Overview of University of Wisconsin IEC Research Program-2011


December 7-8, 2011
13th U.S.-Japan IEC Workshop
Overview

• Progress since the 12th Meeting in Osaka, 2010.

• Specific Highlights on Selected Projects.

• Conclusions & Future Work
The Wisconsin IEC Team
Other UW-IEC Papers at the 2011 U. S./Japan Workshop

(Presenting Author/Title/Time)

- Matt Michalak, “Six Ion Gun Fusion Experiment Findings and Future Work” Wed. 2:00 PM.
- Gabriel Becerra, “Enhancement of an Inertial Electrostatic Confinement Device with a Helicon Ion Source for Helium-3 Fusion”, Wed. 2:30 PM.
- Rich Bonomo, “UW IEC Group 2011: Continuing Preparations for 300 kV Operation – Device Switching”, Wed. 3:00 PM.
- Gil Emmert, “Update on the VICTER Code for Modeling Gridded, Spherically Symmetric IEC Devices”, Thurs. 9:00 AM.
- Eric Alderson, “Negative Ion Studies in an IEC Fusion Device”, Thurs 9:30 AM.
- John Santarius, “Theoretical Exploration of UW IEC Device Operation at Moderate Pressure”, Thurs. 10:00 AM.
Current IEC Research Projects at the University of Wisconsin

- Advanced Fusion Fuels
- Experimental Plasma Physics
- Detection of Clandestine Materials
- Testing of Materials
- Production of Radioisotopes
- IEC Theory
- IEC's as a Power Source
There are Currently Four Different “IEC” Chambers in Operation and One Under Construction at the University of Wisconsin.
Progress at UW IEC Facilities Since the Last Meeting in Osaka

2010

12th @ Osaka

2011

PING Facility (ARGOS Chamber)

VICTER Code Includes Negative Ions

Adjustable TOF Diagnostic

2012

Discovery of W “grass”

Negative Ions in Jets

300 kV Switch Developed

13th @ Sydney
Development of Improved Pulsed Neutron Sources is Progressing

• **Storoid Facility:**
  – patent application
  – results next Workshop

• **PING Facility**
  – Concept developed-2010
  – ARGOS chamber constructed-2011
  – Tests in 2012
The ARGOS Chamber
The MITE-E’s Ion Gun Module

- **Ion Source**: 0 V
- **Focusing Lenses**: -0 to -15 kV
- **Ion Aperture**: Ion Beam
- **Cathode Assembly**: ≤150 kV
- **Sample Holder**: 8 cm
- **Pyrometer**: IR Signal
- **Plasma/ion beam**: Laser light
- **Fiber laser/alignment Mount**: 8 cm
In the MITE-E, Surface Morphology Changes for W are Highly Dependent on Crystal Orientation

Southern, et al.

\[ \phi L \approx 1.5 \times 10^{19} \]

\[ T \approx 700^\circ C \]
“Grass” Morphology Dependent on the Orientation of the Grains

$\varphi_L = 1.3 \times 10^{18} \text{ He}^+ / \text{cm}^2, T = 900^\circ \text{ C}$
Fusion Ion Doppler (FIDO) Diagnostic Was Developed by Boris to Reduce Background Noise During D-D Proton Collection

- Detector face moved out of line of sight of chamber
- Magnetic Deflection
  - Fusion products (MeV)
  - Secondary electrons (Hundreds of keV)

- Pb shielding around collimator channel and detector mount
Bending Arm Allows Both Protons and Tritons to be Detected Along with Doppler Shifts

Current X-ray Noise with Bending Arm and without Pb shield

Previous scale of X-ray noise without Bending Arm and with Pb shield

Doppler Shifted D-D triton peak

Doppler Shifted D-D proton peak
Spatial Profile of Fusion Reactions per Unit Volume Along Radial Line Through IEC (Donovan)

TOF Spatial Profile Along Radial Chord - Shown from (-R) to (+R)
60kV, 30mA, 2mTorr, 20cm Diameter Cathode, 50cm Diameter Anode

- Plot extends from chamber wall (-R) to chamber wall (+R)
TOF Radial Profile Shows a Rise in Fusion Event Concentration in the Source Region (Donovan)

TOF Radial Profile - 60kV - 30mA - 2mTorr Deuterium
20 cm Diameter Cathode - 50 cm Diameter Anode

Relative Concentration of D-D Fusion Reactions (Arbitrary Units)

Core Positive Ions and Neutrals

Inter-Grid Neutrals

Positive Ions Increasing Energy

Negative Ions and Neutrals

Source

Wall

Radial Location (cm) (0 to R)
An Adjustable Diagnostic Arm Has Been Successfully Constructed and Tested

- Capable of reaching at least 1 \( \mu \text{Torr} \)
- Able to study:
  - D-D Fusion (20°)
  - D-He\(^3\) Fusion (15°)
  - Negative Ions (-20°)
- Adjustable rectangular 316 SS bellows arm allows 66 times greater D-D proton capture ability at higher power due to noise reduction
  - X-ray trap and corrugated elbow offer factor of 5 increase in proton collection
  - Increasing angle from 20 to 30 degrees further increases proton capture by factor of 13
Conclusions

• Considerable progress has been made in experimental facilities
  – Adjustable Arm for FIDO and TOF measurements
  – Argos chamber for pulsed neutron generation
  – 300 kV switch for rapid changeover of 4 IEC devices
  – New design for 300 kV feed-through to avoid insulating stalk failures

• IEC Technology spinoff has been used for a materials irradiation facility
Conclusions (cont.)

• Negative ion azimuthal scans reveal structure in “jets”.
• Negative ions seem to be playing an unexpected role in promoting DD fusion in IEC devices.
• Helicon optimization studies improve performance.
• VICTER code now has the ability to include negative ions and their transport in IEC devices.
• Six gun ion experiments reveal more about plasma physics of Hirsch device.
Future Goals of UW IEC Program

- Understand the role of negative ions in the spatial distribution of DD fusion events.
- Apply the TOF adjustable arm diagnostic to D$_3^3$He fusion.
- Test plasma facing component materials at higher temperatures and a wider range of fluences.
- Investigate D$_3^3$He fusion in 6-Gun SIGFE device.
- Analyze test results from STOROID and PING pulsed neutron facilities.
• Compare VICTER theoretical predictions with experimental data from HOMER.

• Increase the He\(^+\) source strength of HELIOS.

• Test pulsing effects on SIGFE.
Questions?