Vapor Deposition in IEC to increase Neutron Production

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Background
Objective
Increase fusion rates by increasing deuterium target density for high energy neutrals that collide with the first wall.

High Energy Neutrals
As ions are accelerated towards the IEC grid they collide with neutral atoms and scatter them towards the first wall. If they collide with a high-density titanium target at the wall, they will generate fusion in the device walls.

Depositing Titanium in Vacuum

In vacuum:
- Titanium has no liquid phase
- Gaseous Ti will propell linearly from cartridge

For this reason two cartridges were employed to:
- Minimize the shadow effect of the top and bottom of one cartridge
- Minimize the shadow effect of electrical leads
- Increase overall amount of Ti being deposited in order to reduce amount of depositing time.

Operation Parameters:
- The cartridges operated at ~30 V and 40 A
- Deuterium pressure was kept at ~ 0.5 Pa
- The thickness was selected to be no less than 0.3 micron at the thinnest location (19 hours of deposition time)

Future Work

- Titanium on the outer grid seems to cause more arching which prohibits steady operation at higher voltage
- If cartridges were installed in the chamber so venting was not necessary between deposition and running the effect of oxidation could be eliminated and the thickness could be increased if desired.
- A substance that reacts with hydrogen species in a similar fashion is amorphous silicon. A study of this substance could lead to higher rates.

Results

Neutron Rated vs. Cathode Voltage

30 mA, 2.5 mTorr D$_2$

<table>
<thead>
<tr>
<th>Cathode Voltage (kV)</th>
<th>Neutron Rate (n/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$1.0\times10^5$</td>
</tr>
<tr>
<td>2</td>
<td>$1.3\times10^5$</td>
</tr>
<tr>
<td>4</td>
<td>$1.6\times10^5$</td>
</tr>
<tr>
<td>6</td>
<td>$1.8\times10^5$</td>
</tr>
<tr>
<td>8</td>
<td>$2.0\times10^5$</td>
</tr>
</tbody>
</table>

Titanium Coating

- Neutron rates were increased by as much as 30% when titanium was applied to the UW-IEC walls
- Titanium on the outer grid seems to cause more arching which prohibits steady operation at higher voltage
- If cartridges were installed in the chamber so venting was not necessary between deposition and running the effect of oxidation could be eliminated and the thickness could be increased if desired.
- A substance that reacts with hydrogen species in a similar fashion is amorphous silicon. A study of this substance could lead to higher rates.

Conclusions

- The NEC TS-20 was a simple and easy tool to accomplish titanium deposition
- Partially shadowed microscope slides were used successfully to determine titanium thicknesses
- The titanium’s ability to absorb hydrogen species was observed when venting the chamber with deuterium
- Neutron rates were increased by as much as 30% when titanium was applied to the UW-IEC walls