Controlling density rise through helium conditioning.

C H Skinner, H Kugel, R Maingi, D Mueller,...

- Surface physics
- TFTR, DIII-D, NSTX results
- XP: Controlling density rise through limiting divertor temp. rise and through He conditioning.

PPPL Jan 7th, 2003

Surface Physics: Complex non-linearly coupled plasma - wall system.

Not a simple homogeneous system on any scale:
- processes on wall include:

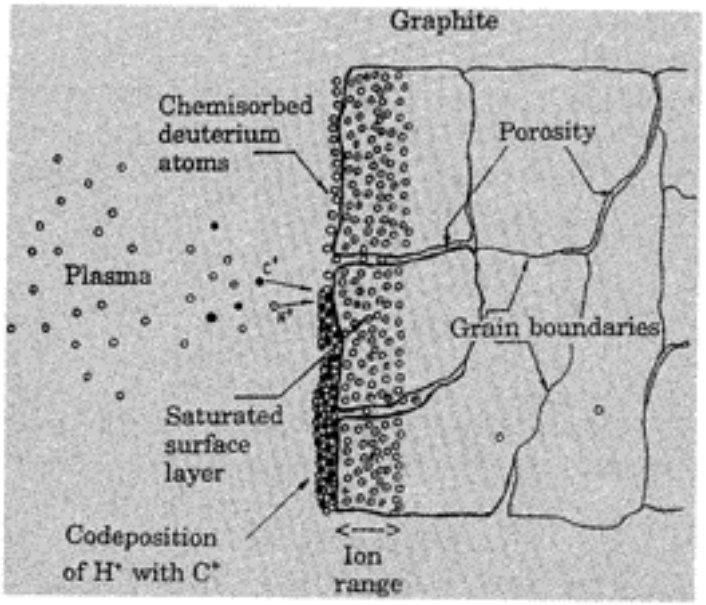
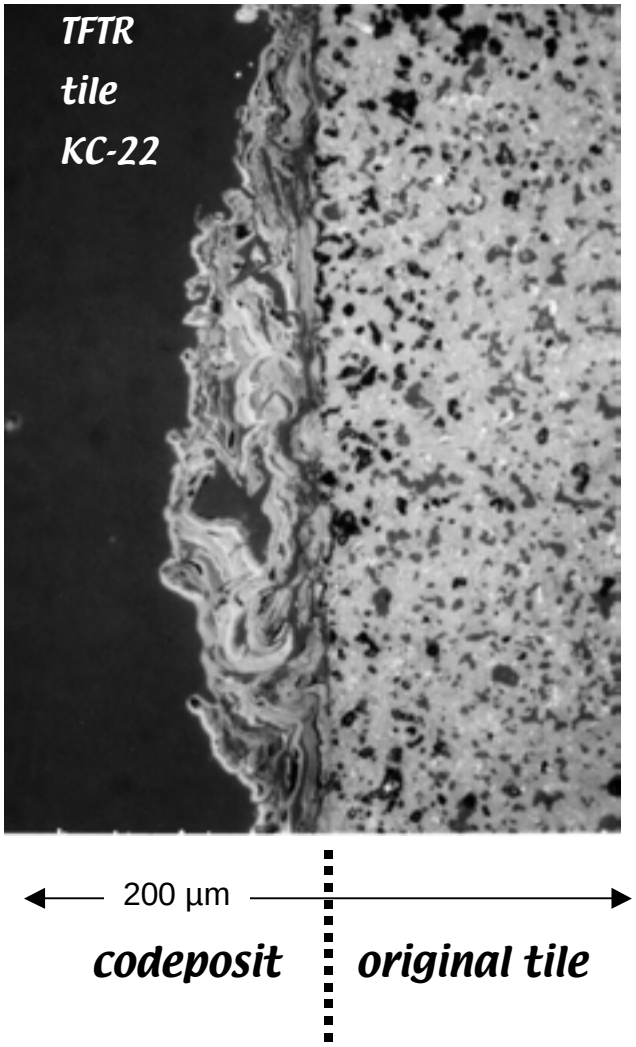


Figure 32. Illustration of hydrogen retention and transport in graphite. (Reproduced with permission from Ref. [207].)

Chiu et al.,

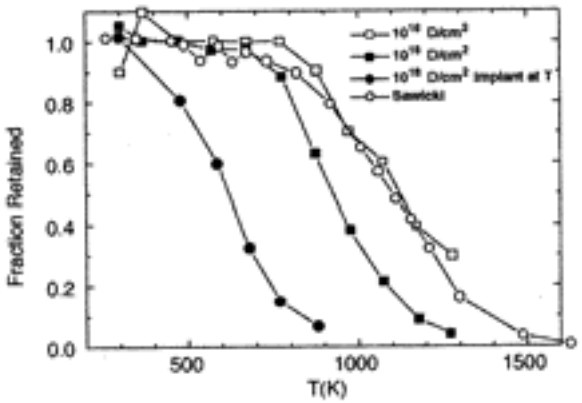
Microscopic-scale perspective



convoluted, highly porous structure, codeposit poorly thermally connected

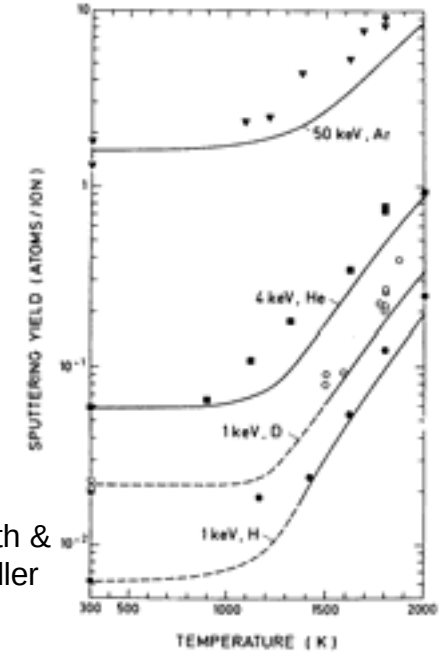
Temperature effects:

D release



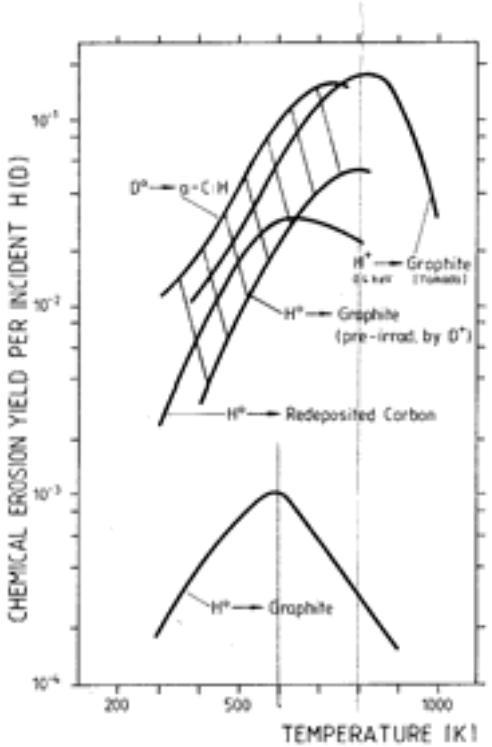
Doyle et al.,

Radiation Enhanced Sublimation (RES) as temp. rises

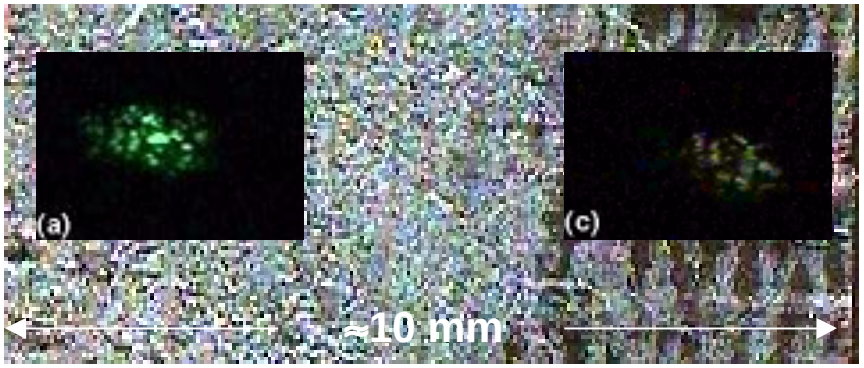


Roth & Moller

Chemical Sputtering



Vietzke & Haasz.



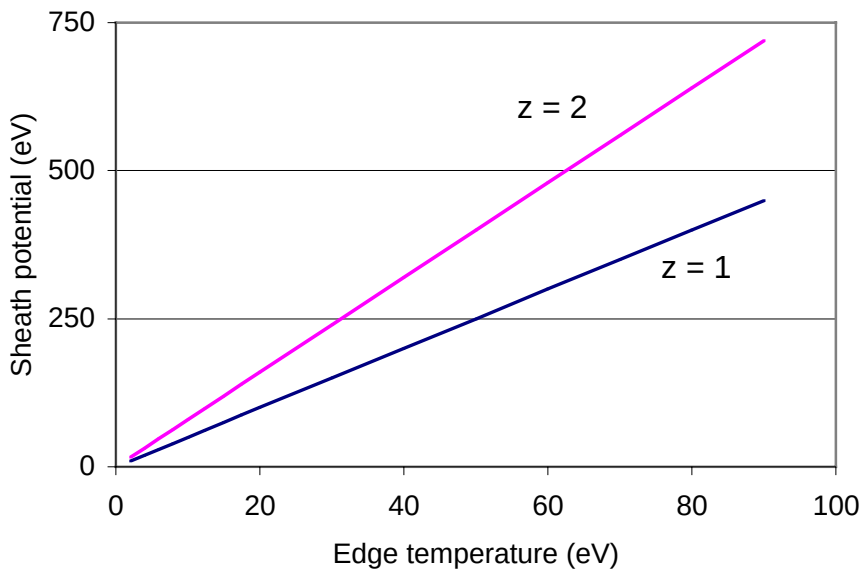
Skinner et al.,

Temp: 1841 °C left, 1181 °C right

Same heat flux (from laser spot)

Microhotspots - surface temperature not single value (varies x2)

High performance shots access depths into wall untouched by He glow GDC.



Interaction Depth:

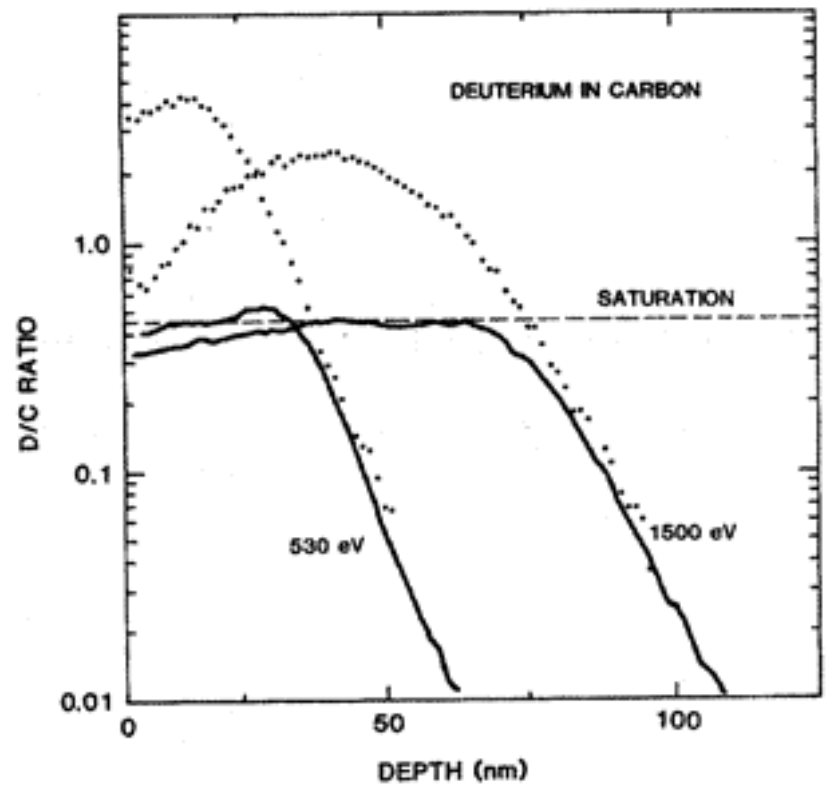


Figure 33. Depth profiles measured by secondary ion mass spectroscopy (SIMS) of deuterium implanted at 530 and 1500 eV into carbon at room temperature at fluences of 10^{22} D·m^{-2} (solid lines) and 10^{20} D·m^{-2} (dotted curves). For comparison, the low dose curves are scaled up by a factor of 100. (Reproduced with permission from Ref. [449].)

Wampler et al.,

Plasma ions approaching the material surfaces are accelerated by the sheath potential to an energy of

$$E \approx 2T + 3ZT,$$

where T is the plasma temperature adjacent to the material and Z is the ion charge.

He^{++} impacts at higher energy than D^{+}

TFTR He conditioning:

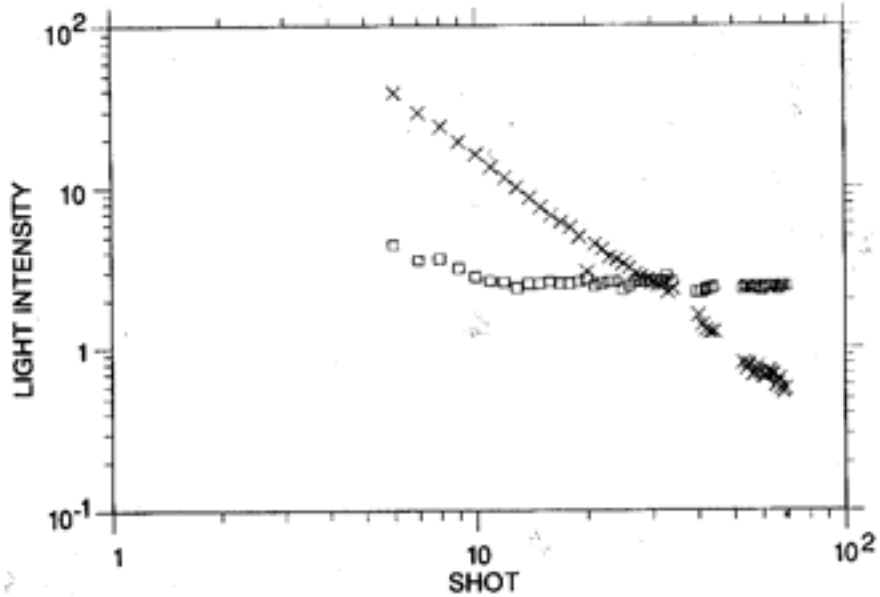


Fig. 11. Hydrogen (×) and carbon (□) influx in helium discharge cleaning pulses following a 1 MA ohmic disruption near the end of a disruptive discharge cleaning campaign.

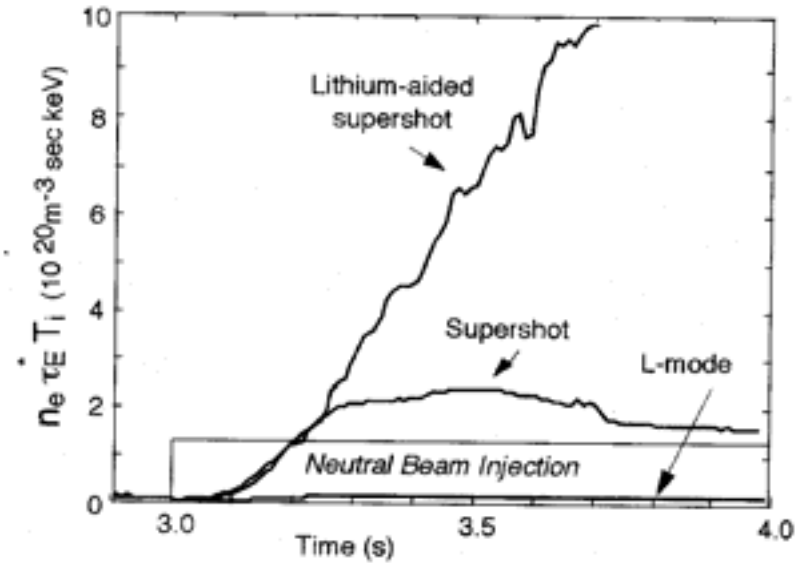


Figure 2. Showing the dramatic 64 × increase in the fusion triple product $n_e \tau_E T_i$ in TFTR with wall conditioning.

Strachan et al.,

Density Rise: DIII-D

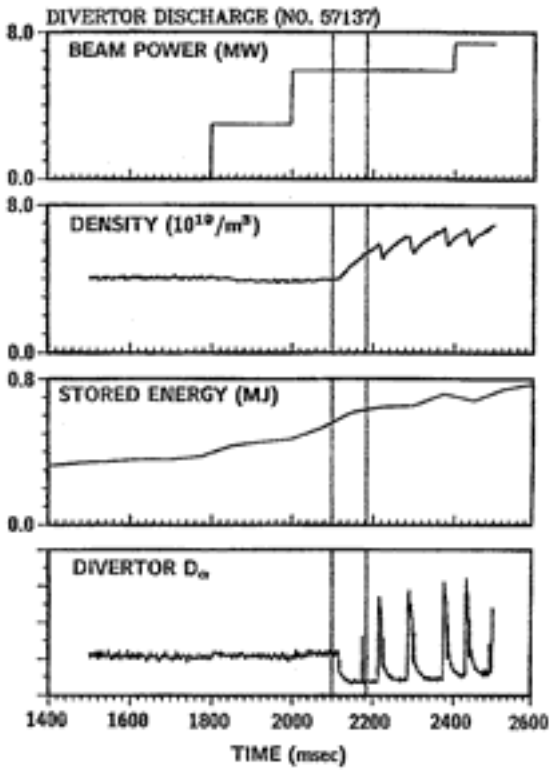
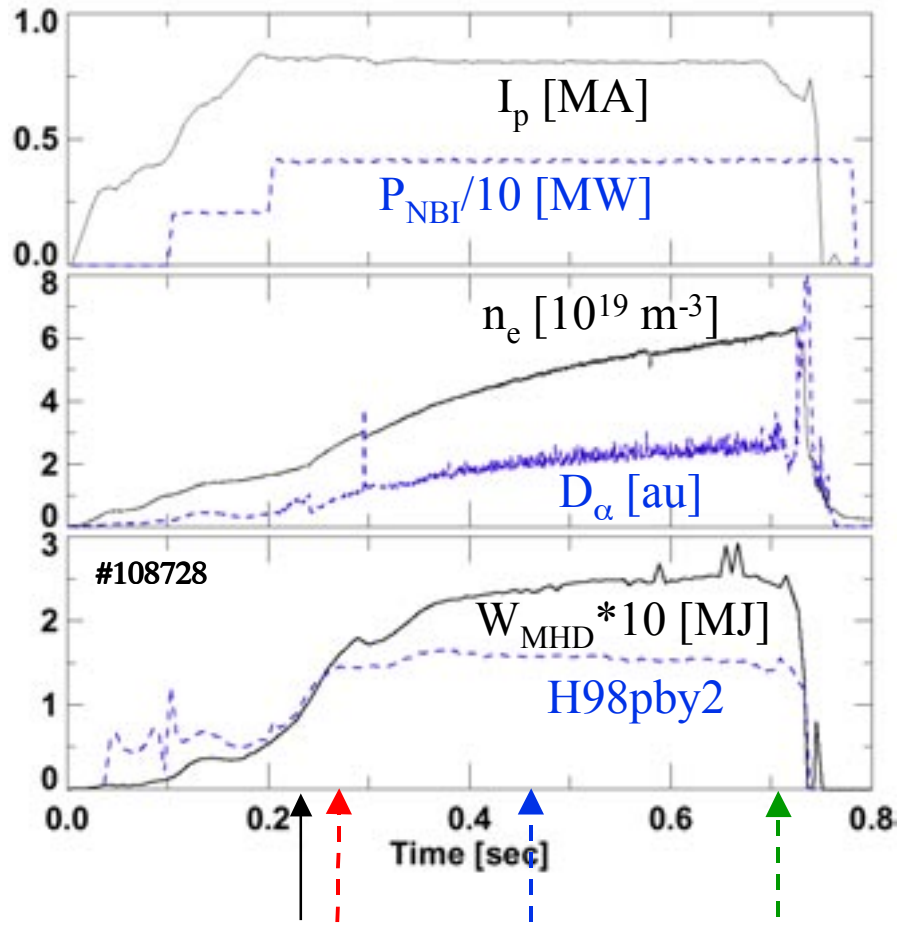


FIG. 9. Time histories of various measured quantities. The L–H transition occurs at about 2120 msec, as indicated by the sharp drop in D_α light intensity at the divertor and the sudden ramp-up of the density. We analyze neutral transport just before and after the transition, as indicated by the two vertical lines.

Rensink et al., modeling showed H-mode density rise due to longer confinement time and thinner scrape off layer more transparent to incoming particles.

Density Rise: NSTX



Maingi et al., 5 yr forum

Outline of XP:

- *Prequisite: well boronized, NBI available*
- *D fiducial e.g. 108741*
- *Jog/ sweep triangularity to move strikepoint to reduce divertor temperature rise*
- *Compare density rise and divertor temperature.*
- *Repeat D fiducial*

- *Run He NBI discharges to deplete D in divertor.*
- *Repeat D fiducial*
- *Compare USL discharges if time permits.*