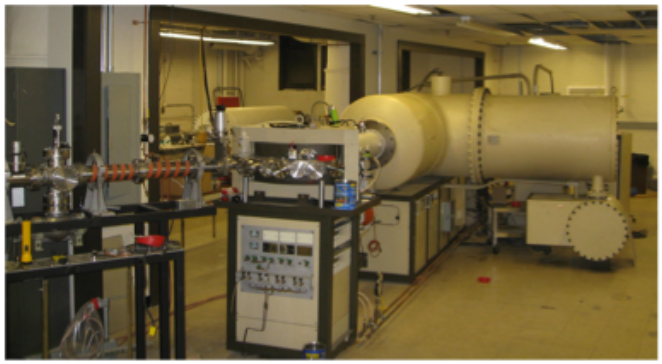
Session 12 Guidelines to chairs

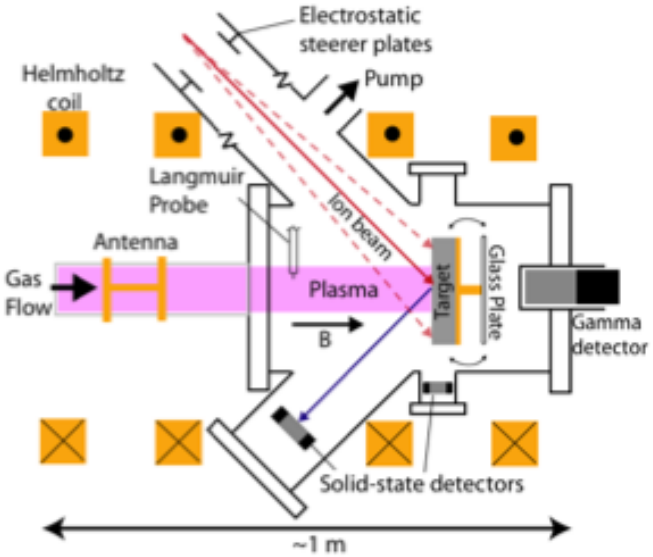
- Your thoughts/perspectives on key outstanding gaps/ studies/needs/issues that you can identify from the collection of talks in your session.
  - *For example, the issue of identifying a "temperature" limit for liquid Li as a PFS.*
- Include these thoughts at the end of your summary slides of your session
- These summaries will help:
  - Guide discussion during the closing of the meeting and hopefully will guide new experiments/studies to address those identified gaps.
  - During discussion we will have other's opinions of critical gaps further enriching discussion.

Wirth, Whyte et al. PSI Center



1.7 MV Cockcroft-Walton tandem accelerator

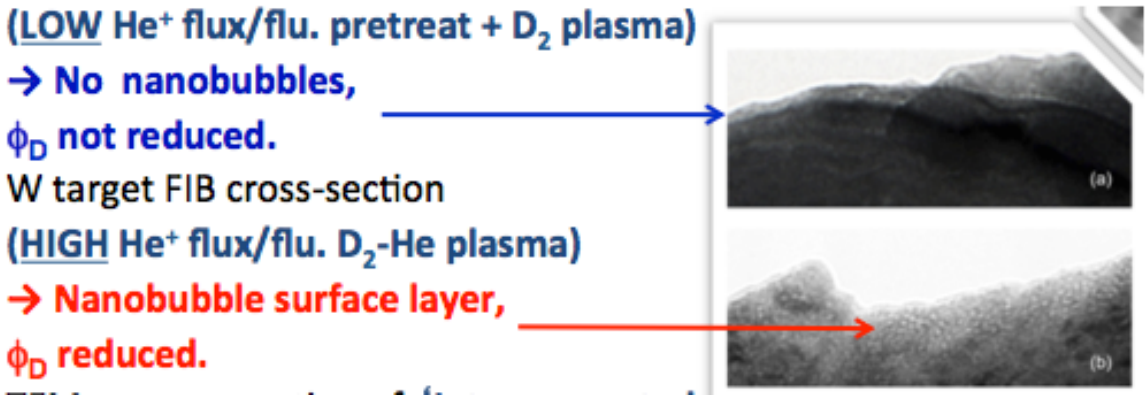
DIONISOS Experiment



- CLASS is part of the DOE-funded PSI Science Center for Excellence in collaboration with UCSD, U. Tennessee, SNL and INL
- Work partly focuses on: tungsten, diagnostic development, materials testing and analyses as well as multi-scale computational modeling
- Measurements on spatial variation of He in W
- Low energy He ions + 900-1400 K can induced fuzz growth in *both* linear plasma devices and tokamak environments (e.g. W in CMOD)
- Atomistic modeling elucidating on He bubble-induced effects on erosion, surface topology evolution
- Further work needed in near-surface He bubble effects on tungsten erosion

Doerner et al.

- TEM conducted in W surfaces (~ 50 nm layer) exposed to energetic He
- He nano-bubbles reduce deuterium inventory near surface for D irradiations with He seeding at high fluxes
- TDS shows reduced hydrogen inventory with He uptake
- No detectable D retention in W “fuzz” for various He irradiation treatment conditions
- Interconnected return pathways to PMI surface due to nanobubble growth suspected as the mechanism that interrupts D transport to bulk [1]



[1] W. Wampler and R.P. Doerner, 42 Nucl. Fusion (2009)

Kolasinski et al.

- Three projects presented by Rob:
  - Hydrogen precipitate model
  - Tritium plasma experiments (surface morphology, permeation)
  - Surface studies with the ARIES system at SNLL
  - Scope of studies ranging from fundamental to applied studies
- Modeling focused on understanding bubbles filling with H
  - At low room temp, bubbles grow at low H concen.
  - At high temps, need high H for bubbles to grow
- Development of plasma-driven permeation experiments
  - Temperature control of samples (with realistic features)
  - Additional uncertainties addressed
- Surface analysis in ARIES
  - Detailed study of H adsorption on surfaces that elucidates on mechanisms for: recycling, desorption, dissociation/recombination, model validation
  - Surface channeling strongly affected by H bonding location
  - New TOF capability in ARIES increases sensitivity by 10^4

Shimada et al. and El-Atwani et al

- **INL group:** studying deuterium depth profile from neutron-irradiated tungsten at various temperatures: 100, 200 and 500 C
- **INL group:** Comparison of ion-irradiated and neutron-irradiation damage in W, publication is upcoming
- **Allain group:** SPS tungsten studies show high strength materials with ion-induced morphology evolving at fluences between 10^{17}-10^{18} cm^{-2} and 200 eV

Kurtz and MASCO group

- Atomistic modeling of W underway to look at fundamental deformation mechanisms; building appropriate potentials of W-He and H; dislocation nucleation and mobility; near surface He effects, grain boundary chemistry and cohesion
- Test methods and characterization protocols: deformation and fracture, thermal creep
- Alloy development including: nanostructured alloys, composites and ductile phase toughening

Highlights of Joint PFC/MASCO session discussion

- Promoting plastic deformation
  - More ductile tungsten
    - Processing of tungsten and impact on micro to macroscopic mechanical properties
  - Odette pointed out ductility attribute of W depends on specific application and deformation conditions
- Development of alloy structural materials vs thin-layer of W
- MASCO folks also learning where W is envisioned in a tokamak device
- Goldston pointed out the temperature window for W and Li are not overlapping although ductility window may be possible at 400 C
  - However Zinkle pointed out that once irradiation-induced embrittlement takes over, limit shifts to 800 C
- Majeski pointed out studies needed for other Li substrate materials
- Ulrickson reminded folks of the practical engineering design approach that needs to account for thermal conductivity in any design using W
- Odette suggested exps that includes PMI coupled to heat exposure effects