Isolating the Detrapping of Deuterium in Heavy Ion Damaged Tungsten via Partial Thermal Desorption

M.J. Simmonds[a], T. Schwarz-Selinger[b], J.H. Yu[a], M.J. Baldwin[a], R.P. Doerner[a], G.R. Tynan[a,c]

[a] *Center for Energy Research, UC San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0417, USA*
[b] *Max-Planck-Institut für Plasmaphysik Boltzmannstrasse 2 D-85748 Garching, Germany*
[c] *Mechanical and Aerospace Engineering, UC San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0411, USA*

msimmonds@eng.ucsd.edu

We investigated the use of partial Thermal Desorption Spectroscopy (TDS) of deuterium (D) from tungsten (W) trap sites to isolate both their spatial location and detrapping energies. W damaged with heavy ions and then implanted with D_2 plasma typically display multiple release peaks in the experimental TDS data. These release peaks are associated with various detrapping energies convoluted by an unknown spatial distribution of that type of trap. While Nuclear Reaction Analysis (NRA) gives some spatial information, it only measures the sum total of all D filled traps. Typically the NRA profile displays three distinct spatial zones: (I) the very near surface due to plasma implantation stress, (II) the region where heavy ions cause displacement damage, and (III) the intrinsic defects throughout the bulk.

We devised an experiment to successively depopulate each trap with increasing detrapping energy, thus allowing us to differentiate the spatial location associated with a particular detrapping energy. The experiment consisted of multiple W samples that were prepared identically with surface polishing and annealing prior to induced displacement damage with 5 MeV Cu ions and peak dpa of 0.12. All samples were subsequently exposed to the same D_2 plasma conditions and received a total fluence of 10^{24} D/m^2 over 1.5 hours at a temperature of 383 K. Next, one control sample was not thermally desorbed at this stage, while the other samples were subjected to a partial TDS (pTDS) up to various peak temperatures chosen to depopulate individual traps. Each sample reached a different peak, spanning 467 to 762 K, and was held for an hour at this temperature. NRA was then performed to determine the spatial profile of the D concentration remaining after pTDS as well as for the control. Lastly, TDS was performed up to 1300 K to remove all remaining D.

The simulation of the pTDS, NRA, and full TDS stages are well constrained by both the identical initial conditions and the controlled depopulation of each trap. Here we assume each trap concentration and spatial profile as well as the filling thereof during D implantation are the same for all samples. Comparing the NRA data from the control sample, without pTDS, and the lowest pTDS temperatures demonstrates that all of zone I was depopulated by holding the sample at 525 K. In addition, the highest detrapping energy is nearly depopulated completely by a pTDS temperature of 762 K. For pTDS peak temperatures between 525 and

762 K, the D profiles measured via NRA are similar to the displacement damage profile predicted by the Stopping and Range of Ions in Matter.