SAND2005-7602P

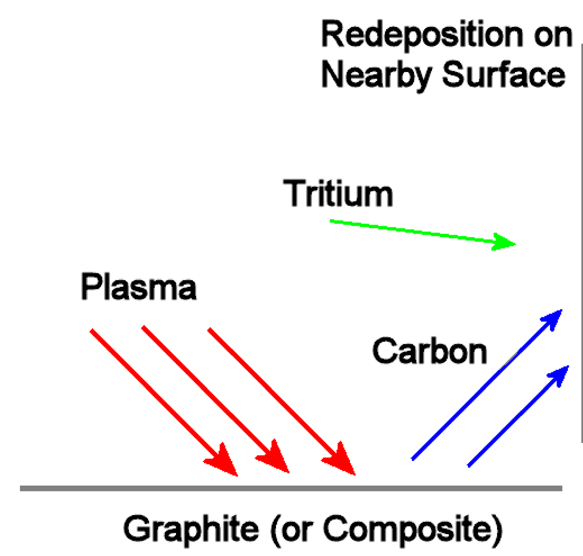
Removal of the Codeposited Carbon Layer using He-O Glow Discharge

C.L.Kunz[1], R.A.Causey[1], M.Clift[1], D.F.Cowgill[1], B.E.Mills[1], W.R.Wampler[2]
[1] Sandia National Laboratories, Livermore, CA; [2] Sandia National Laboratories, Albuquerque, NM

Introduction

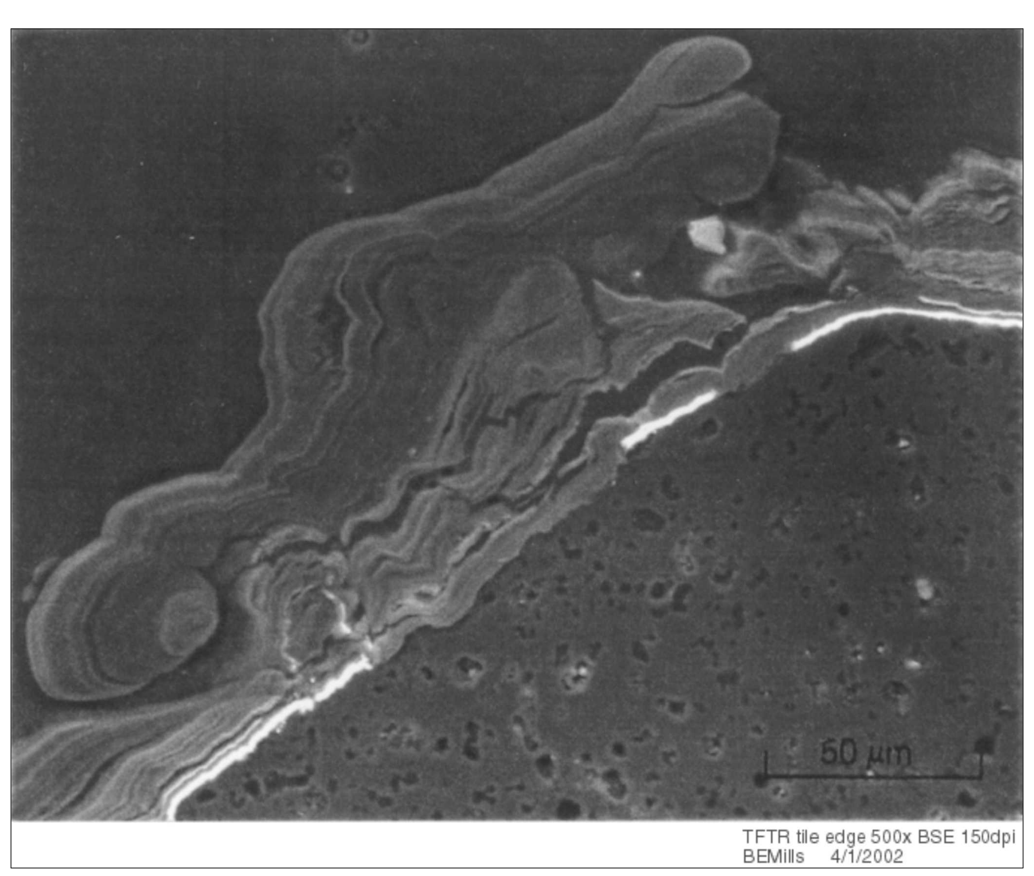
- Plasma disruptions and sputtering erode carbon surfaces
- Carbon is redeposited on nearby surfaces along with hydrogen from plasma
- Presence of tritium in the plasma will lead to a large tritium inventory in the codeposited layer
- If deposition rate is larger than erosion rate, codeposited layer will grow indefinitely leading to large tritium inventory

Creation of the codeposited layer



- Several techniques have been evaluated for codeposition removal
  - Heating in air or oxygen [1], laser ablation [2,3], flash lamps [4], and He-O glow discharge [5] (at room temperature)
- Each of these techniques have limitations that make them unlikely to be used for tritium removal
- *The current experiment investigates the effect of heating the sample during a He-O glow discharge*

Example of a codeposited layer on a TFTR tile



Experimental Details

- Four samples were taken from a TFTR tile [6]
  - –Analysis of tile showed a uniform codeposited layer with a deuterium to carbon (D/C) ratio of ~0.2
  - –Samples were obtained by removing a 2 mm thick layer from the top of the tile
- Samples were examined using: Auger scanning electron microscopy, He^3 Nuclear Reaction Analysis (NRA), and 2.5 MeV proton Rutherford Backscattering (RBS)
- From the NRA analysis, the deuterium layer thickness was found to be 1.2 mg/cm^2
  - –If we assume a density of 1.5 g/cm^3, typical for tokamak codeposited layers, the maximum depth of the deuterium would be 8 µm
- The samples were then exposed to a He-O glow discharge with sample temperatures varying from 373 K to 513 K

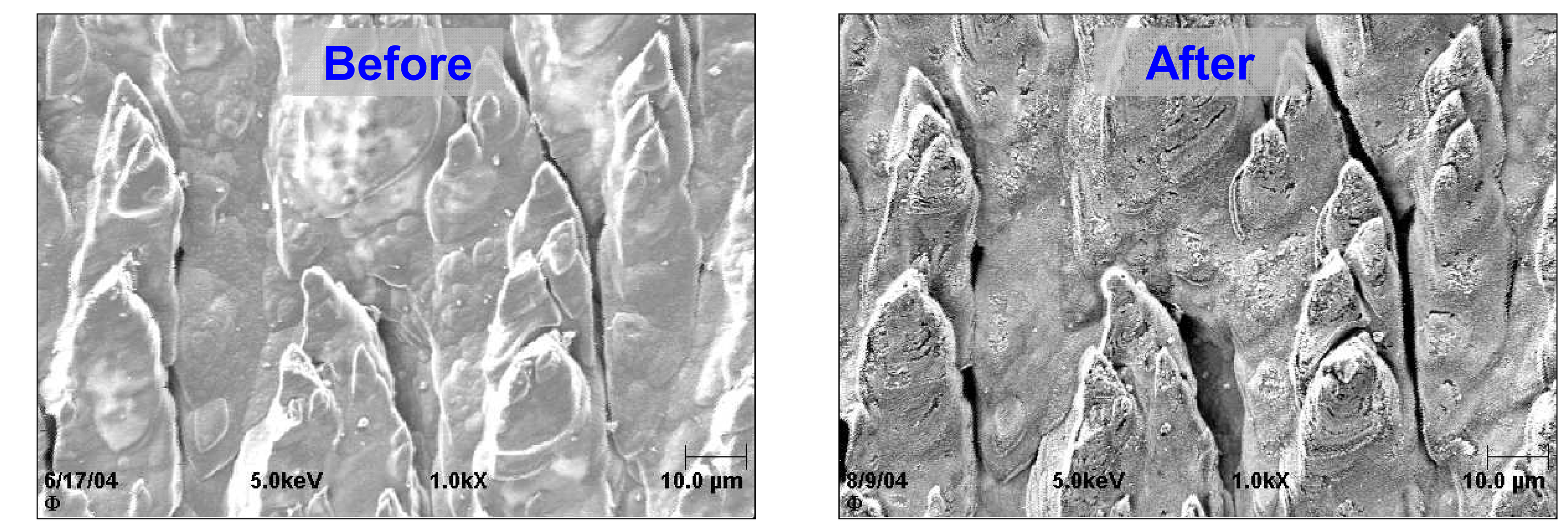
	Temperature (K)	Time
Sample 1	373	1 hour
Sample 2	443	1 hour
Sample 3	513	1 hour
Sample 4	443	4 hours

- The discharge consisted of 80% Helium and 20% Oxygen held at 13.2 Pa
- Fresh gas was supplied to maintain purity
- A voltage of 470 V was required to create the discharge
- The incident flux on target was ~10^{15} ions/cm^2 s

Results

- After exposure, the samples were analyzed using the same techniques.
- The scanning electron microscopy (SEM) results for sample 4 are shown in the next column
  - –All other samples show less erosion
  - –A qualitative comparison of the two images can be made by overlaying the two images, concluding that > 1 µm of material was removed
- The results from RBS analysis place an upper limit on removal at 5% of 13.3 µm or 0.667 µm
- RBS suggests that 5×10^{18} carbon atoms were removed, based on a density of 1.5 g/cm3

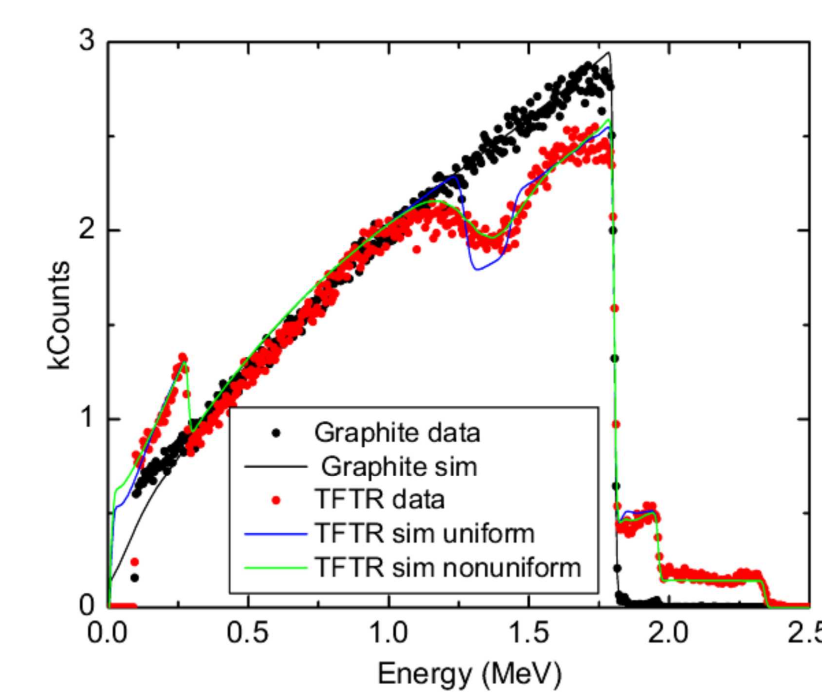
SEM of sample 4 before and after exposure at 443 K for 4 hours



•The total fluence for a 4 hour exposure is 1.44×10^{19} ions/cm^2 this results in a removal rate of 0.35 carbon atoms/ion

•The result reported here is less than the 5 carbon atoms/ion reported by Hsu [5], however this is likely due to a difference in the layer density and/or the shorter sample exposure time used in those experiments

RBS results for sample 4



Conclusion

Experimental results using scanning electron microscopy, Rutherford Backscattering, and nuclear reaction analysis of sample exposed to He-O glow discharge during heating all confirm the combination of removal techniques is not an effective way of removing the codeposited carbon/tritium layer produced in fusion reactors. Surface roughening along with near surface removal of hydrogen isotopes does occur, but the etch rate of the layer is too slow for use on the thick films anticipated.

Works Cited

1. R.A. Causey, W.R. Wampler, and D. Walsh, J. Nucl. Mater. 176 & 177 (1990) 987.
2. C.H. Skinner et al., J. Nucl. Mater. 301 (2002) 98
3. C.H. Skinner et al., Physica Scripta T103 (2003) 34.
4. K.J. Gibson et al., J. Nucl. Mater. 337-339 (2005) 565.
5. W.L. Hsu, J. Vac. Sci. Technol. A 7 (1989) 1047.
6. A.E. Pontau et al., Fus. Engineering & Design 10 (1989) 365.

National Nuclear Security Administration

Sandia is a multiprogram laboratory operated by Sandia Corporation, a LockheedMartin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia National Laboratories