**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 \( \text{He}^+ \) and \( \text{D}^+ \) in carbon-carbon velvet (CCV) and the range of \( \text{He}^+ \) tungsten coated carbon-carbon velvet (CCV/W).
- CCV and CCV/W samples were irradiated to \( 1 \times 10^{19} \text{He}^+/\text{cm}^2 \) at ~1150°C and a CCV sample was irradiated to \( 1 \times 10^{19} \text{D}^+/\text{cm}^2 \).
- 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.

### Ion Range & Carbon-Carbon Velvet Composition

<table>
<thead>
<tr>
<th>Base</th>
<th>CCV</th>
<th>CCV/W</th>
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</thead>
<tbody>
<tr>
<td>Pitch</td>
<td>Carbon</td>
<td>CVD Pyrolytic Carbon Coating</td>
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- **He** and **D** Irradiation of CCV and CCV/W
  - 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, \( \text{He}^+ \) and \( \text{D}^+ \) 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

- \( \text{CCV} \) and \( \text{CCV/W} \) irradiated with \( \text{He}^+ \) to a fluence of \( 1 \times 10^{19} \text{ions/cm}^2 \) at ~1150°C
- \( \text{CCV} \) and \( \text{CCV/W} \) irradiated with \( \text{D}^+ \) to a fluence of \( 1 \times 10^{19} \text{ions/cm}^2 \) at ~1150°C

### CCV and CCV/W Conclusions

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

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