Introduction

• Overview of MRF Tritium Capability
• Thermal Desorption Spectroscopy
  – TDS at CCFE
  – TriCEM
  – TLF
• Tritium and Fusion (DEMO)
  – Example from Blanket concept designs
• Tritium and Fission
MRF Tritium Facility
MRF Tritium Facility

MRF Tritium Capability
MRF Tritium Facility

Gives the MRF the ability to feed and recover significant quantities (10s of TBq) of Tritium to a range of experiments either in pure T2 form or diluted with, primarily, other Hydrogen isotopes.
Thermal Desorption Spectroscopy (TDS)

A Baron-Wiechec et al, CCFE
TDS

Sample stage
• 20mm diameter and thicknesses up to 10mm
• Programmable heating from 300K to 1273K
• 10K/min ramp rates typical

Analytics
• Hiden mass spec with electron multiplier with LOS orientation for direct detection

Mass Separation
• System tuned to allow mass separation of He and D$_2$ peaks at 4amu
First TDS Results of JET Samples

TDS can also be used for the analysis of tritium (T). Figure shows release spectra for T2 (mass 6) from IWGL and divertor sample. There is a similar sharp release at ~100°C and some release over the temperature range of the first component of the release from the divertor sample (~250°C-650°C).

Not all the D is released as D2. There is a significant release of HD which is observed at mass 3. The release spectrum has a similar shape to that for D2 as a function of temperature, and the D in the HD represents about 20% of the total amount of number of D atoms released.
TDS & Hydrogen Corrosion Studies

Hydrogen count for as-received Zircaloy-4

Lower temperature peak due to surface hydrogen

Temperature, °C

Time, s

Hydrogen
Temperature

J Sayers et al, Oxford University & NNL
TDS & Hydrogen Corrosion Studies

Where the oxygen migrates to the bulk, allowing hydrogen to escape

45 days oxidised sample

Temperature, °C

Time, s

J Sayers et al, Oxford University & NNL
TriCEM

Tritium Characterization in materials with Evolving Microstructure

Aims:
To study the retention of tritium in fusion relevant materials as a function of the evolution of the microstructure.
To study tritium retention in materials which change due to radiation

How:
Samples will be sent to beam facilities for self ion bombardment, or cold worked, in order to produce the required types of microstructural damage. These samples will then be implanted with tritium ions by TESG. The loaded samples will then be analyzed by Thermal Desorption Spectroscopy (TDS) and Secondary Ion Mass Spectroscopy (SIMS). This work will provide experimental validation for a new modelling program which will account for the alteration of materials due to radiation damage.

A de Backer, A Hollingsworth, D Whittaker et al, CCFE
The sample manipulation and holding system will be a modified version of the example outlined here. The sample must be placed on the holder plate as it is inserted. This grips the sample using two thin rails at the sides of the sample face.
Tritium Loading Facility (TLF)

Objective

• Reproduce the tritium ions implantation in plasma facing components.

Scope

• Study of the short term outgassing due to plasma ops
• Study of the influence of parameters
  o Ion surface concentration (up to $10^{20}$ cm$^{-2}$ on 1cm$^2$ samples)
  o Ion energy (including disruption simulations)
  o Loading temperature & material state (new/used)

Materials

• Bulk beryllium (Inner Wall Guard and Wide Poloidal Limiter)
• Tungsten lamellae

X Lefebvre et al, CCFE
Tritium & Fusion

Breeder Blanket schematic for DEMO
Tritium & Fusion

T flows from HCPB to Fuel Cycle

- Hydrogen dilution according to reference purge gas scenario
  - 0.1% H₂ in He @ 10,000 m³/h
  - 10 m³/h H₂ (~400 mol x 24 h)
  - 500 g T₂ (~80 mol)
  - T/H < 0.008
  ➥ Significant impact on ISS (isotope separation system)

Is such amount of H manageable by ISS?

- Possibility to reduce H₂, or change for H₂O?
There are some Fusion/Fission synergies re Tritium

- **Graphite from AGRs (and other Fission)**
  - The UK has an inventory of approx 100,000 tons of graphite from AGR cores. Tritium levels in the graphite of 10s of kBq/g categories it as ILW. Reduction to LLW would result in significant cost savings. Worldwide stocks of such graphite at 250,000 tons

- **Tritium from PWR operation & fuel processing**
  - PWRs discharge 10s TBq per year of Tritium. Processing plants (le Hague, Sellafield) discharge 10s grams of Tritium per year. Future requirement to mitigate?

- **UK Legacy Nuclear Sites**
  - Both Dounreay and Chapelcross have significant Tritium inventories that need managing

- **Fukushima (UKAEA invited to consult on issue)**
Summary

• The MRF Tritium facility provides a unique capability to users

• We’re keen to understand the needs of the wider scientific/engineering community