Ion Implantation Effects on CVD SiC and Carbon-Carbon Velvet

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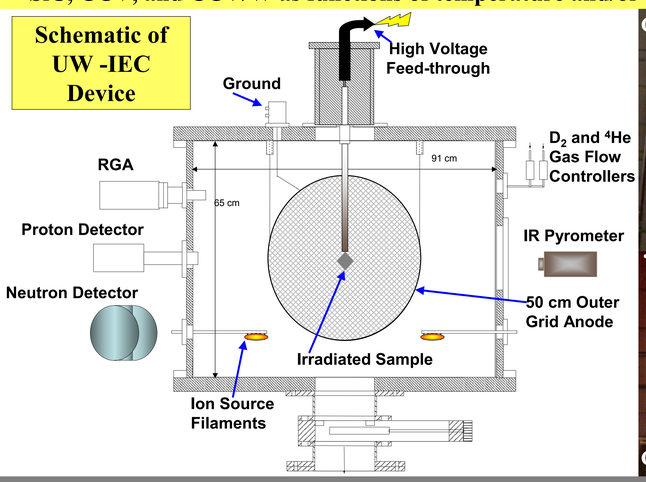
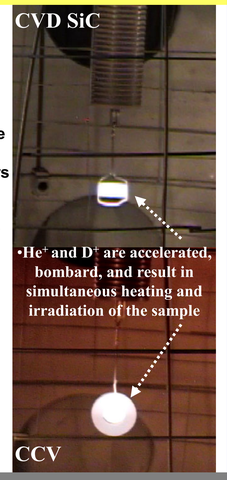
Materials Irradiation Experiments and the UW-Madison IEC Device

Summary of Presented Experiments

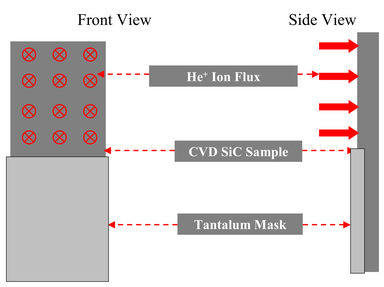
- **SRIM calculations have been used to estimate the range of He^+ in CVD silicon carbide (SiC) as well as the range of He^+ and D^+ in carbon-carbon velvet (CCV) and tungsten coated carbon-carbon velvet (CCV/W).**
- **CVD SiC samples (supplied by ORNL) were irradiated in the UW IEC device to $1x10^{18}$ and $1x10^{19}$ He^+/cm^2 at 850 and 950 °C.**
- **A partially masked SiC sample was irradiated to ~$1.5x10^{19}$ He^+/cm^2 at 950 °C**
- **CCV and CCV/W samples were irradiated to $1x10^{19}$ He^+/cm^2 at 1150°C and a CCV sample was irradiated to $1x10^{19}$ D^+/cm^2**
- **SEM analysis has been performed to evaluate the surface damage on the CVD SiC, CCV, and CCV/W as functions of temperature and/or fluence.**

Schematic of UW -IEC Device

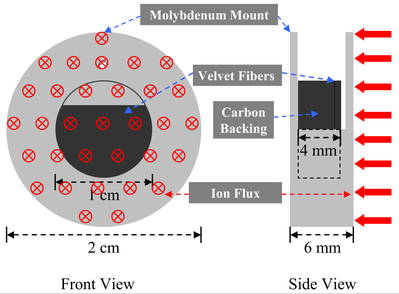




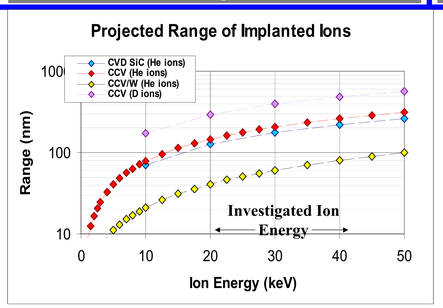
SRIM Range Calculations and Sample Setup



Sample Mount Schematic for masked CVD SiC Sample



Molybdenum Irradiation Holster for CCV and CCV/W



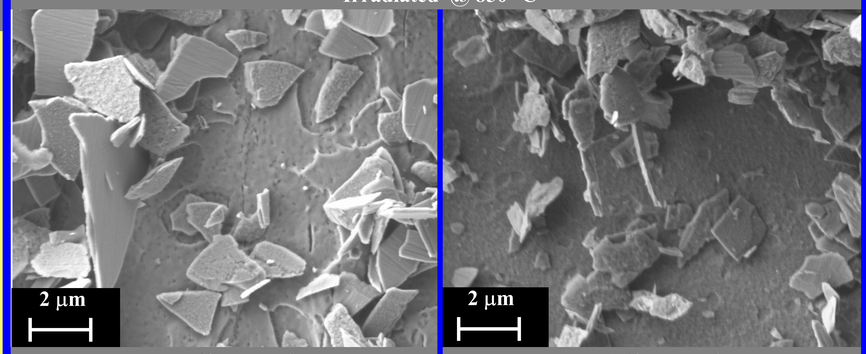
•To the left, ion ranges in CVD SiC, CCV, and CCV/W are shown as a function of the IEC ion energy. Investigated implantation energies are noted

•Helium ion range in the CVD SiC corresponds roughly to the flake thickness resultant from irradiation (a few microns).

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

He^+ Irradiation of CVD SiC

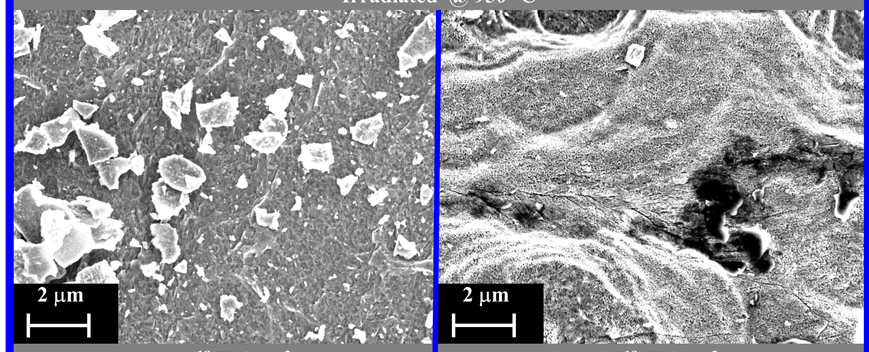
Irradiated @ 850 °C



$1x10^{18}$ He^+/cm^2 | **$1x10^{19}$ He^+/cm^2**

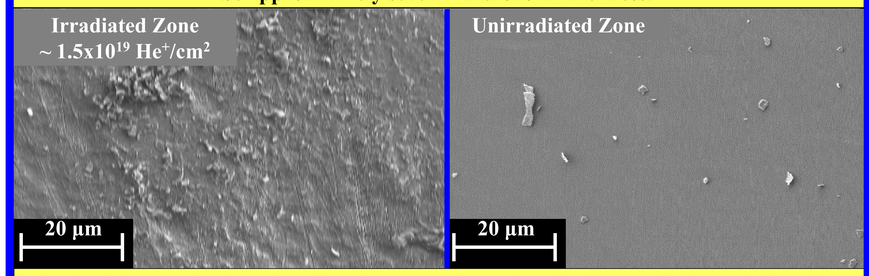
At 950 °C we notice flaking and pore formation in the $1x10^{18}$ He^+/cm^2 sample and an increased level of pore formation in the sample irradiated to $1x10^{19}$ He^+/cm^2

Irradiated @ 950 °C



$1x10^{18}$ He^+/cm^2 | **$1x10^{19}$ He^+/cm^2**

Once again excessive flaking is evident on both specimens, though the level of pore formation is not as high as the $1x10^{19}$ He^+/cm^2 and 950 °C specimen. These flakes appear to be approximately several microns in thickness.



Lack of damage in the unirradiated zone confirms that the damage is due to helium ion fluence. The particles in the unirradiated zone are most likely a post-irradiation artifact.

SiC Conclusions

- **Significant changes in SiC surface morphology occur at both 850 and 950 °C and fluences ($1x10^{18}$ He^+/cm^2 to $1x10^{19}$ He^+/cm^2)**
- **At constant He^+ fluence, the characteristic damage of the sample is a function of the temperature at which the sample is irradiated**
- **However, ion fluence - NOT temperature, causes these surface morphology changes**

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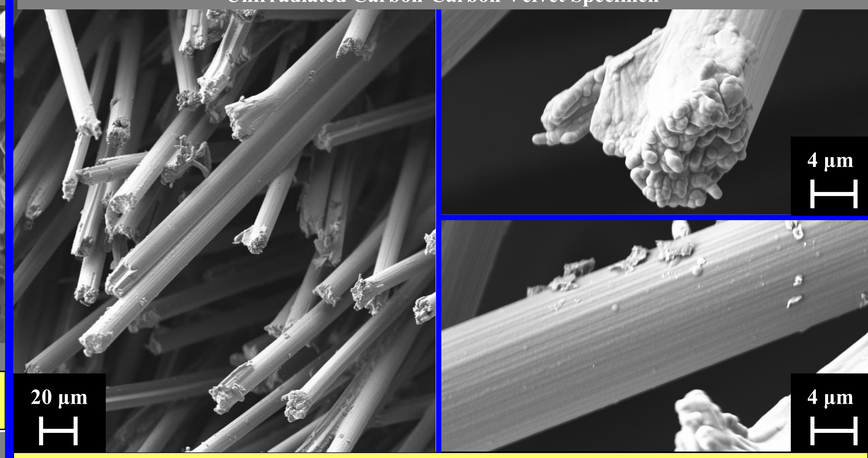
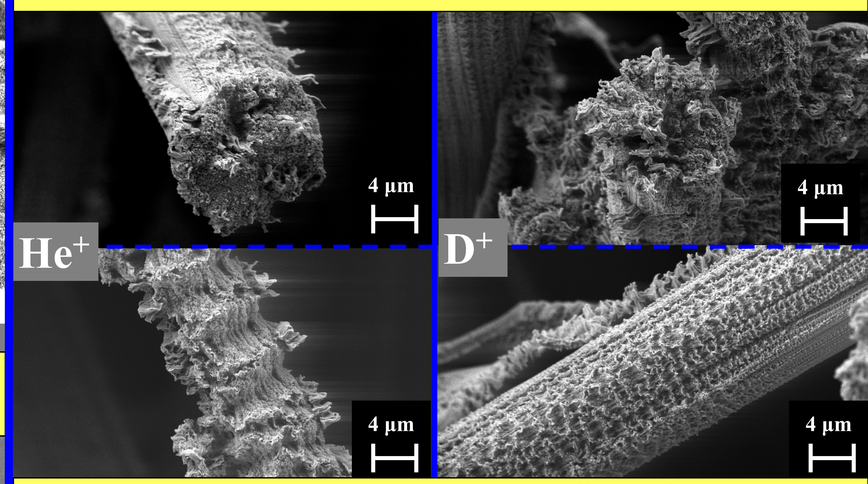
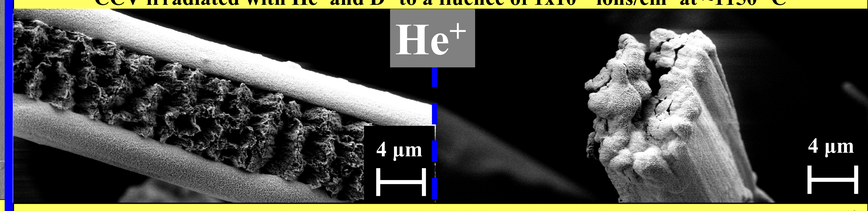
He^+ and D^+ Irradiation of CCV and CCV/W

Unirradiated Carbon-Carbon Velvet Specimen





CCV irradiated with He^+ and D^+ to a fluence of $1x10^{19}$ ions/cm² at ~1150 °C



Tungsten-coated carbon-carbon velvet (CCV/W) irradiated with He^+ to a fluence of $1x10^{19}$ ions/cm² at ~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.**
- **Both He^+ and D^+ irradiation of carbon-carbon velvet specimens causes fiber shaft corrugation, though He^+ irradiated samples have a more pronounced effect**
- **Some W-coated carbon fiber shafts incur rupturing, in addition to increased W surface roughness after He^+ irradiation**