Improvements to the Materials Irradiation Experiment and Investigation of Tungsten as a Plasma Facing Component for Fusion Reactors

IEC Laboratory

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1. Introduction

•Tungsten will be used as a divertor plate material in ITER and was selected for the first wall armor of the High Average Power Laser (HAPL) chamber.
•The University of Wisconsin Inertial Electrostatic Confinement Laboratory performs experiments on tungsten to better understand the changes that occur to the material under simulated fusion reactor conditions—temperatures >500°C and helium ion bombardment.

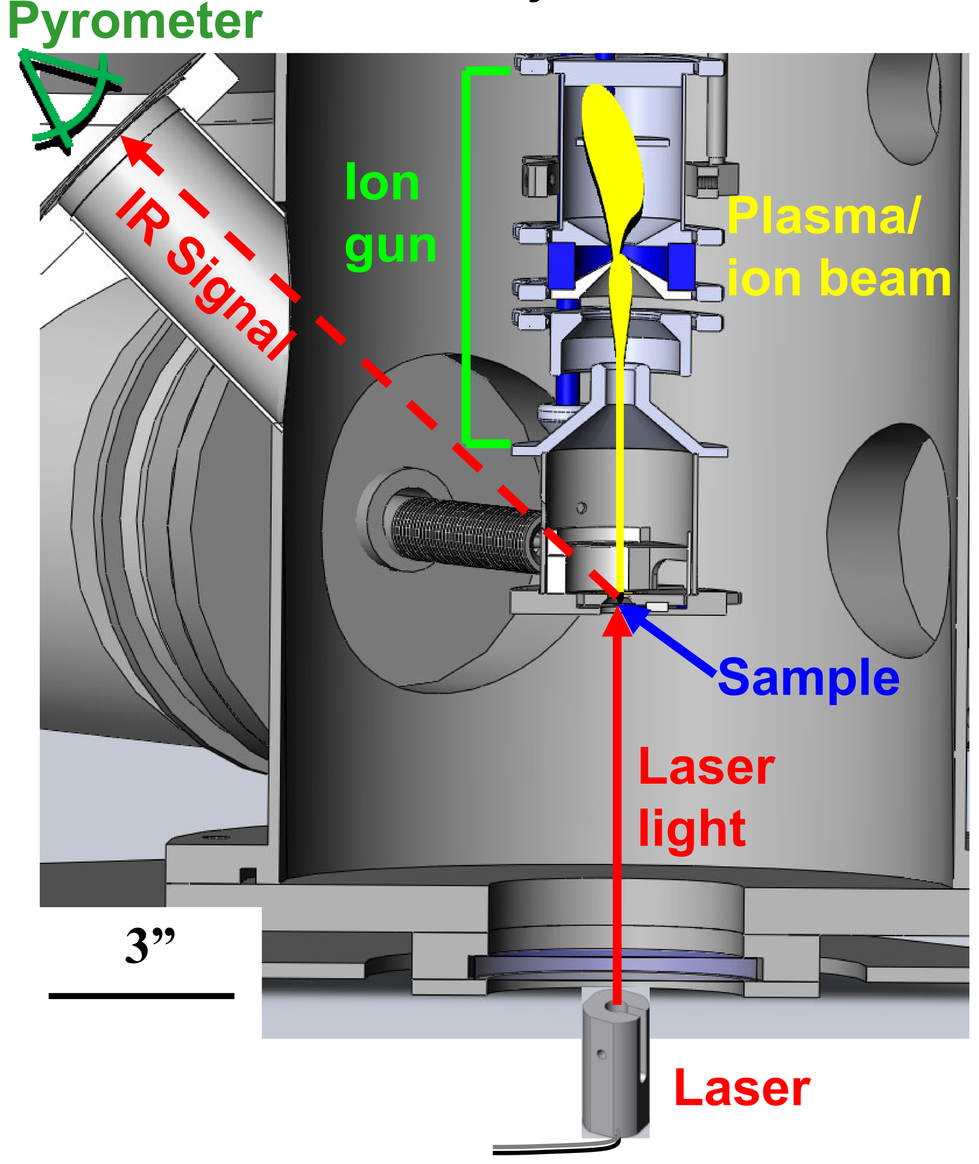
2. Research Objectives

•Simulate operation of the ion gun using the program SIMION® with the end goal of creating uniform irradiation of samples.
•Develop a model for the formation of the "grass" structure on tungsten.
•Install new Gamma RR15-5N/M1030 and Glassman P5/MK15N05.0 power supplies to remotely control the extraction and focus lenses.

3. Research Methods

The Materials Irradiation Experiment (MITE-E) Features
- •ion gun with two adjustable electrostatic lenses to make an ion beam of He^+
- •Nd-YAG variable power laser to maintain a constant temperature during irradiation
- •new advanced power supplies

The program SIMION® was used to calculate the potential in the ion gun and simulate ion trajectories.

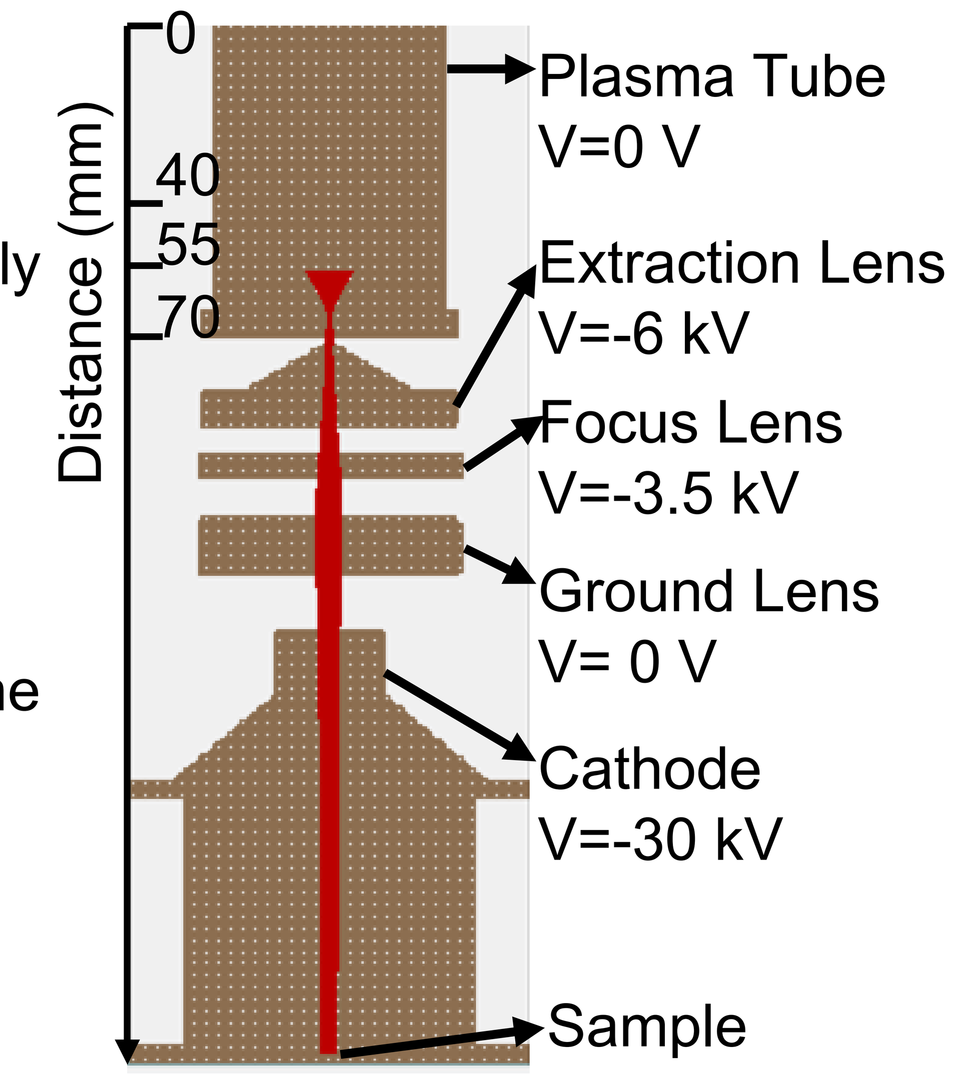


Solidworks™ model of the MITE-E

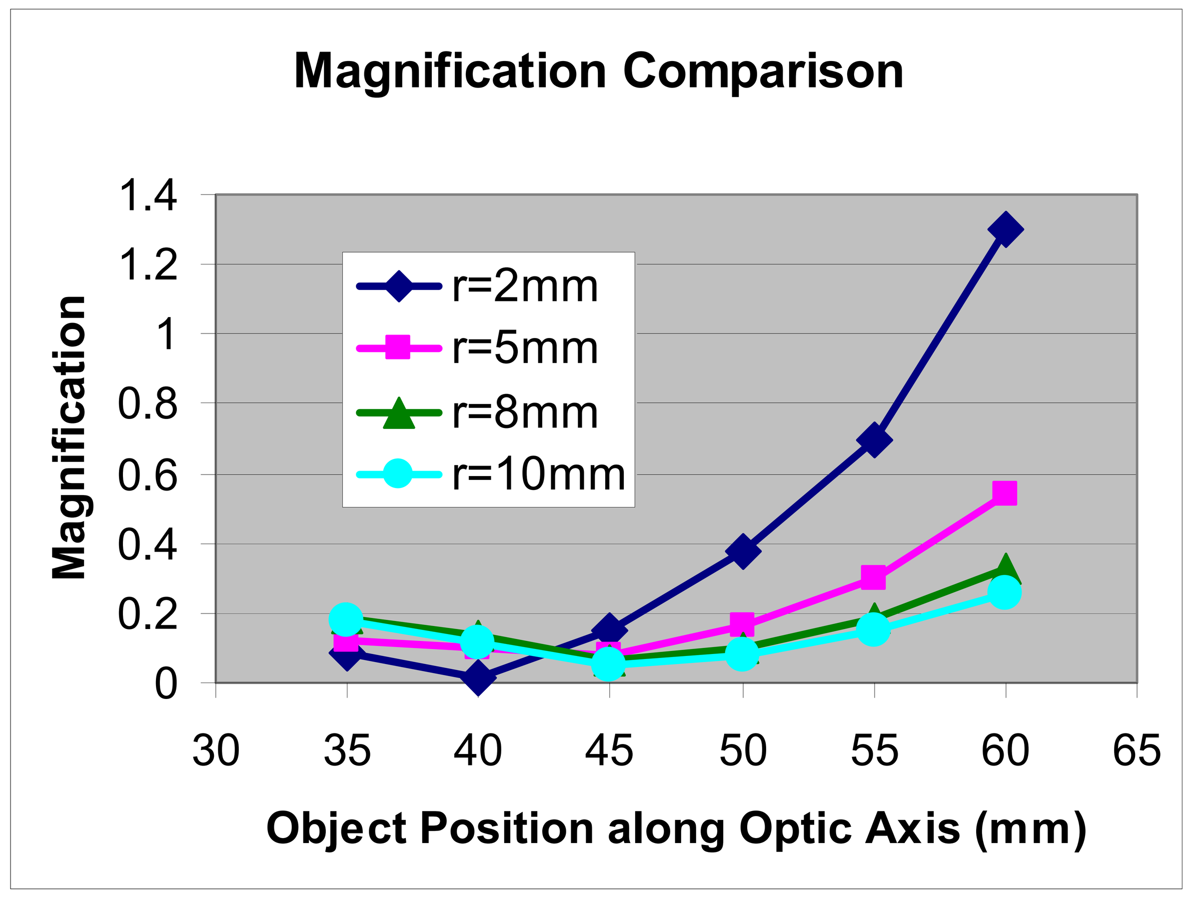
4. Results

4.1 Simulated Ion Optics

•Resulting ion impact distribution on the sample is highly dependent on the plasma source conditions.
•Magnification was less than one for all cases except the 2 mm radius disk started at 60 mm.
•Half angle for all cases was less than one degree.
•For all combinations of extraction and focus voltage simulated, the poissance was <<1 everywhere along the optic axis except in the plasma tube, meaning space charge effects can be neglected except in the source region.



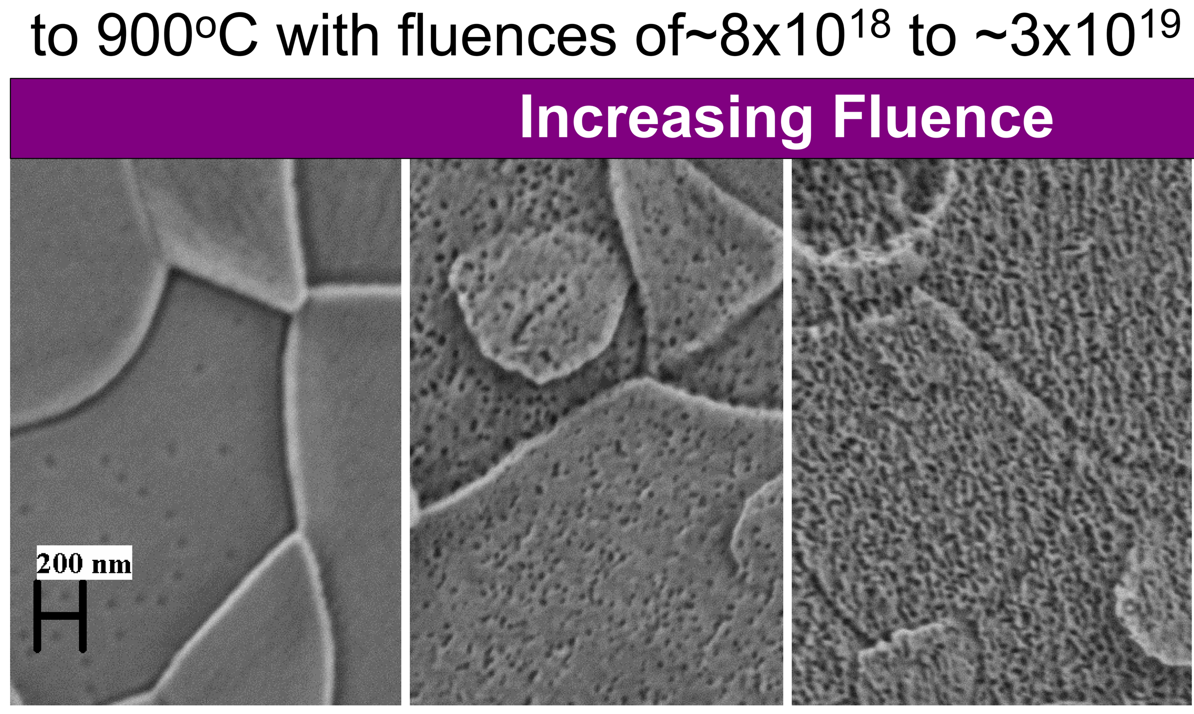
A SIMION® simulation, the ion trajectories are red



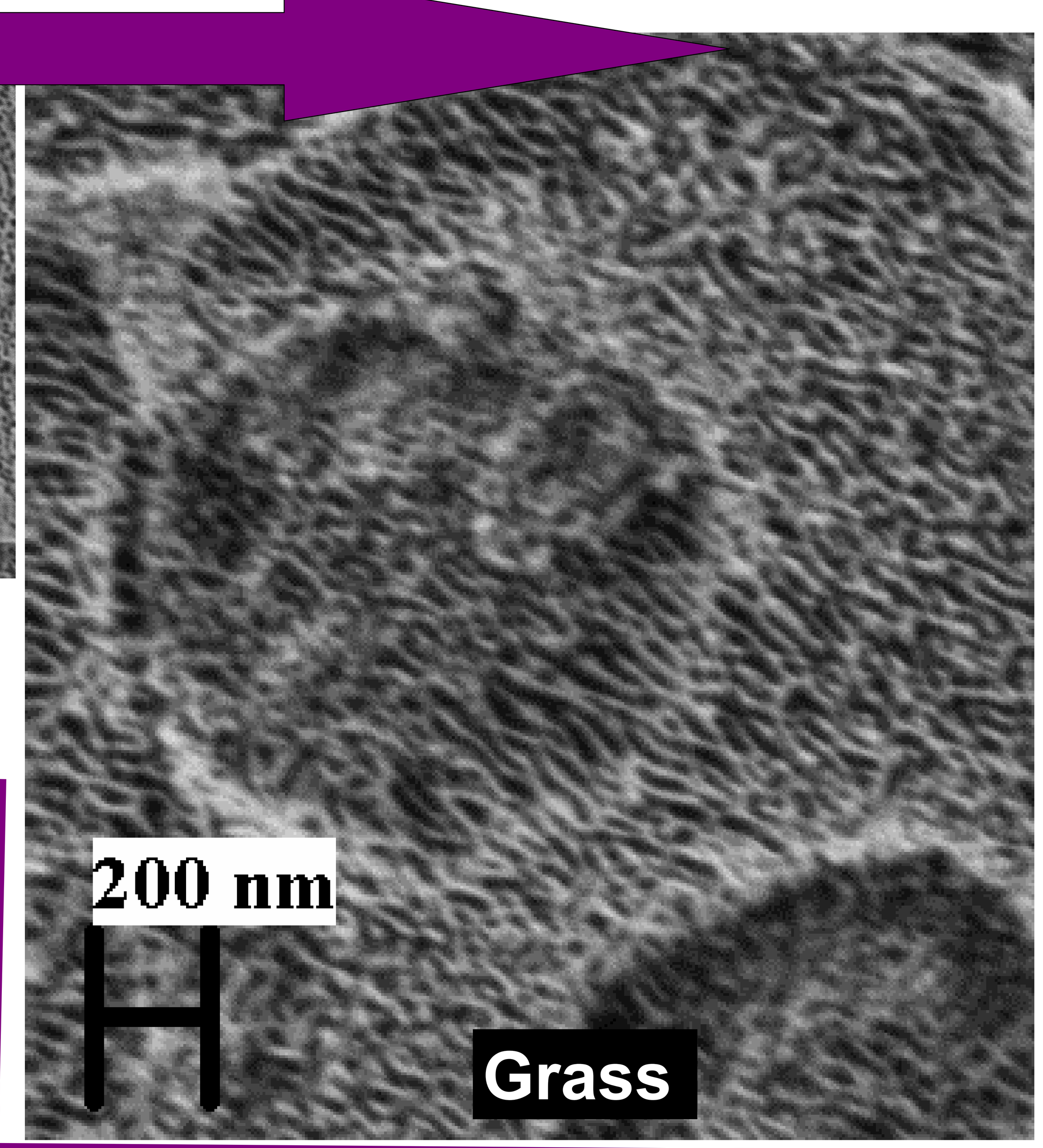
Magnification calculated for ion sources of different radii and initial position.

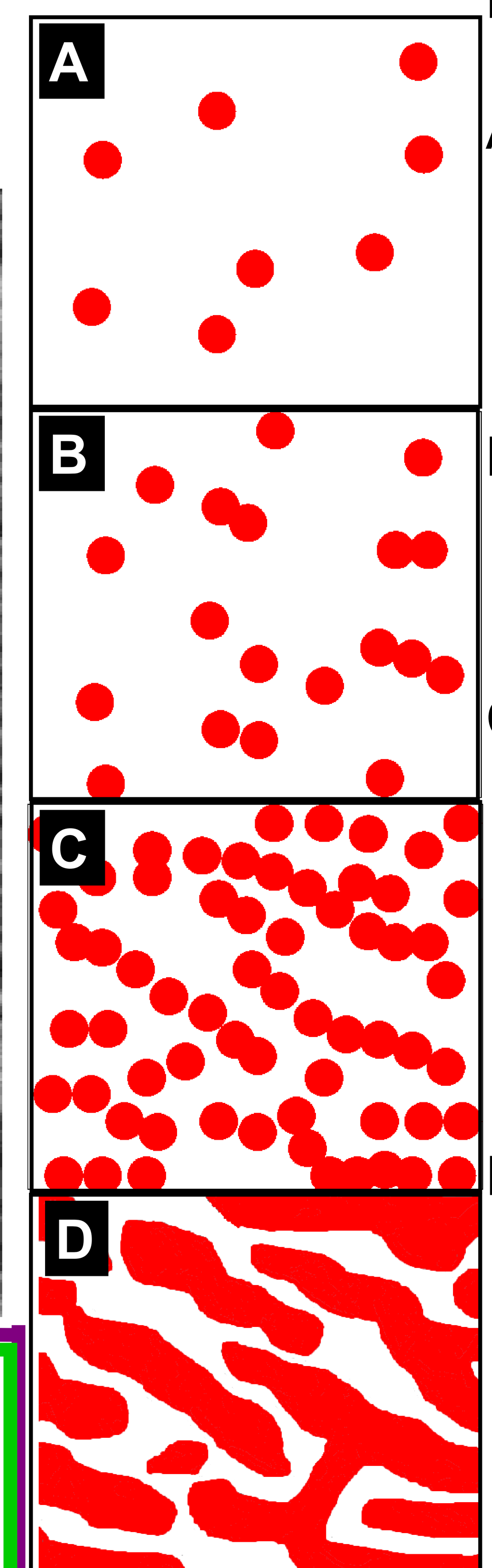
4.2 Grass Structure

•Grass Structure first seen by Zenobia (JONM) on polycrystalline tungsten (PCW) samples irradiated at 700 to 900°C with fluences of~$8x10^{18}$ to ~$3x10^{19}$ He^+/cm^2



PCW samples implanted with 30 keV He^+, T=900°C, fluence ~10^{16} to ~10^{18} He^+/cm^2





Model of Grass Structure Formation
A. Small He bubbles break the surface where they encounter the least resistance. Certain grains form pores before others.
B. More small pores form, often next to existing pores, creating many oblong features.
C. Bubbles continue to break the surface and connect with already present pores. Individual pores are still visible, but the structure has some overall directionality on each grain.
D. Pores join together until individual pores are no longer apparent. Thin strips of W are left with thin trenches between them—the grass structure.

5. Conclusions

•SIMION® simulations are helping to understand the operation of the ion gun, but more needs to be done before being able to create a uniform distribution of ions on the samples.
•The grass structure appears to be formed by small helium bubbles breaking the surface at locations favorable to the crystal structure. Then, with increased fluence the pores on the surface overlap each other to create the narrow trenches of the grass structure.

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