中国科学技术大学
University of Science and Technology of China

Ultrahigh Vacuum Technology Status at NSRL

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NSRL 中国科学技术大学 国家同步辐射实验室 NATIONAL SYNCHROTRON RADIATION LABORATORY

Outline

- **Key technologies of vacuum chamber for future Accelerator**
- **Vacuum technology status at NSRL**
- **Our future plans**

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Key technologies of vacuum chamber for future Accelerator

★ **NEG-coated vacuum chambers** enable small apertures and high magnet gradients.

★ **Lower activation temperature films** to avoid deformation or oxidation, also for energy conservation

★ **Lower SEY(Secondary Electron Yield) materials for** inhibition of electron cloud

★ **Lower ultimate pressure**

★ **Less space** for installation of vacuum pumps

★ **Cleaner and more smooth** inner surface of vacuum chamber

*Vacuum technology status at **NSRL***

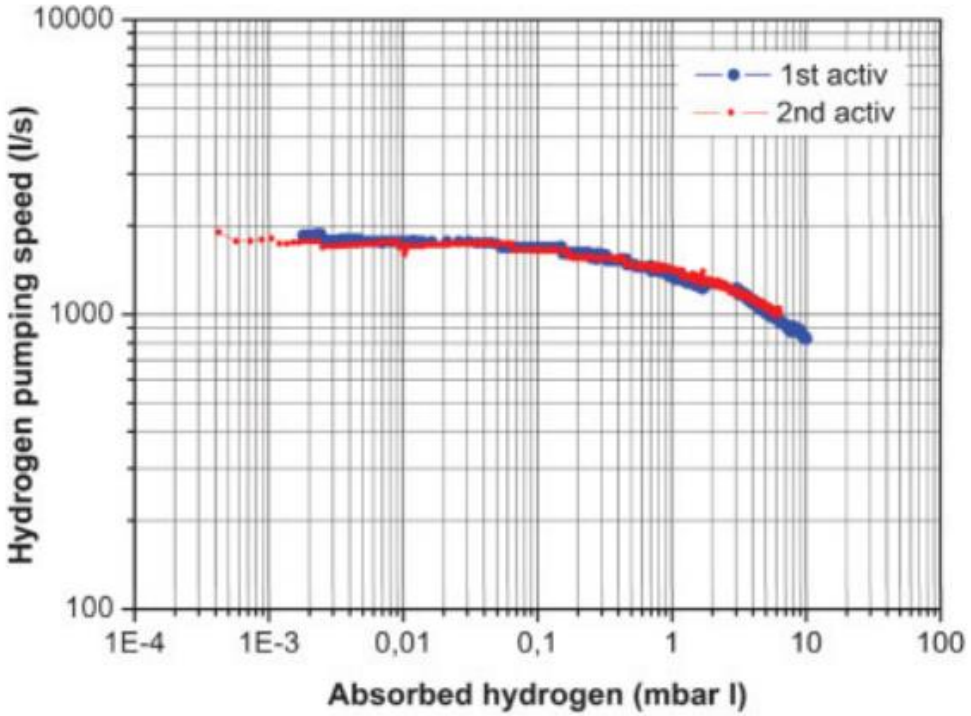
- ***1. TiZrV/Pd NEG film***

※ Advantage

★ The H_2 sorption capacity of the NEG-Pd film is higher compared with TiZrV film.

★ The number of possible regenerations is, in principle, endless.

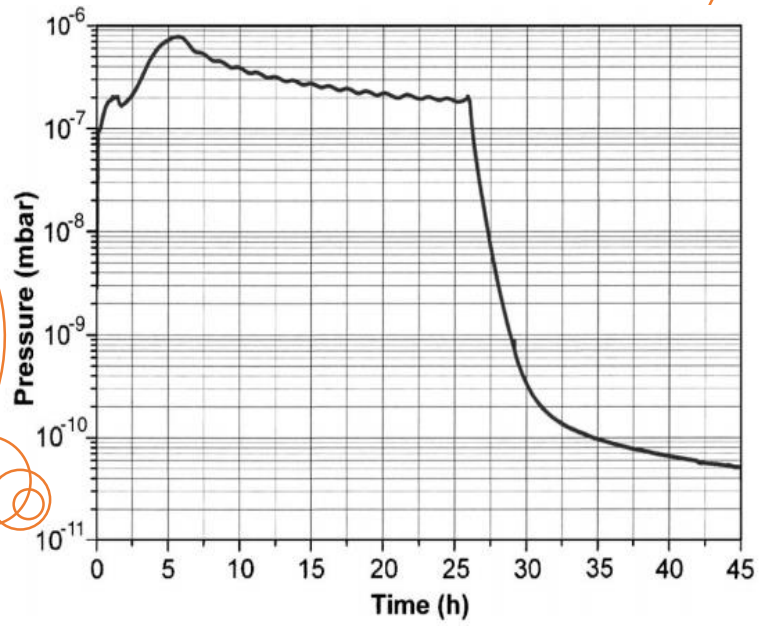
★ the lifetime of the film is strongly enhanced.



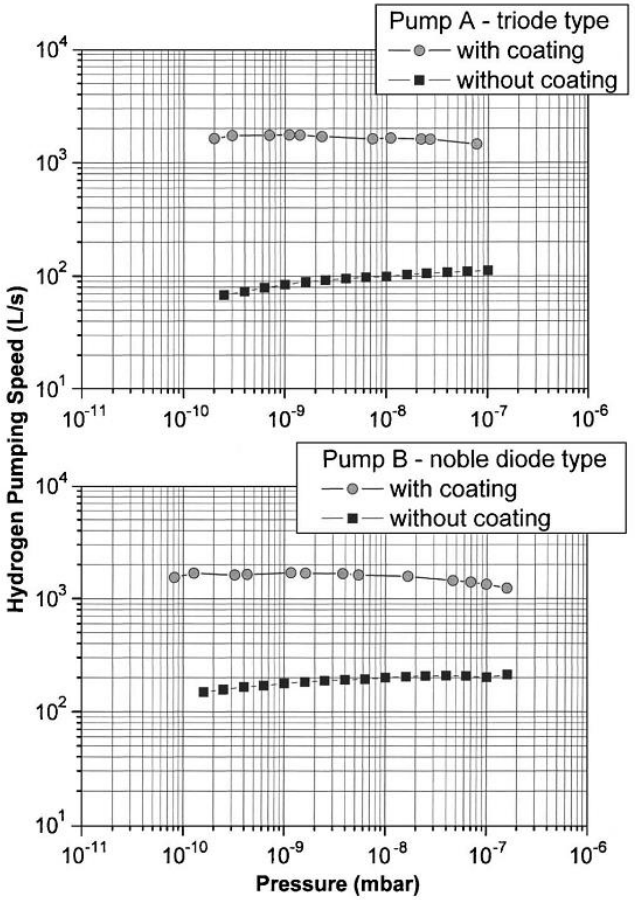
*Vacuum technology status at **NSRL***

- ***1. TiZrV/Pd NEG film***

Typical pressure descent at the end of the baking-activation cycle for a NEG-Pd-coated pump.



Hydrogen pumping-speed curves for pumps A and B, plotted as a function of pressure. The behavior of the NEG-Pd-coated pumps is compared to that of identical pumps, subjected to the same thermal cycle, but without the film.



Vacuum technology status at ***NSRL***

- **2. TiZrV coated stainless steal pipes (10 years ago)**

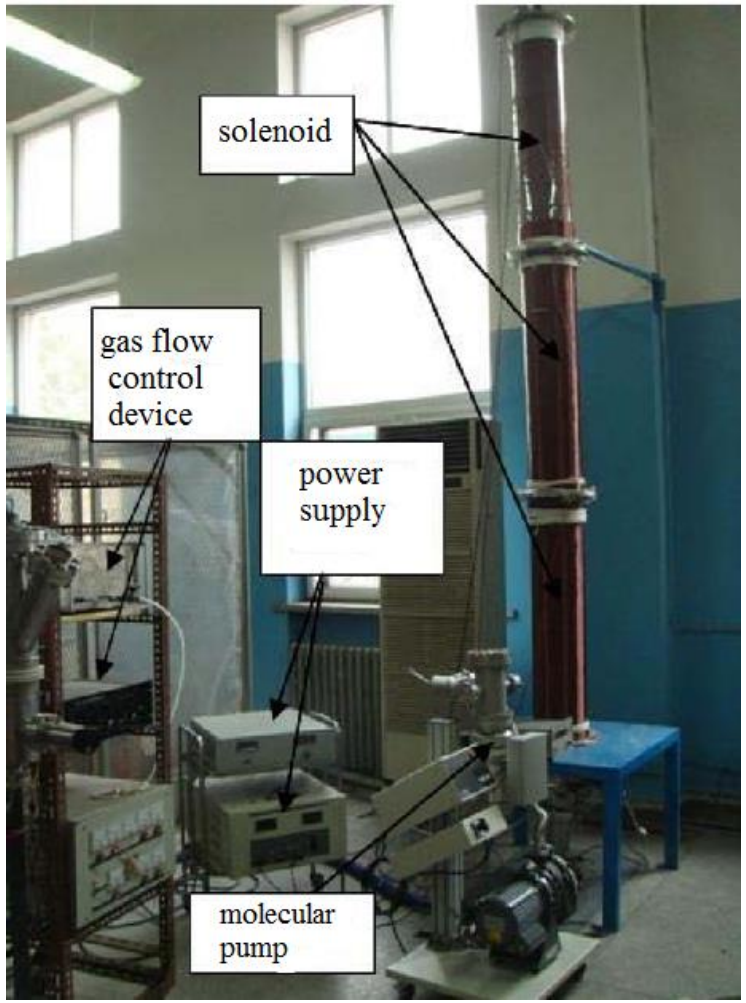
★ TiZrV coated undulator vacuum chamber at Hefei light with a size of Φ 86 mm x 3000 mm

★ Also, film coating on 5 meters long pipes' inner surfaces are OK for us.

★ Straight and curved pipes are OK for us.

- **Current running situation**

★ TiZrV coated undulator pipes had been installed in Hefei light source storage ring.



*Vacuum technology status at **NSRL***

- ***3. TiZrHfV NEG film***

  ※ Advantage

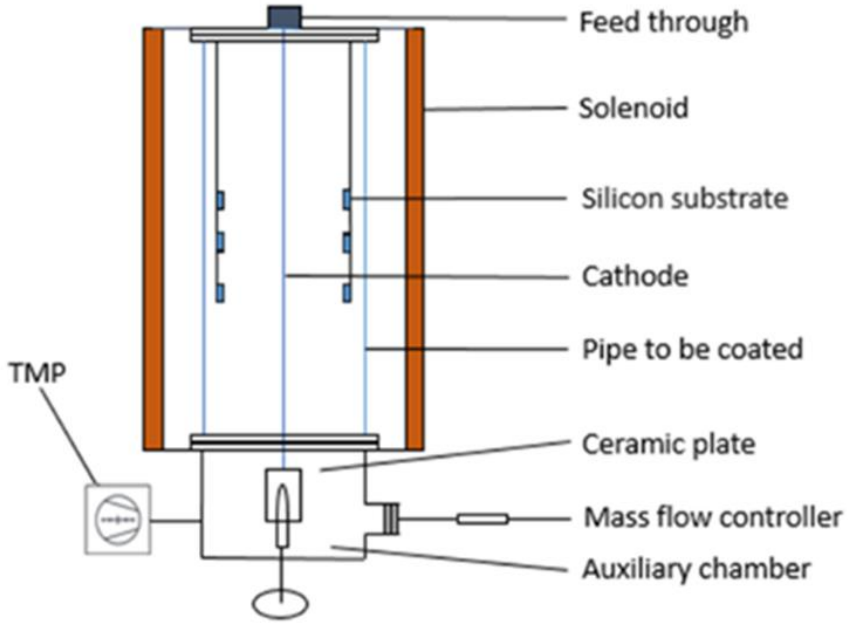
  ★ Low activation temperature

  (reduced to 150℃）

TiZrHfV NEG film coating equipment at NSRL.

*Vacuum technology status at **NSRL***

- ***3. TiZrHfV NEG film***

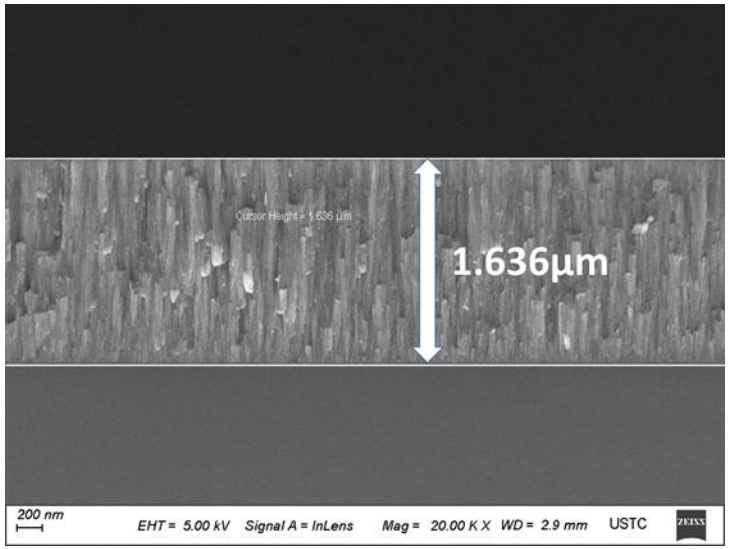


Direct current (DC) magnetron sputtering

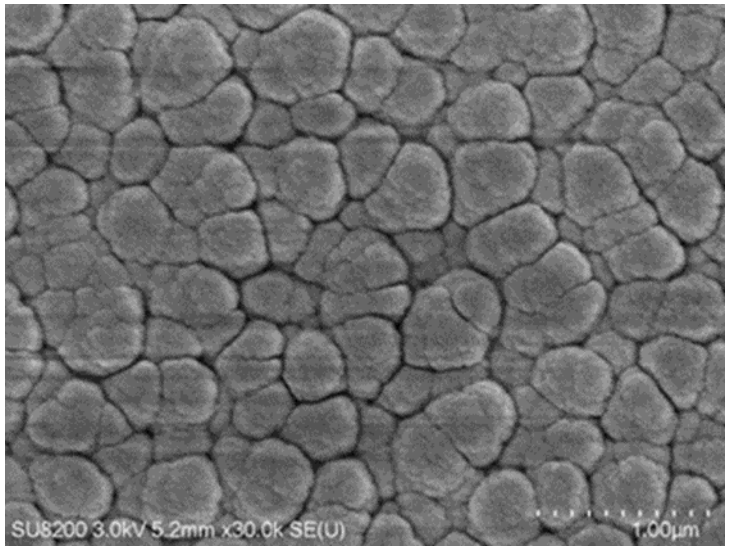
The material of pipe to be coated：
Stainless steel
Pipe size： Φ86 mm×540 mm
Discharge gas： High purity Kr gas
Pumping system： Oil-free molecular pump unit
Solenoid coil： Wrapped from a 2.5 mm copper enameled wire
Cathode target: Four twisted metal wires (Ti, Zr, Hf and V) with a diameter of 2 mm
DC power supply： 3KW

*Vacuum technology status at **NSRL***

- ***3. TiZrHfV NEG film***



Cross section of the Ti-Zr-Hf-V film obtained by SEM

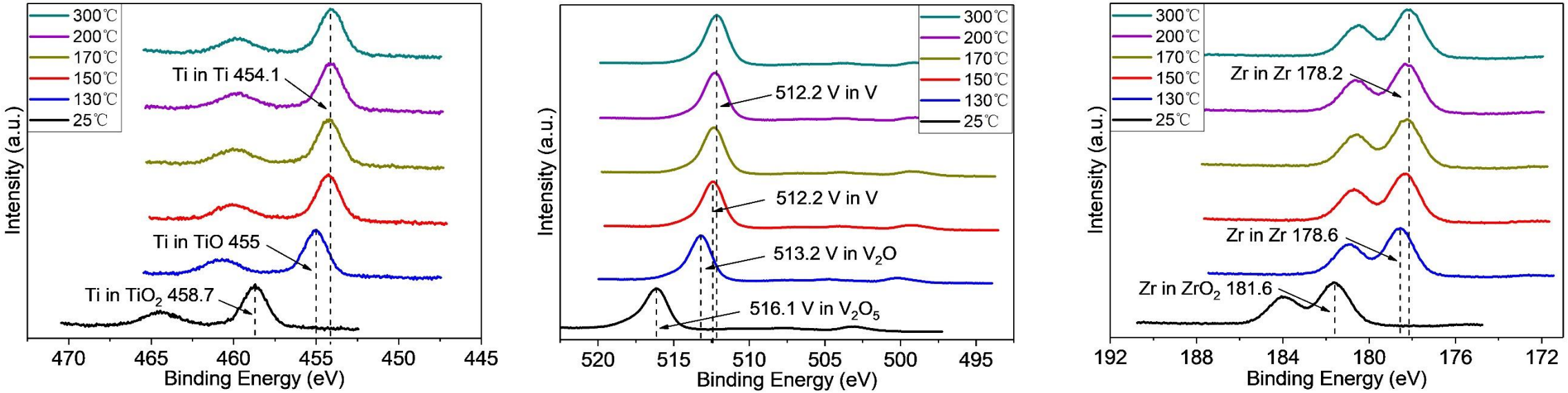


Surface Observation of the Ti-Zr-Hf-V film obtained by SEM

*Vacuum technology status at **NSRL***

- ***3. TiZrHfV NEG film***

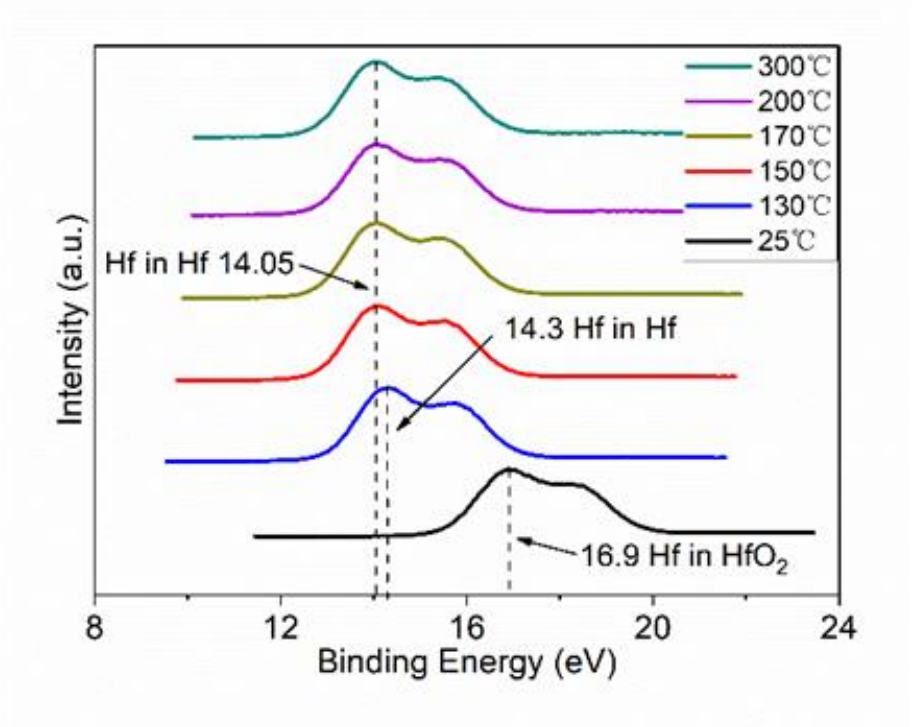
Use XPS to measure the activation temperature of the TiZrHfV NEG



The substrate was gradually heated from room temperature to 130 ℃, 150℃,170 ℃, 200 ℃ and 300 ℃ with a heating rate of 5 ℃/min and held at each target temperature for 30 min

*Vacuum technology status at **NSRL***

- ***3. TiZrHfV NEG film***



Hf 4f XPS spectra of TiZrHfV film at various heating temperatures

★ The oxides of Ti and V have been reduced to the metal state at 150 °C while the reduced temperature of Zr and Hf oxides are 130 °C.

★ The TiZrHfV film has completed the transformation of oxides to sub-oxides and metals at relatively low temperatures.

Lower activation temperature of TiZrHfV NEG film compared to traditional TiZrV NEG film.

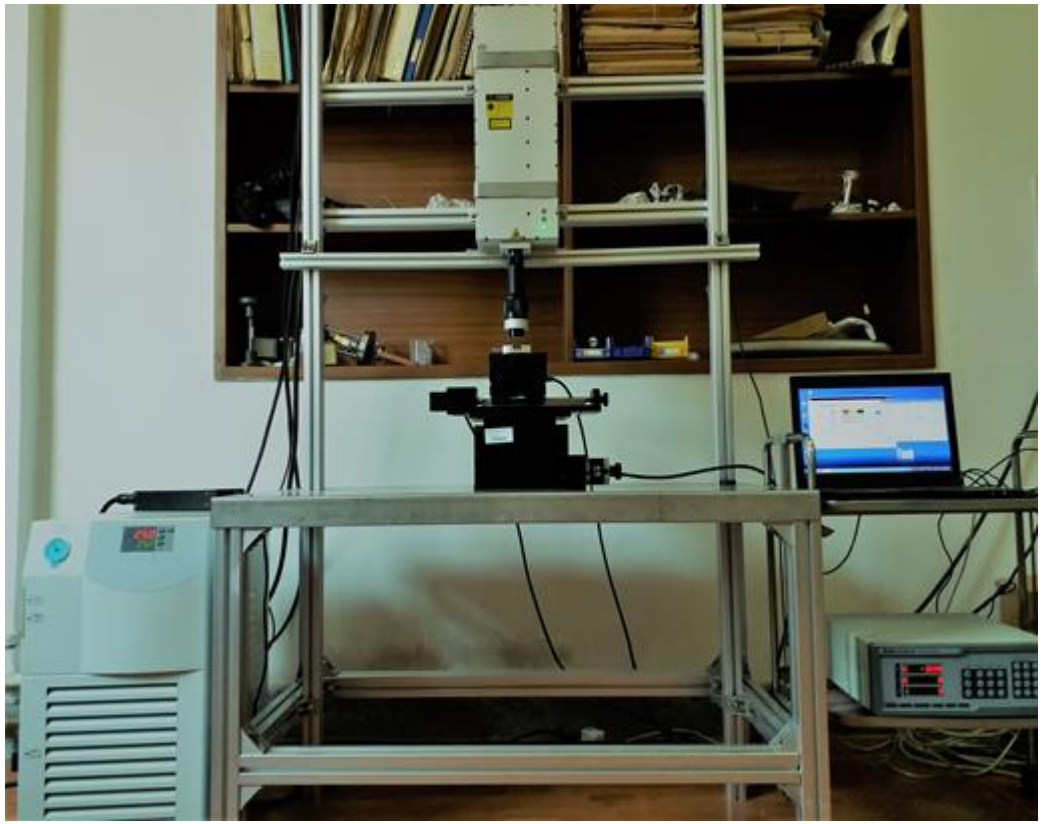
*Vacuum technology status at **NSRL***

- ***4. Laser Treatment***

※ Advantage

★ Low SEY(Secondary Electron Yield)

★ Low cost, esay to carry out, and good stability



Laser Treatment equipment at NSRL.

Our future plans

- ***1. Lower activated-temperature film***
  - ★ Wider application range
  - ★ Energy conservation
  - ★ Further investigation in this direction is needed.
- ***2. Establish a film coating equipment for small apertures vacuum chambers***

Our future plans

- ***3. Test more materials***

★ measuring the SEY of different material which are used for beam chambers;

★ investigating the effect of temperature, incident angle, cleanliness, current intensity on the SEY of different materials;

★ comparing different materials and mitigation coatings.

Our future plans

- ***4. Develop new low SEY materials≤1.2***

★ Different coatings on the stainless steel base will be studied to reduce the wall impedance and secondary electron yield at 4-60 K.

★ The possibility of further improvement by substituting palladium with other Pd-based alloys will also be evaluated.

★ Amorphous carbon coatings technology .

Thank You

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