DoD's Multi-Institution Collaborations for Discovery Science

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PPPL PRINCETON PLASMA PHYSICS LABORATORY

Motivation

Fusion Research requires Multidisciplinary Research Program:

Contains plasma science, surface science, atomic physics, accelerators, materials, chemistry, radiation.

Need to educate scientists and engineers in the interdisciplinary areas important to advancing fusion and plasma science => organically connect University and National Laboratory Research.

Current research is split between Universities and National Labs with little connections. Few Plasma Centers are building bridges between Universities and National Labs but much more can be done for integration.

DOD's program for Multidisciplinary Research Program of the University Research Initiative (MURI) is an example for future DOE OFES possible approach to research in the science and engineering areas intersecting more than one traditional discipline.

Multidisciplinary Research Program of the University Research Initiative (MURI)

MURI supports basic research in the science and engineering areas intersecting more than one traditional discipline. The program is focused on multidisciplinary team efforts to address issues of critical concern to the DoD. The goal of this program is to advance defense research, accelerate technology transition, and educate scientists and engineers in the interdisciplinary areas important to national defense.

MURI is a DoD-wide program, which complements other DoD programs that support university research through the single-investigator awards. The awards are typically for a period of three years with two additional years as options. New awards can be funded up to $1.5M per year, with the actual amount contingent upon the availability of funds, the specific topic and the scope of the proposed work. All the award selections result from a merit based competition of the proposals. Proposal submission is a two-stage process including white papers and full proposals.

http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=9327

Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE)

NSF has long recognized the value of interdisciplinary research in pushing fields forward and accelerating scientific discovery. Important research ideas often transcend the scope of a single discipline or program. NSF also understands that the integration of research and education through interdisciplinary training prepares a workforce that undertakes scientific challenges in innovative ways. Thus, NSF gives high priority to promoting interdisciplinary research and supports it through a number of specific solicitations. NSF also encourages researchers to submit unsolicited interdisciplinary proposals for ideas that are in novel or emerging areas extending beyond any particular current NSF program.

PIs must make a formal inquiry by submitting a FastLane Letter of Intent (LOI), and must obtain a full-proposal invitation authorized by the INSPIRE Management Team on the basis of evaluation of the LOI by NSF staff. All invitations will reflect interest in considering a full proposal by at least two NSF program directors (PDs) from intellectually distinct NSF divisions or programs.

http://www.nsf.gov/od/iia/additional_resources/interdisciplinary_research/.

Integrated Projects are well funded in Europe.

"Jahresbericht 2012 - Programme und Projekte"
FOR 1123 **Physics of Microplasmas** (0.62 Mio EUR)

TRR 24 **Fundamentals of Complex Plasmas** (1.5 Mio EUR, since 2008, max 12 years)
TRR87 **Pulsed High Power Plasmas for the Synthesis of Nanostructural Functional Layers** (2.8 Mio EUR, since 2012, max 12 years)

DIFFER
Dutch Institute for
Fundamental Energy Research

DIFFER in Nederland

The 'nanolayer Surface and Interface Physics' department, addresses topics in surface science, and in thin film and multilayer physics, including their boundary areas. Research involves physical and chemical phenomena at surfaces and in the layered solid state, as well as XUV optical and plasma physics aspects.

Samsung Centers

Examples of PPPL projects:

Dr. Mike Berman AFOSR/RTE, Directorate of Chemistry and Life Sciences
Fundamental studies of reactive processes at plasma-surface interfaces
Bruce E. Koel, Principal Investigator, Princeton University

Goal is to provide experimental data and computational simulations needed to develop models of dynamical processes at surfaces in complex reactive plasma environments to advance our understanding of reactions and surface modification associated with nonequilibrium plasmas, thus enabling the design of new applications for chemical processing and providing opportunities to increase the lifetime of such plasma devices.

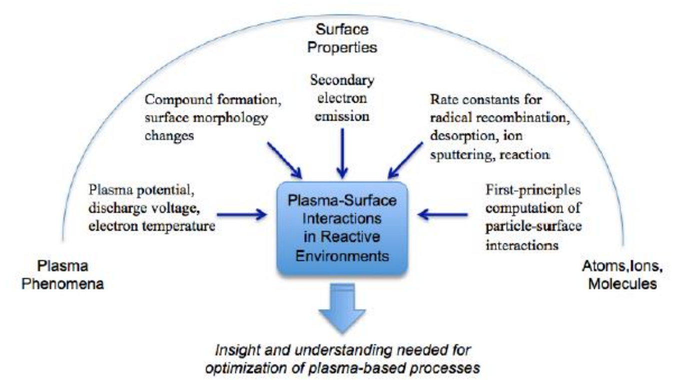


Fig. 1. Integrated research effort for investigating plasma-materials interactions, including studies from the atomic to the macroscopic scale of how the plasma affects the surface and the surface affects the plasma.

Examples of PPPL projects:

2013 AFOSR Aerospace Materials for Extreme Environment, **Ali Sayir, Aerospace Materials for Extreme Environments, Directorate of Aerospace, Chemistry and Materials Science, Air Force Office of Scientific Research**

FA9550-11-1-0282 MICRO-ENGINEERED MATERIAL SURFACES FOR ELECTRIC PROPULSION AND PULSED POWER

Effects of Electron-Induced Secondary Electron Emission (SEE) on Plasma-Wall Interactions

Yevgeny Raitses and Igor Kaganovich

Status quo: Plasma with a strong SEE is relevant to plasma thrusters, high power MW devices, etc. Strong SEE can significantly alter plasma-wall interaction affecting device performance and lifetime. The observed SEE effects in space-relevant plasma applications requires fully kinetic modeling.

New insight: Engineered materials with surface architecture can be used to control and suppress SEE.

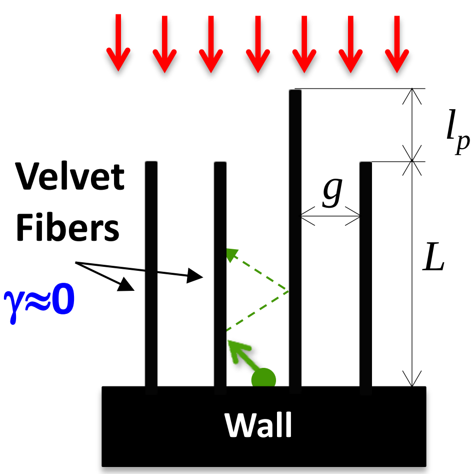
Project goal: Characterize effects of surface architecture on plasma-wall interaction with focus on SEE and application for Hall thrusters

Main accomplishments

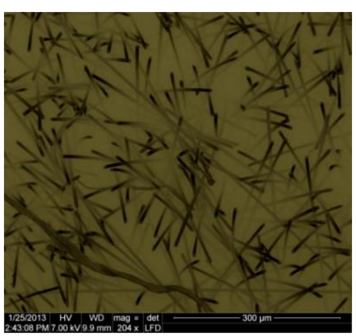
-Micro-architectured materials facing the plasma may suppress SEE, but induce field emission

How it works:

Plasma flow

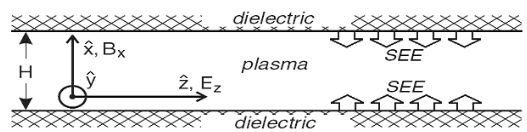


SEE image of velvet using SEM demonstrates strongly reduced SEE

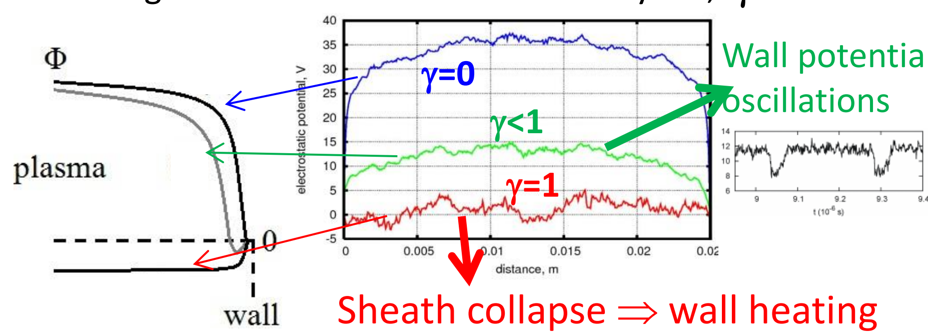


To avoid field emission $g, l_p < \lambda_D$, Debye length

Kinetic modeling predicts: strong SEE can cause unstable sheath, sheath collapse, inverse sheath



Three regimes for different effective SEE yield, γ



Key publications in 2012

Phys. Rev. Lett. **108**, 255001; Phys. Rev. Lett. **108**, 235001
Phys. Plasmas **19**, 123513; Rev. Sci. Instr. **83**, 103502;
Phys. Plasmas **19**, 093511

Examples: NSF ISPIRE

Concept Development for Active Magnetospheric, Radiation Belt, and Ionospheric Experiments using In-situ Relativistic Electron Beam Injection

Managing NSF Program Director **Robinson, Robert, Atmospheric and Geospace Sciences Division, Program Director for Geospace Facilities and Gitomer, Steven, Physics Division, Program Director for Plasma**

Energetic particles are fundamental to the geospace environment. These particles, and their interactions that produce gamma rays, x-rays, and radio emissions, shed light on the fundamental physics of the space environment. In geospace, particles are accelerated by various mechanisms in the magnetosphere, with energies upwards of 10 MeV. Targeted space-based particle injection experiments have enabled scientific investigations of space plasmas since at least the 1950s. Controlled experiments with MeV class electron beams will open up the transformative capability of a laboratory in-space, enabling plasma physics experiments in an entirely new energy regime.

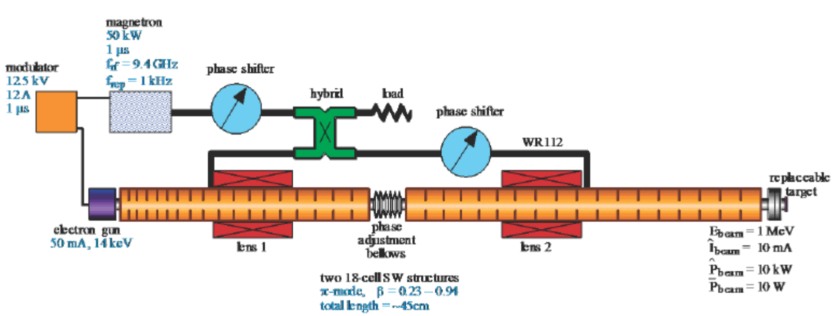


Figure 7. X-band compact LINAC and components developed at SLAC as a compact x-ray source. See text for details.

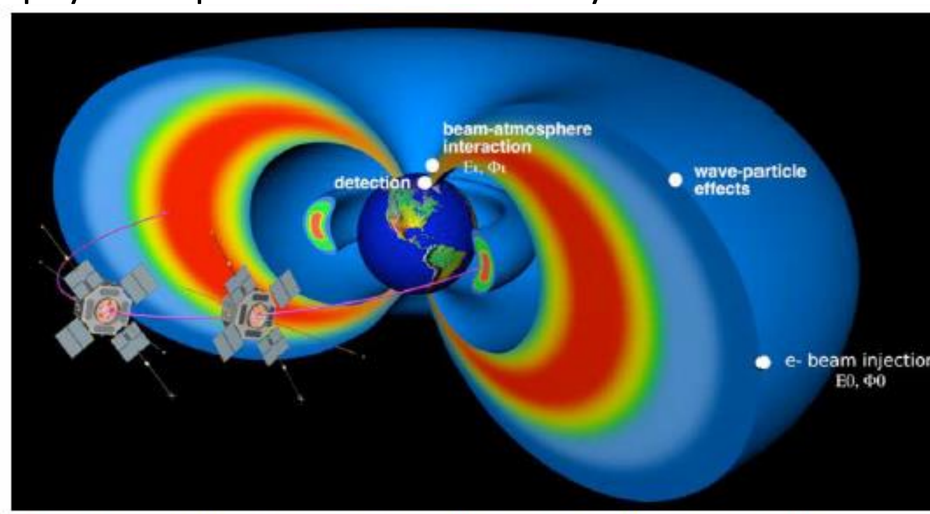


Figure 1. Scientific regions and topics of relevance to the proposed investigation.

Ed Barnat: Small-scale collaborative efforts achieved by OFES funding through Plasma Science Center

- During the 5 year FES-PSC program, SNL hosted and participated collaborative interactions
  - Consisting of hosting visitors as well as participating in multi-organization research efforts.
  - High rate of return: ~ 70k$ per publication.
- Interactions are beneficial to both parties that usually have different "end goals"
  - National labs: Identify bright talent, stay current on recent developments, incorporate new capabilities
  - Universities: Potential careers for students, access to professionals, access to advanced capabilities (labs and code)
- Collaborative efforts achieve goals that serve the interest of the nation
  - To solve tough problems, important problems, a strong team with diverse background is needed.

Modest levels of funding on both sides of the collaboration enabled these interactions

Concluding Remarks

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