Indian Institute of Technology Delhi

School of Interdisciplinary Research (SIRe)

SIRe Project Number

2024-02-36

Project Proposal for Ph.D.

Project Details	
Project Title	Development of hydrogen beam plasma extraction system for large area plasma processing and ion beam applications
Project Summary (Minimum 500 and maximum 2000 characters)	Hydrogen negative ion (H^-) is one of the many active species (ions, atoms, radicals) found in hydrogen plasma which has a lot of potential applications in the field of plasma-based material processing and production of ion beams. One of the major implementations of H^- ion beams is found in neutral beam heating of fusion plasmas and diagnostic neutral beams. Hydrogen plasma production for fusion plasmas needs to meet certain attributes like high plasma number density (n ~10^{16} – 10^{18} m^{-3}), good plasma uniformity (Δn / n ~ 1-5 %), high system efficiencies and in some cases moderately large volume (~ 100 – 1000 m^3) plasmas which are very challenging. International Thermonuclear Experimental Reactor (ITER), which is being built in Cadarache, France under an international collaboration in which India is also an equity partner to realize self-sustained controlled thermonuclear fusion, is planned to have two auxiliary heating neutral beam injectors (HNBI) with specifications of 17 MW power per beam line and pulse length of 3600 sec based on H^- ion currents of ~ 45 A accelerated up to 1 MeV energy which requires one to extract H^- current densities ~ 30-35 mA/cm^2 across a large area (~ 2.0 m × 0.6 m). Current RF-based inductively coupled plasmas technologies utilize power input ~ 800 kW whereas electron cyclotron resonance (ECR), known to be a more efficient source, remains relatively unexplored with reference to production of large area H^- ion beams. Plasma Lab, IIT Delhi has been associated in developing such a prototype ECR-based large area negative ion beam source (mini-ELNIBS) and its characterization for the past few years. The lab has recently obtained a relatively large area uniform (40-60 cm diameter), high density (n ~10^{17} m^{-3}) hydrogen plasma in mini-ELNIBS and currently being optimized for H- production. This proposal expects the student to utilize this source and develop a large area ion beam source for potential large-area, plasma-based ion beam applications.

Ph.D. Supervisors

Role	Name of Faculty	Academic Unit in IITD/Institute/University	Email ID (Official)
Supervisor 1	Ramesh Narayanan	Department of Energy Science and Engineering, Indian Institute of Technology Delhi	rams@dese.iitd.ac.in
Supervisor 2	Mainak Bandyopadhyay	Professor in Homi Bhabha National Institute [HBNI], DAE	

Project requirements (Student qualifications, experience required, etc)
***The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)**

- M. Tech. in Electrical Engineering or M. Tech. Electronics and Instrumentation Engineering or B. Tech. in Electrical Engineering. M. Sc. (Physics) students may also be considered, if found suitable.
- An exposure to high power supplies and / or vacuum systems may be preferable.
- Some knowledge of design and fabrication of electrical and electronic circuits is preferable.

Source of fellowship/funding
(CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)

Candidate with his/her own fellowship/ Institute Fellowship

Role of Faculty Members involved:	
Supervisor-1	Prof. Ramesh Narayanan will be responsible for mentoring the student for planning the beam plasma experiments and their characterization for optimal H- extraction in the experimental system already available at IIT Delhi.
Supervisor-2	Prof. Mainak Bandyopadhyay has experience in working on the beam extraction grid in Institute for Plasma Research (IPR), Gandinagar. The development of this grid will be the most crucial part of this research proposal. Hence, Prof. Bandopadhyay will mentor the student for the same. Visit of student to IPR, Gandhinagar to obtain exposure and training may also or visit of Prof. Bandopadhyay may be needed from time-to-time.