RaDIATE Collaboration

Radiation **D**amage **I**n **A**ccelerator **T**arget **E**nvironments

Collaboration on accelerator target materials initiated at 1st PASI workshop at Fermilab, January 2012.

http://www-radiate.fnal.gov/index.html

Key objectives:

- Introduce materials scientists with expertise in radiation damage to accelerator targets community
- Apply expertise to target and beam window issues
- Co-ordinate in-beam experiments and post-irradiation examination

MoU signed by 5 US/UK institutes – Fermilab, BNL, PNNL, RAL, Oxford Materials Dept.

ESS, CERN, SNS, PSI, FRIB to be added in next round

- **New collaborators welcome**
- NB membership of RaDIATE does not commit anyone to spending any money – it is just a collaboration framework

Meetings/workshops

- Next international PASI meeting:
  - 7th - 9th May 2014 at Fermilab
- First RaDIATE Collaboration Meeting:
  - 19th May 2014 at Fermilab, followed by:
- 5th High Power Targets Workshop , 20th - 23rd May 2014

Agenda for 5th High Power Targets Workshop , 20th - 23rd May 2014

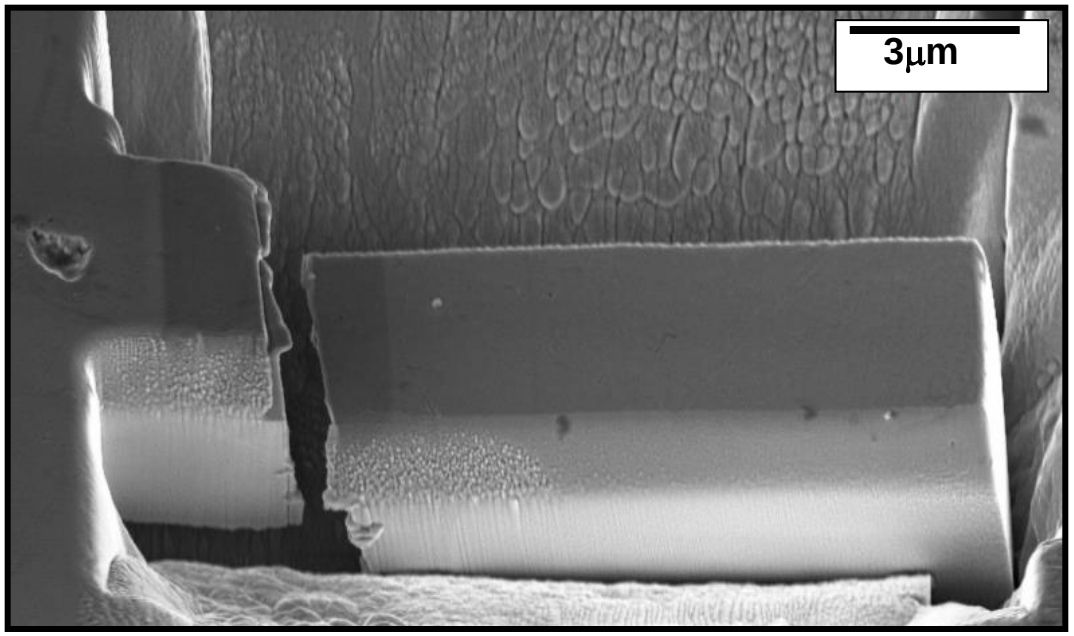
- Survey of Target Facility Landscape
  - Neutrino Beams, Spallation Sources, Radioactive Ion Beam facilities, Accelerator-based materials irradiation facilities
- Target Design Challenges
  - thermo-mechanical and hydraulic response of targets and beam windows
- Radiation Damage and Material Limits
  - in context of target design challenges and establishing allowable material limits for critical components
- Target Facility Simulation Challenges
  - including requirements for target facility design/operation, validation with empirical measurements, and unique applications
- Target/Beam Monitoring & Instrumentation
  - high radiation/temperature systems for target and facility diagnostics, safety, and physics
- Target Facility Challenges
  - optimizing facility architecture for operational performance, including radiation protection, remote handling, availability, and upgrade-ability

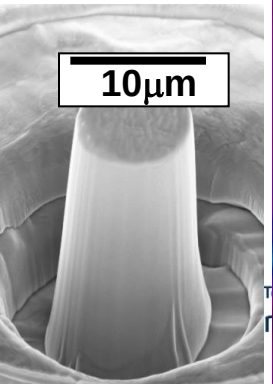
More news:

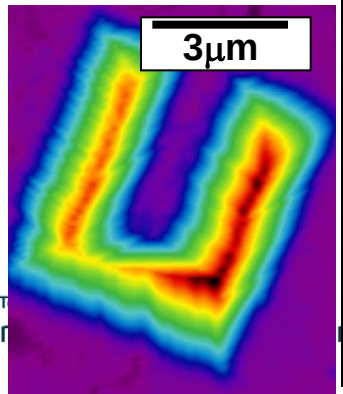
- PASI Post-doc: Dr Viacheslav Kuksenko
  - Starting in Oxford University Materials for Fission & Fusion Power Group in January 2014
  - Employment costs covered 50/50 by STFC/Fermilab
  - Project costs covered by Fermilab
  - Will lead research into beryllium and alloys: windows and radiation damage studies
- Oxford/NNL & colleagues: Stage 1 literature study completed – ¾ inch thick (but not yet circulated) covering:
  - Graphite
  - Beryllium
  - Tungsten
- RaDIATE now separated into separate work groups for different materials
- CJD to initiate tungsten group

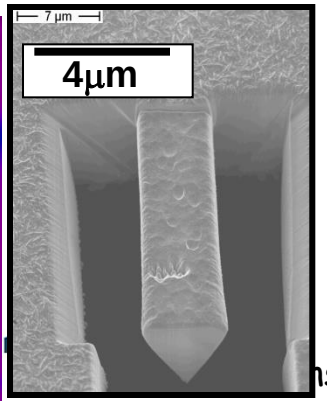
Micro-mechanical testing

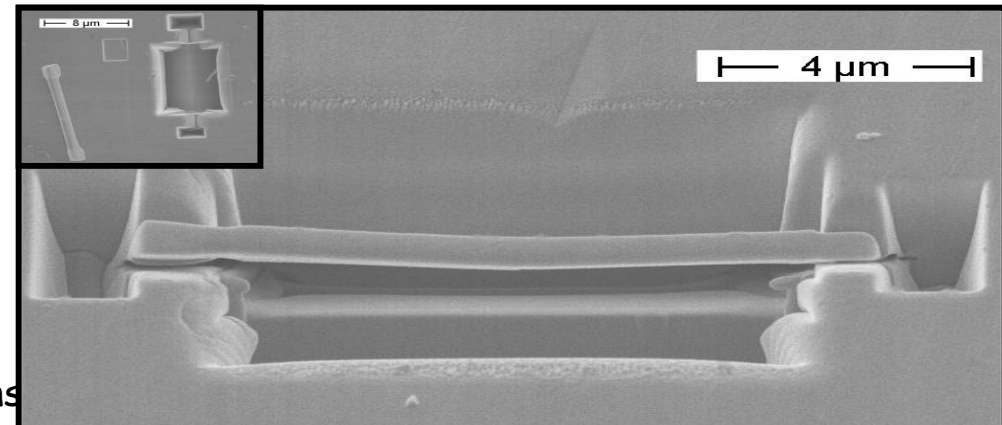
- Unique materials expertise at Oxford (Materials for Fission and Fusion Power (MFFP) Group
- Micro-cantilevers machined by Focused Ion Beams
- Compression tests
- Tension tests
- Three Point Bend
- Cantilever bending

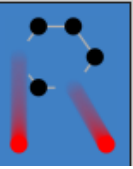












Pitch to ESS last Friday:

Opportunity for ESS - RaDIATE Tungsten programme

- Scoping study of literature on tungsten radiation damage nearly ready (by Oxford/NNL)
  - Characterisation of unirradiated samples of ISIS tungsten targets at Oxford (MFFP) currently underway
- NNUF (National Nuclear User's Facility) currently being constructed at Culham To perform activated materials testing (micro-mechanical)
  - £15 M equipment purchased
  - Ready to handle active samples in 2015
- Possibility for PIE of ISIS tungsten targets (**c.100 DPA**)
  - Sellafield (main UK nuclear facility) are currently preparing a quotation to cut up a spent ISIS tungsten target
  - Samples would be passed to NNUF (and other interested parties) for micro-mechanical tests
  - ISIS will pay for pure target disposal costs, but not extra costs for cutting samples
  - **Contributions sought to cover costs of sample preparation and PIE**
    - Fusion materials community?
    - ESS?

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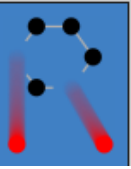

Facility (startup)	Operating conditions[1]							Proton beam parameters
	Avg. T (°C)	Peak T (°C)	DPA	Source		Gas production (appm/DPA)		
						He	H	
ISIS (1980 -)	200	205	27/yr	Brookes/Davenne (MARS/ FLUKA)		10	30	200 kW; 0.8 GeV; 50 Hz; σ_{rms} = 16.5 mm
ESS (2020)	500	650	0.9/yr	KIT/ESS TDR				5 MW; 3 GeV; 15 Hz; σ_x = 200 mm, σ_y = 60 mm
Mu2e (2020): L = 160 mm, D = 6 mm	1500	1600	260/yr	Hartsell/MARS		20	60	8 kW; 8 GeV; 0.75 Hz; σ_{rms} = 1 mm

NB Questions over different methodologies (and results) for calculation of Displacements per Atoms
- Needs resolution

Topics of Interest from PIE

Thermal conductivity
Integrity
Void swelling
H2/He embrittlement
Creep/Fatigue
Differentiation of failure mechanisms
Impurity effects on embrittlement
Irradiation creep

Science & Technology Facilities Council
Rutherford Appleton Laboratory

Chris Densham

Other irradiation facilities in pipeline:

- TRITON (Triple Ion-beam Testing of Nuclear Materials)
  - Proposal submitted to EPSRC/Large Facilities Capital Fund with blessing of STFC
- FAFNIR – see talk by Tristan

Very new collaboration on Ti6Al4V and Ti6Al4V1B

- Ti6Al4V used in T2K beam windows for resilience to pulsed beams
- MSU/FRIB intend to use Ti alloy for beam dump window, will see very high radiation damage rates
- Collaboration between KEK, MSU, FNAL and RAL starting up to perform:
  - Neutron damage experiments
  - Heavy ion damage experiments at MSU
  - Investigation of relevance to T2K beam parameters, possibility to test used T2K beam windows?

Summary

New collaborators invited to participate in:

- Materials & radiation damage calculations – particularly to resolve any discrepancies in cross-sections, neutrons vs protons etc
- Irradiation facilities?
- Post-Irradiation Examination/materials characterisation?
- Anything else?

Materials in programme so far:

- Graphite (neutrino production targets)
- Beryllium (beam windows)
- Tungsten (spallation targets)
- Titanium alloys (beam windows)
- Anything else?