# Photodesorption and Photoelectron Yields from 150-nm Thin NEG Coatings

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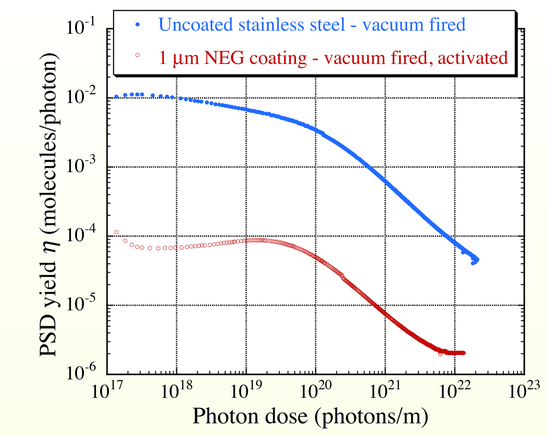
## Thinner NEG Coatings for Advanced Accelerator Vacuum Systems

In **the FCC-ee high-luminosity collider** and **future high-brightness synchrotron radiation (SR) sources**, the fundamental properties of **Ti-Zr-V non-evaporable getter (NEG) coatings**, namely, high effective pumping speeds, low photon stimulated desorption (PSD) yields, and low total electron yields, are expected to be efficiently exploited.

On the other hand, there is an **increasing demand for thinner NEG coatings** in such advanced accelerators because stored beams are more likely to be susceptible to the **resistive wall impedance** generated by NEG coatings. Since reducing the film thickness **may limit a maximum number of venting/activation cycles** due to its small bulk capacity, the NEG surface after several activation cycles can be saturated with adsorbed oxygen and carbon.

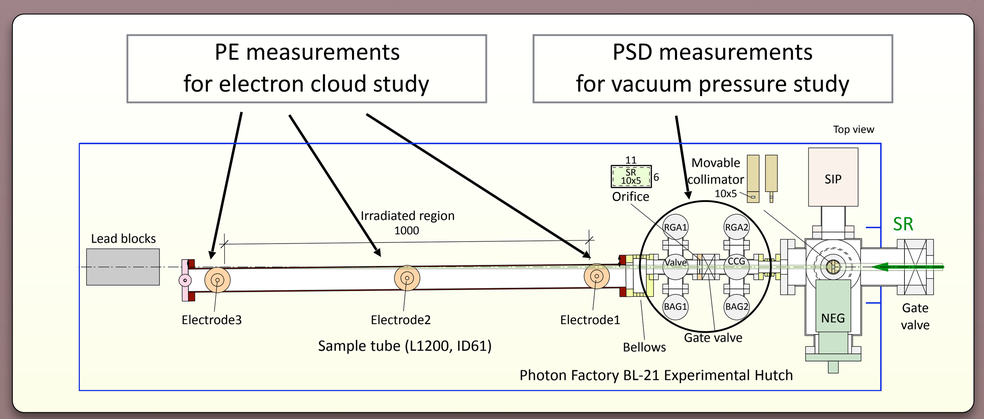
Nevertheless, the vacuum systems utilizing such thin NEG coatings have a potential to perform satisfactorily if the PSD yields quickly reach **$10^{-6}$ molecules/photon**, the same order as those of standard 1-μm NEG coatings and about two orders of magnitude lower than uncoated surfaces.

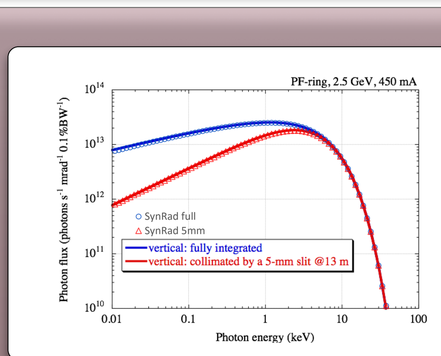



M. Ady et al., Proceedings of IPAC2015, 3123.

## Experimental setup

In order to investigate **the aging effects** on these properties of thin NEG coatings, **PSD and photoelectron (PE) yields** from **a 150±30 nm NEG coating** deposited at CERN in a 1.2 m long vacuum tube are measured on an SR beamline at the KEK Photon Factory (PF).

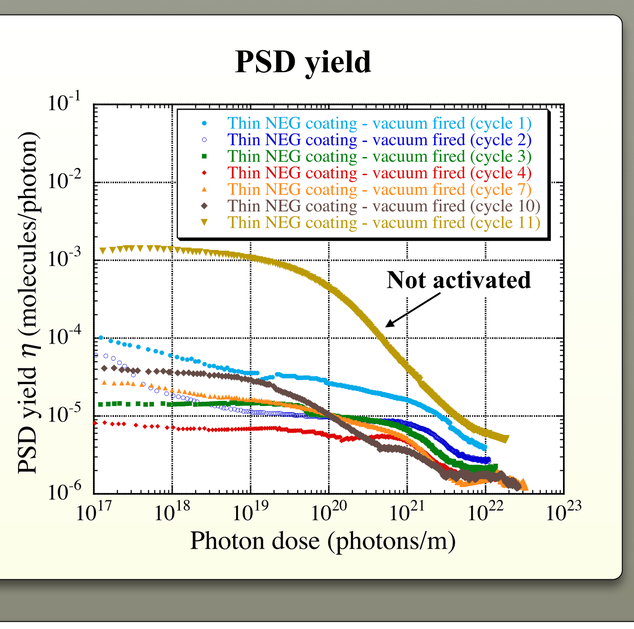


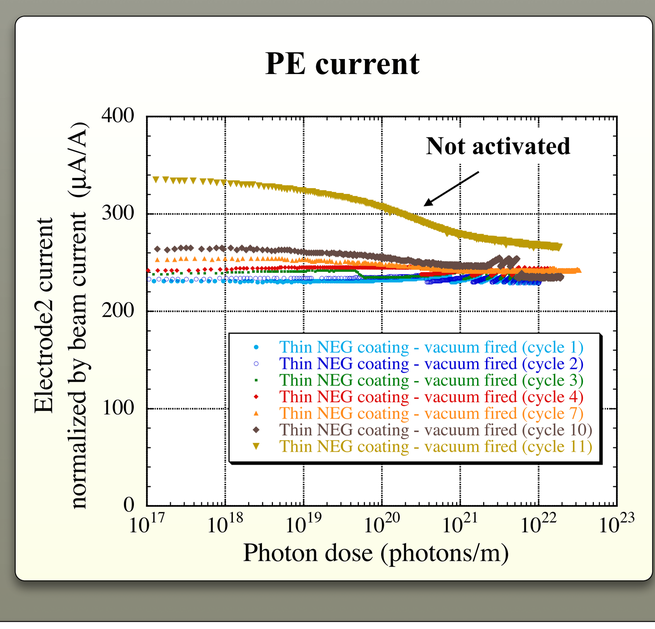

**SR Parameters on sample tube:**
- **Critical energy : 4 keV**
- **Incident angle: 10 mrad**
- **Beam size: 5 mm (V) × 1000 mm (H)**
- **Power density: 20 W/m**
- **Photon flux: $4.6\times10^{16}$ photons $s^{-1}$ $m^{-1}$**

The sample tube underwent 11 venting/activation cycles, each of which includes:
- Venting with dry air and **exposure to atmosphere** (~50 min)
- System bakeout at 200 °C for 10~24 h (NEG coating: 120 °C)
- **NEG-coating activation** at 250 °C for 4 h
- **PSD and PE measurements** with an SR dose of about $10^{22}$ photons/m (skipped in 5th, 6th, 8th, and 9th cycles)

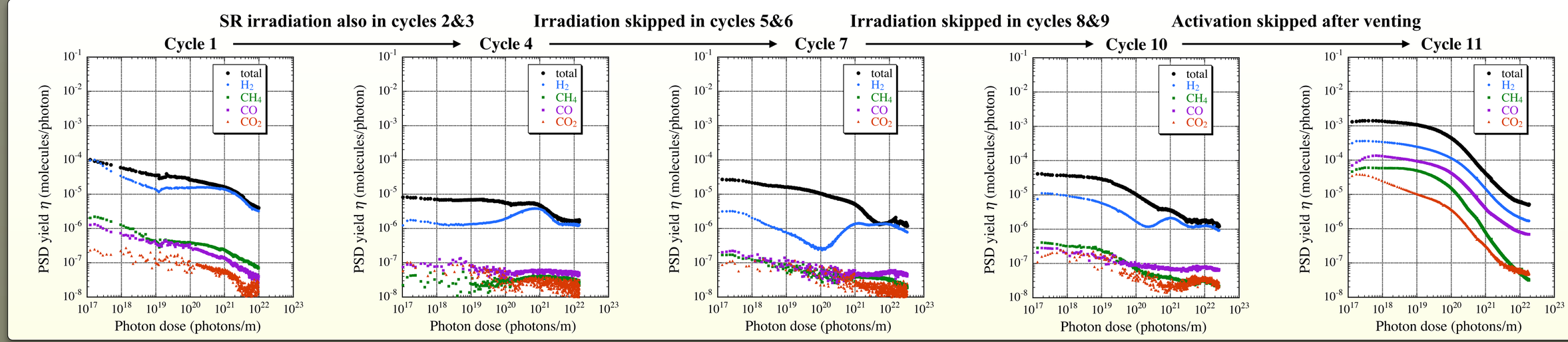
## Photon Stimulated Desorption and Photoelectron Measurements




- PSD yields of the thin NEG coating can reach as low as **$10^{-6}$ molecules/photon** after SR doses of $10^{21}$ photons/m, which is **similar to standard 1 μm thick NEG coatings**.
- **Continuous improvement in the initial PSD yields was observed up to 4 cycles**, possibly attributed to the so-called memory effect.
- Degradation appeared after cycle 7, but **the ultimate PSD yields after large SR doses reached $1\times10^{-6}$ molecules/photon up to 10 cycles**.
- Non-activated NEG coating (cycle 11) exhibited a higher PSD yield.




- **PE currents gradually degraded as the cycle repeated.**
- The PE currents of the activated thin NEG coating and their conditioning curves (almost independent on SR dose) were **similar to standard 1 μm thick NEG coatings.**
- Non-activated NEG coating (cycle 11) exhibited a higher PE current.




- **Composition ratio in the PSD outgassing was similar to those of standard 1 μm thick NEG coatings.** CH4 desorption was low enough for application to a real machine.
- **Degradation appeared after cycle 7**; continuous irradiation could have been effective to remove hydrogen in the film and in the substrate.
- **CO was relatively high on the non-activated NEG film**, suggesting that the film has no (or little if any) pumping speed for CO while the NEG surface could be slightly 'activated' by SR (even after the bulk is saturated) once thermally activated before irradiation.

## Conclusions

- In expectation of applying thin (below a few 100 nm) NEG coatings to future accelerators, **PSD yields and PE currents of a 150 nm thick NEG-film** deposited on a vacuum-fired stainless steel were **measured repeatedly with cycles of air-exposure and NEG-activation**.
- Even though the thin NEG coating is considered to have a limited bulk capacity (i.e., little pumping speed after a few cycles), **no degradation in the ultimate PSD yield was observed up to 10 cycles**.
- **Activation of the NEG coating is surely effective to reduce both the PSD and PE yields** even after the film has undergone multiple venting/activation cycles.
- We conclude from these measurements that the thin NEG coatings will be able to **provide a low pressure and a low electron emission in a real machine** as long as it is activated.