Deuterium Inventory in Tore Supra

- Load the PPCs in D
- Do in situ particle balance
- Dismantle the Toroidal Pump Limiter
- Do ex-situ post mortem analyses

Toroidal Pump Limiter

Positions of the analysed toes with respect of the deposition pattern

This Study

Post mortem SEM, TEM, AFM, Raman analyses of the top surface of eroded TS tiles

- Experimental estimation of the erosion rate of CFC
- Differential fibre/matrix erosion rate
- Ripple patterning characterization on tile surface

All the TPL tiles were provided by the SEP Company and the CFC is a C/C composite. N1885polycarb type, composed of a 3D texture of bundles of ex-PAN fibers embedded in a pyrolytic carbon matrix. Fibers and matrix are both graphitic.

Cutting of the tile F27T10

Virgin tile edge designed with a 2 mm curvature

Net erosion thickness measured on toroidal cross-section of tiles

D-stream gap deposit is covered / U-stream gap deposit is sharp

D-stream is covered / U-stream gap is shadowed

Thin layer of a-C on top surface

- SEM analysis
  - Smooth surface with oblique striation
  - Exposed to high heat and particle fluxes
  - CPF porosity partially filled by deposits (~10 µm)
  - Contribution to retention
  - Contrast shows fiber section

- TEM analysis of FIB foil
  - Amorphous carbon layer on top
  - Amorphization due to ion bombardment
  - a-C layer thickness 30±10 nm

D implantation depth

Differential erosion fiber / matrix

- AFM analysis on F27T10 tile
  - Fiber lower than matrix (~500 nm)
  - Fiber erosion rate higher than matrix
  - Fiber roughness lower than matrix roughness

Rk = \sqrt{\frac{1}{n} \sum (h(x) - h)^2}

- Surface roughness Rq
  - Fiber (Rq = 6 nm)
  - Matrix (Rq = 11 nm)

- Raman analysis on virgin tile

Raman shift / cm

- Formation of disorder
  - Fiber more disordered than matrix (aromatic domain size smaller)
  - Raman estimation of aromatic domain size, Lm

\[ \frac{\nu_P}{\nu_G} = 1.02 \]

- Erosion rate fiber / matrix erosion rate

Ripple patterning of the tile surface

- SEM/AFM analysis on eroded tile
  - Formation of a ripple pattern
    - Dynamic balance among
      - Fundamental surface processes (erosion of birefringent, ion-induced defect creation)
      - And the induced evolution of the surface morphology
    - Impinging flux projection A to wave vector

- Direction of the impinging flux on the TPL surface

Formation of a sawtooth profile

- Shading effect due to different erosion rates
  - Impinging flux projection is directive

Conclusions

- First determination of the erosion rate a few nm/s
- First observation of rippling: oblique direction show that the poloidal component of the ion velocity is of the same order of magnitude than the toroidal component, possible origins still to unravel
- First observation of a differential erosion of fiber and matrix, importance of the carbon microstructure in the erosion rate