mass spectrometry to unravel elementary processes in the plasma and at the plasma surface boundary. This is complemented by fluid and kinetic modeling in cooperation with partners. Current topics are plasma supported electrolysis to design targeted species conversion based on renewable energies, the understanding of high power pulsed magnetized discharges to manufacture excellent ceramic metastable materials and fundamental surface processes during plasma catalysis as the interaction of vibrationally excited species with complex catalysts.

Publications: 163 publications, H index 47.

Nanosecond pulsed discharges in distilled water-Part II: line emission and plasma propagation
von Keudell, A; Grosse, K; Schulz-von der Gathen, V
PLASMA SOURCES SCIENCE & TECHNOLOGY 29, 85021 (2020)

Nanosecond plasmas in water: ignition, cavitation and plasma parameters
Grosse, K; Held, J; Kai, M; von Keudell, A
PLASMA SOURCES SCIENCE & TECHNOLOGY 28, 85003 (2019)

Electron density, temperature and the potential structure of spokes in HiPIMS
Held, J; Maass, PA; Schulz-von Der Gathen, V; von Keudell, A
PLASMA SOURCES SCIENCE & TECHNOLOGY 29, 25006 (2020)

Non-equilibrium excitation of CO2 in an atmospheric pressure helium plasma jet
Urbanietz, T; Boke, M; Schulz-von der Gathen, V; von Keudell, A
JOURNAL OF PHYSICS D-APPLIED PHYSICS 51, 345202 (2018)

Pattern Formation in High Power Impulse Magnetron Sputtering (HiPIMS) Plasmas
Held, J; von Keudell, A
PLASMA CHEMISTRY AND PLASMA PROCESSING 40, 643 (2020)

Summary of research plan

Background: Plasma based thrusters are a common application for plasmas being used as electric propulsion device on satellites for station keeping or satellite orientation. Especially for deep space mission, the excellent mass to thrust ratio makes electric propulsion a unique technology. Plasmas for propulsion operate at very low pressure being compatible with space. Current concepts are based on gridded plasma thrusters or on Hall thrusters. The long term operation, however, is limited by the load onto the internal surfaces of these thrusters either at the grid or in the annular space inside a Hall thruster. Both aspects are related to the high energy density of theses plasmas. The research on magnetized plasmas at higher pressures as being used for coating applications reveal very interesting concepts for novel magnetic confinements that could be transferred to the lower pressure propulsion counterpart with a lower load on the plasma exposed surfaces.

Study objective: The goal of the project is to develop an alternative large area plasma thruster based on a magnetically confined plasma using an extended magnetron with a complex magnetic field topology (Example TriPak). By proper excitation of the electrons in these plasmas, a stochastic heating mode is explored to allow for efficient ionization. Biasing electrodes will be employed to steer the thrust of the escaping ions. This analysis will be compared with kinetic modelling of the discharge in cooperation with partners.

Expected Results: The heating mode of these complex plasmas will be explored and identified. A proof-of-principle thruster will be manufactured and its performance being evaluated. The experimental results will be benchmarked with modelling. The results will be published.

Methods: Emission spectroscopy, fast camera measurements, probe measurements, kinetic modeling. Alle infrastructure is available.

Candidate Requirements: MSc degree in physics mandatory. Methodological expertise in experimental physics preferred. Good English language skills.

Motivation for CSC application (max 250 words): The project is an explorative project to extend the research expertise from the Coordinated research centre TR 87 (www.sfbtr87. de), where high power impulse magnetron plasmas were studied for 12 years (project A5). The Phd is integrated in a large chair of experimental physics with typically 12 PhD students working together on various plasma projects. The PhD student has also access to an integrated training programme of the CRC1316.