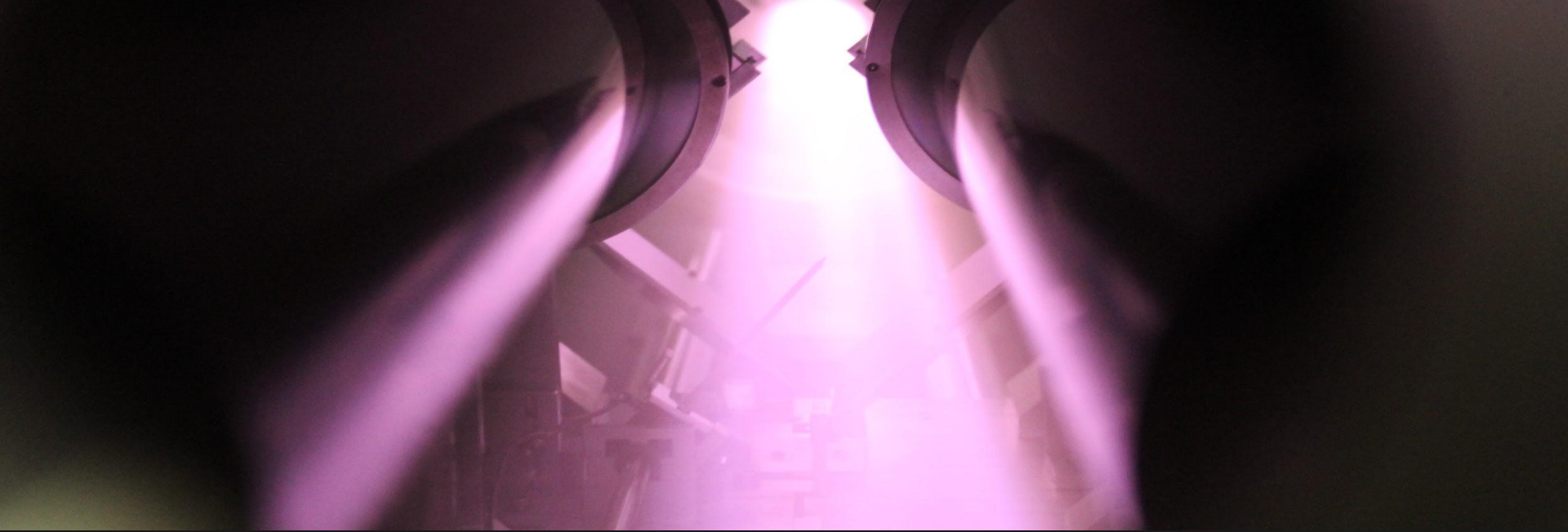


Ion Interactions with Fusion Relevant Materials

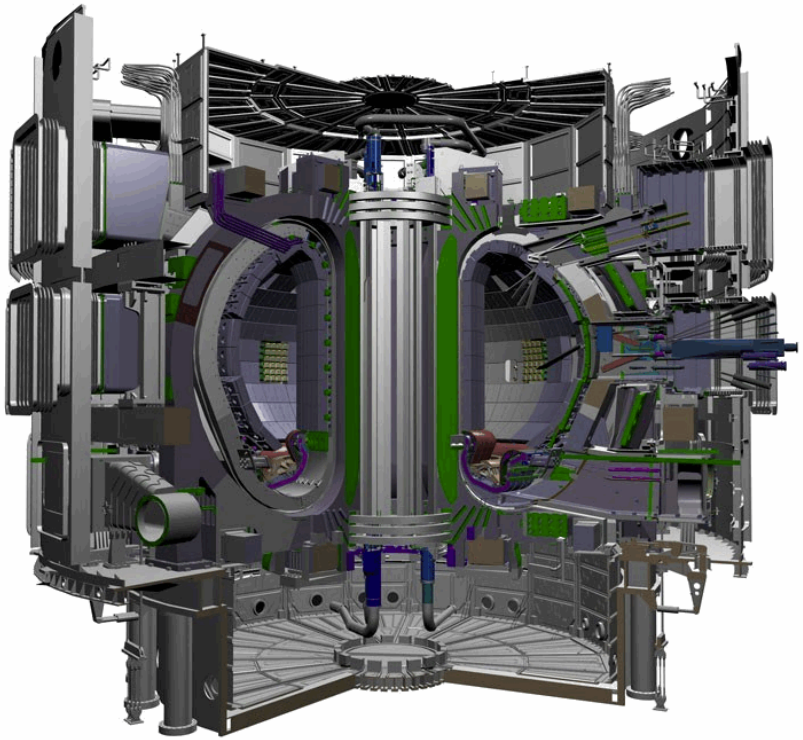
Frank Zhao
Thomas Palazzo
October 2014

Background

"We say that we will put the sun into a box. The idea is pretty. The problem is, we don't know how to make the box."

- Pierre-Gilles de Gennes (French Nobel laureate)

ITER



- The ITER project aims to construct the largest experimental nuclear fusion tokamak reactor in the world.
- Reactor surfaces will experience harsh operating conditions due to high particle and heat flux.
- Plasma in the ITER exhaust region interacts with the surface of the confinement material
- The cumulative effect of these processes causes contaminants to leak into the plasma causing it to cool and reduce the efficiency of the reactor.

Plasma Containment

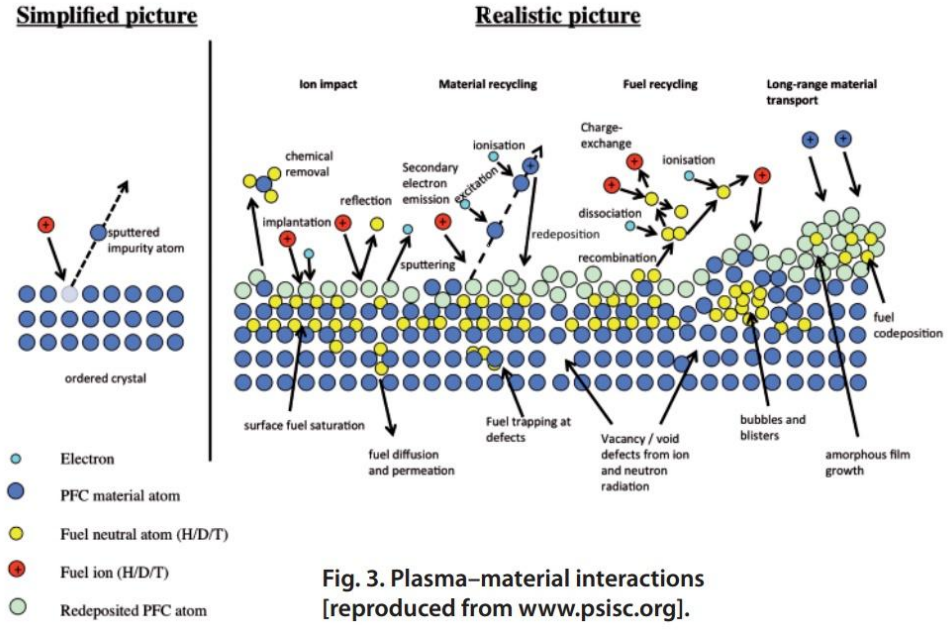
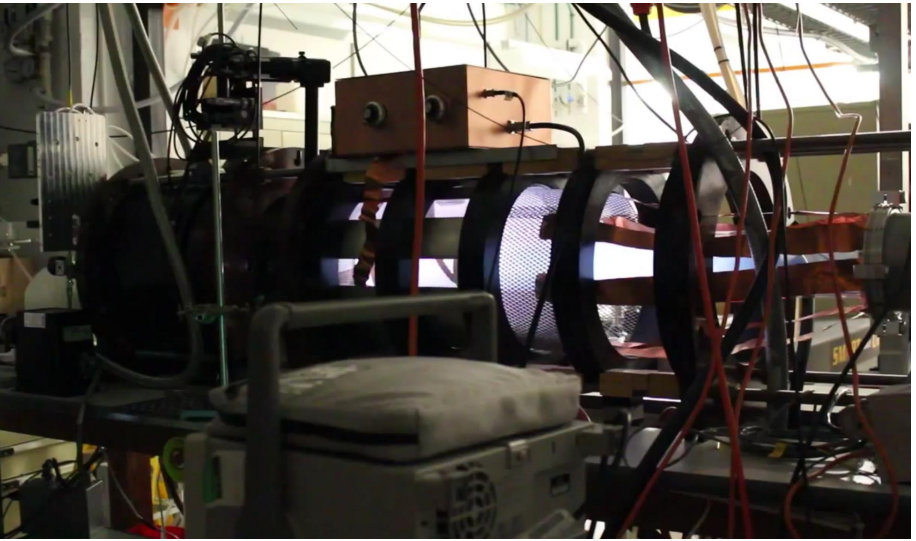


Fig. 3. Plasma–material interactions [reproduced from www.psisc.org].

- Plasma containment is an ongoing problem
- Some materials might erode or degrade quickly, requiring frequent replacement
- Other materials release excessive material into the plasma, contaminating it and leading to cooling of the burning plasma.

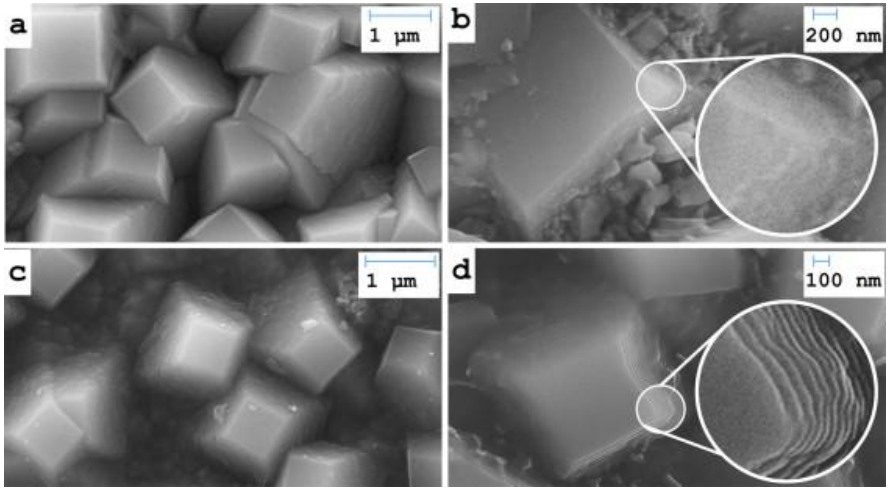
MAGPIE



- Cormac started the Plasma-Surface Interaction group, and worked on the construction of MAGPIE
- MAGPIE is a linear plasma device, low temperature plasma (5eV ~60,000K)
- Simulated conditions found in the exhaust regions of ITER to be simulated directly

http://youtu.be/29rXBo23718?t=12s

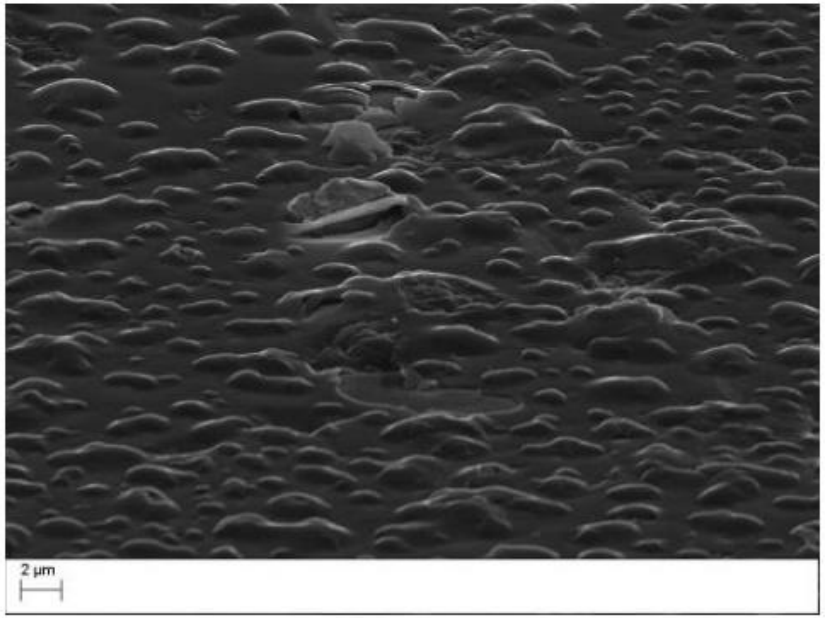
Surface Interactions



Ion damaged diamond

- After exposure to MAGPIE plasma, samples are then analysed using a variety of techniques: angle x-ray diffraction, neutron imaging, spectroscopy and EXAFS

Surface Interactions



sample of irradiated tungsten-alloy (*below*).

- Research conducted by the Plasma Surface Interactions group feed directly into the ITER project
- The current candidate for the exhaust region surface is pure tungsten.
- Tungsten the advantage of low deuterium/tritium retention and low erosion/high lifetime, but causes more cooling

Summary

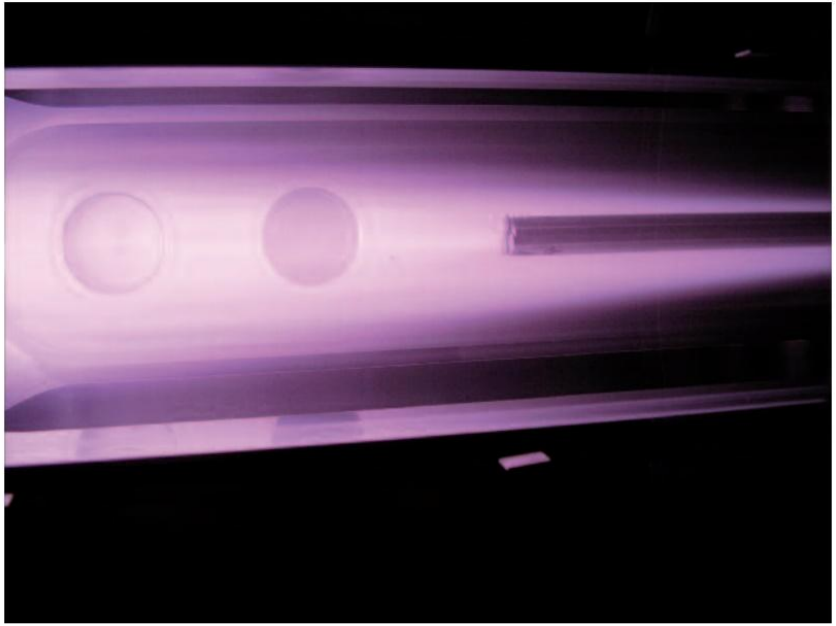


Fig. 4. Schematic of the MAGPIE device and a photo of the plasma interacting with a target.

- Surface interactions of materials with plasma still present a problem in the on going search towards fusion power
- MAGPIE is leading the world in low temperature plasma surface interaction experiments

References

[1] C. Corr, C. Samuell, M. Thompson, M. Guenette, A. Deslandes and D. Riley, *Fusion-relevant plasma surface interactions*, 31st ICPIG, Granada, Spain (2013)

[2] C. Corr, C. Samuell, B. Blackwell, J. Howard, J. Caneses and R. Lester, *MAGPIE: A new linear plasma device for studying fusion relevant plasma-surface interactions*, http://meetings.aps.org/link/BAPS.2012.GEC.DT2.6 (2012)

[3] A. Deslandes, M.C. Guenette, C.M. Samuell, I. Karatchevtseva, M. Ionescu, D.D. Cohen, B. Blackwell, C. Corr, D.P. Riley, Initial damage processes for diamond film exposure to hydrogen plasma, Fusion Engineering and Design, Volume 88, Issue 12, December 2013, Pages 3101-3107, ISSN 0920-3796, http://dx.doi.org/10.1016/j.fusengdes.2013.08.010. (http://www.sciencedirect.com/science/article/pii/S0920379613006480)

[4] https://www.youtube.com/watch?v=29rXBo23718

[5] http://people.physics.anu.edu.au/~csc112/Corr/News_files/Australian%20Physics_Corr2012.pdf