Ion Implantation Effects on Carbon-Carbon Velvet

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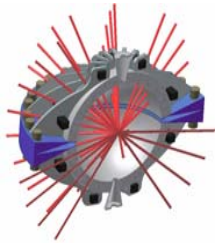
Carbon-Carbon Velvet Irradiation Experiments for the First Wall of the HAPL Reactor

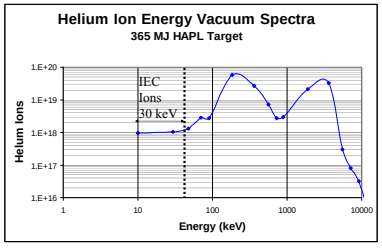
Summary of Presented Experiments

- SRIM calculations have been used to estimate the range of He^+ and D^+ in carbon-carbon velvet (CCV) and the range of He^+ tungsten coated carbon-carbon velvet (CCV/W).
- CCV and CCV/W samples were irradiated to $1x10^{19}$ He^+/cm^2 at 1150ºC and a CCV sample was irradiated to $1x10^{19}$ D^+/cm^2
- SEM analysis has been performed to evaluate the surface damage on the CCV and CCV/W as functions of temperature and/or fluence.

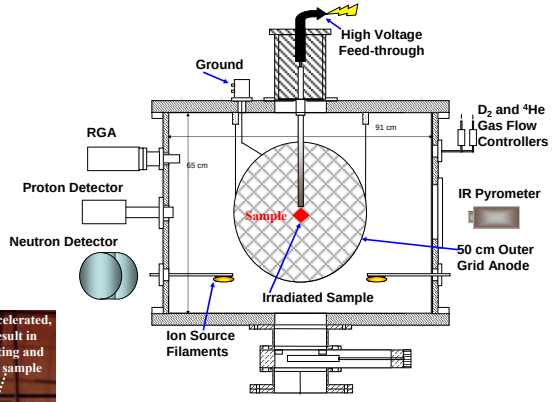
Objective: Investigate the damage effects of helium and deuterium implantation on the first wall armor of the High Average Pulsed Laser (HAPL) reactor



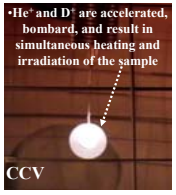
Cutaway Schematic of HAPL Chamber



IEC Setup for Materials Irradiation

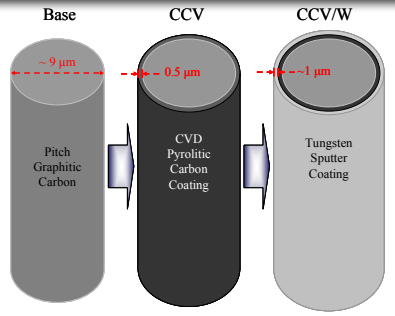


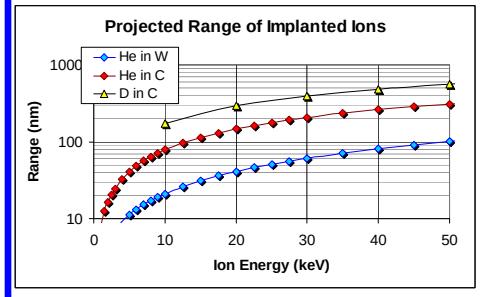
Schematic of UW -IEC Device



•For materials irradiation experiments the inner cathode grid is replaced with the carbon velvet specimens

Ion Range & Carbon-Carbon Velvet Composition





•Velvet fibers are ~1 mm long by ~10 µm diameter. CCV specimens use pitch graphitic carbon as the base material of the fiber (~9 µm diameter) and are then CVD coated by an amorphous carbon layer (~0.5 µm).

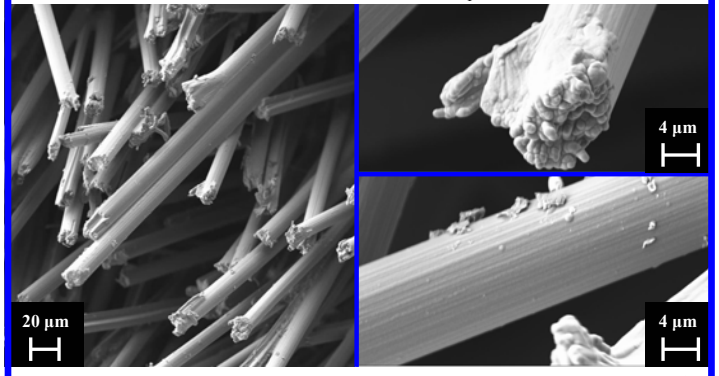
•CCV/W samples receive an additional sputter coating of tungsten ~1 µm thickness.

•To the left, He^+ and D^+ ranges in CCV, and CCV/W are shown as a function of the IEC ion energy.

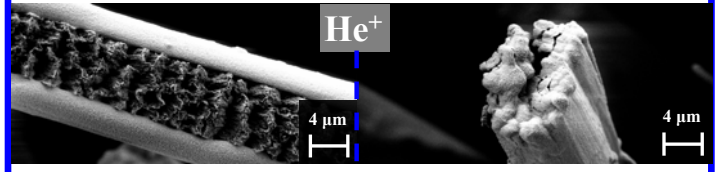
•None of the calculated ion ranges correspond to the damage penetration depth observed in the velvet specimens.

He^+ and D^+ Irradiation of CCV and CCV/W

•Unirradiated Carbon-Carbon Velvet Specimen

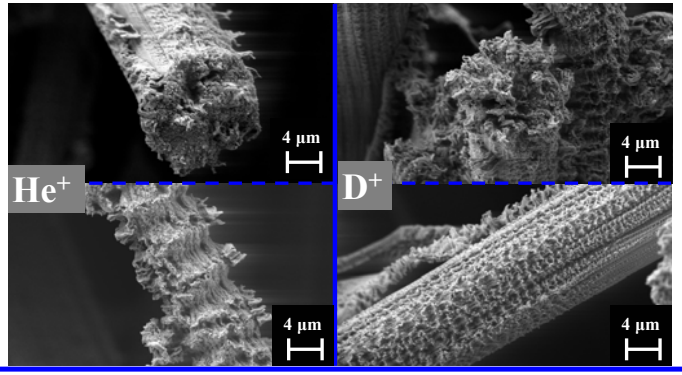


•Tungsten-coated carbon-carbon velvet (CCV/W) irradiated with He^+ to a fluence of $1x10^{19}$ ions/cm^2 at ~1150 °C

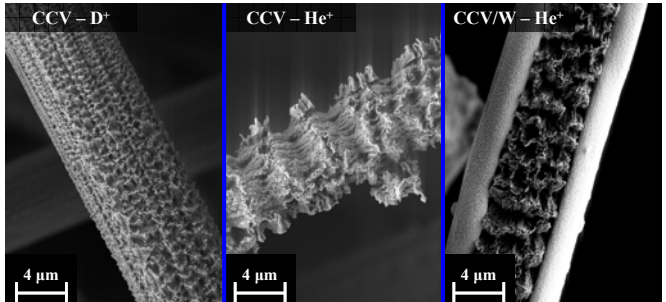


He^+ and D^+ Irradiation of CCV and CCV/W

•CCV irradiated with He^+ and D^+ to a fluence of $1x10^{19}$ ions/cm^2 at ~1150 °C



•CCV irradiated with He^+ and D^+ and CCV/W irradiated with He^+ to fluences of $1x10^{19}$ ions/cm^2 at ~1150 °C



CCV – 10^{19} D^+/cm^2 @ 1150 °C | CCV – 10^{19} He^+/cm^2 @ 1150 °C | W/CCV–10^{19} He^+/cm^2@1150°C

CCV and CCV/W Conclusions

- Both He^+ and D^+ irradiation of carbon-carbon velvet specimens cause fiber shaft corrugation, though He^+ irradiated samples have a more pronounced effect.
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- Some W-coated carbon fiber shafts incur rupturing, in addition to increased W surface roughness after He^+ irradiation
- Each sample experiences measurable mass loss after irradiation

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