Vapor Deposition in IEC to increase Neutron Production

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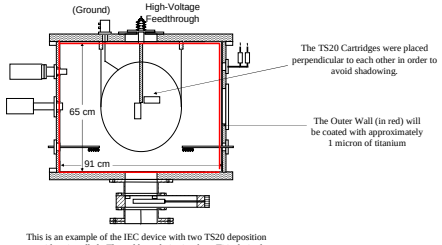
Background

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.



This is an example of the IEC device with two TS20 deposition cartridges installed. The red boundaries is where Ti is desired.

Titanium is known for readily absorbing hydrogen species. Vapor depositing an approximately 1 micron thick layer of Ti on the first wall of the IEC and exposing it to deuterium gas will cause a titanium-deuteride crystal to form. This suspended deuterium on the wall will act as a target for high energy neutral atoms.

The National Electrostatics Corp's TS-20 Ti Sublimation Cartridge was selected for the job due to it's reusability and simplicity.

Two cartridges were placed in parallel oriented in order to minimize shadowing effect. The cartridge had an inner filament that heated an outer cylinder of Ti and caused sublimation.

Experimental Setup

Depositing Titanium in Vacuum

In vacuum:

- Titanium has no liquid phase
- Gaseous Ti will propel 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.

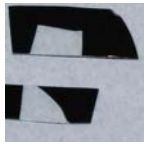
Operation Parameters:

- 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)

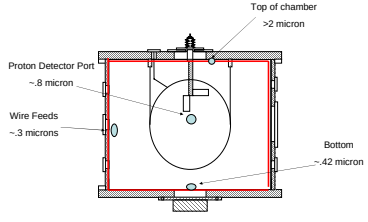
Microscope Slides for Measurement

In order to measure the thickness of the Ti deposited on the outer wall, microscope slices were placed around the chamber and partially covered in order to have a shadowed effect.

Here the shadow effect on the first wall is very obvious with the lighter colored stainless steel and the darker Titanium.



The slides themselves were partially covered in order to have a step that could be measured by an Alpha-step microscope*.



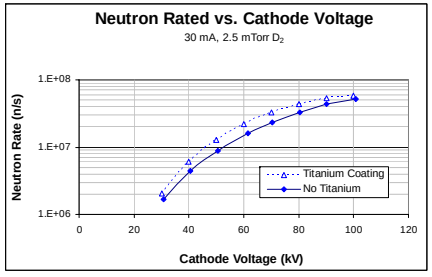
This schematic of the IEC Fusion Device shows the thickness of the Ti layer at different parts of the first wall.

*Special Thanks to the UW Microelectronics Center for assistance in measuring layers.

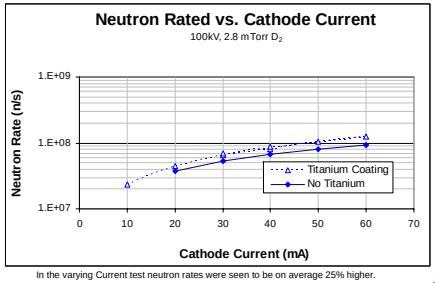
Future Work

- 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



In the varying Voltage test, neutron rates were seen to be on average 30% higher.



In the varying Current test neutron rates were seen to be on average 25% higher.

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