

Surface treatment procedures to mitigate ion-induced desorption in heavy ion accelerators

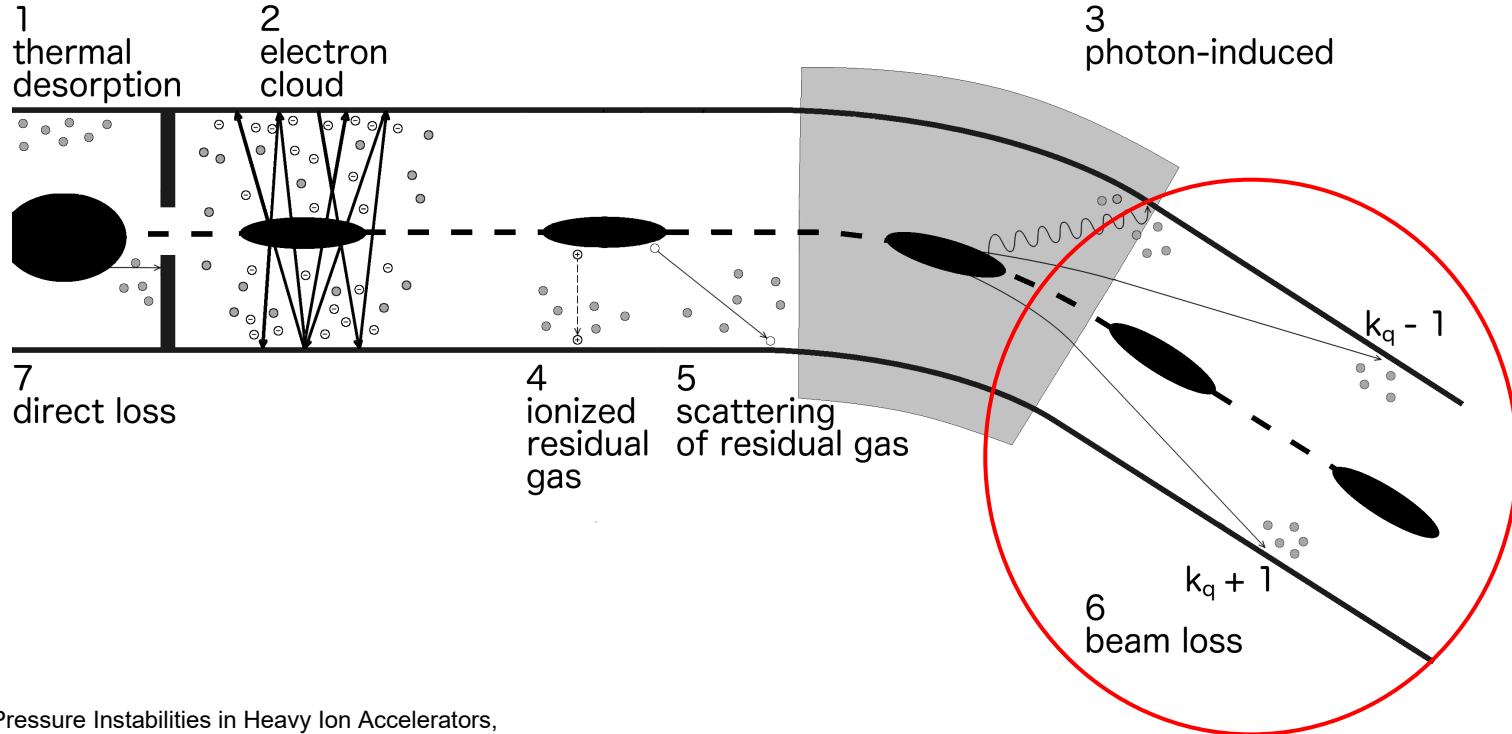
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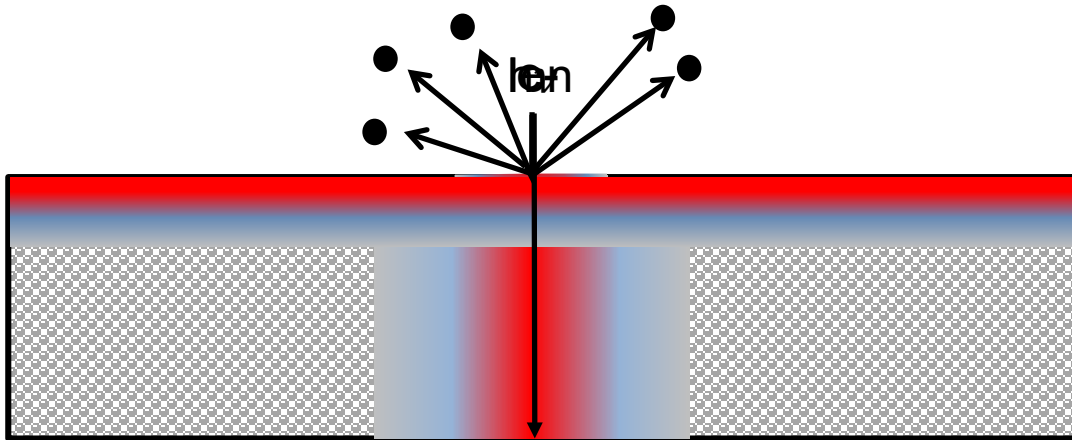
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Motivation: Dynamic vacuum problem



M. Bender, Pressure Instabilities in Heavy Ion Accelerators,
in O. B. Malyshev (ed.) Vacuum in Particle Accelerators, 2020



- Ions: large penetration depth
- Ion excite bulk atoms
→ electron cascade
→ energy is transferred to atomic lattice
→ local surface heating
→ desorption

Experimental Setup

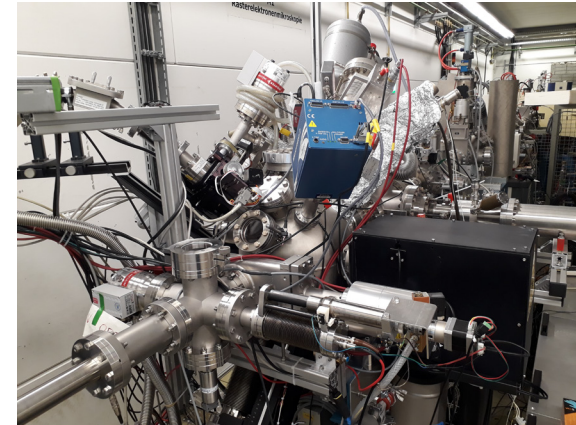
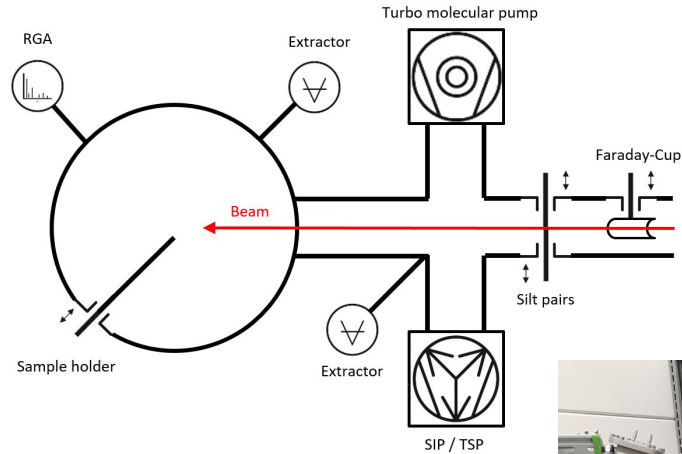
- Ions: Ca^{10+} , Ca^{19+} , Au^{26+} and Au^{52+}
- Energy: 4.8 MeV/u
- Beam line: M1 at UNILAC of GSI
- Extractor gauge and quadrupole mass spectrometer measure the pressure increase during irradiation

- Desorption Yield: $\eta = \frac{\Delta p \cdot S}{\dot{N}_{ion} \cdot kT}$

Δp : pressure increase

S: effective pumping speed

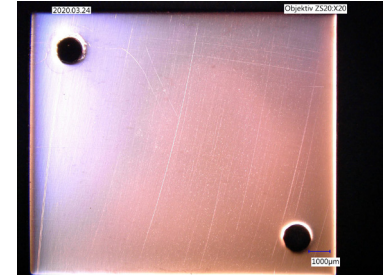
\dot{N}_{ion} : number of ions per sec



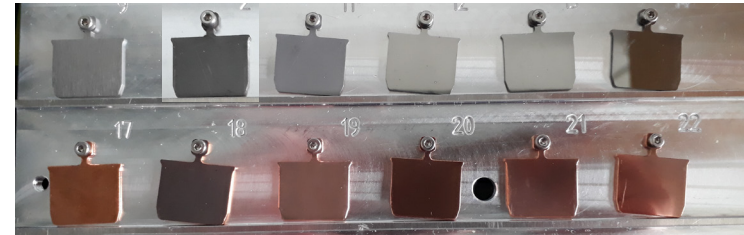
- Oxygen-free copper (OFCu) and tungsten
- Pretreatments by milling, lapping, polishing and etching
- Sputter-cleaning of OFCu samples with 5 keV argon ions
- OFCu sputter coated with TiN or carbon
- Stainless steel sputter coated with TiZrV (non-evaporable getter, NEG)



OFCu milled
(size 15x13 mm)

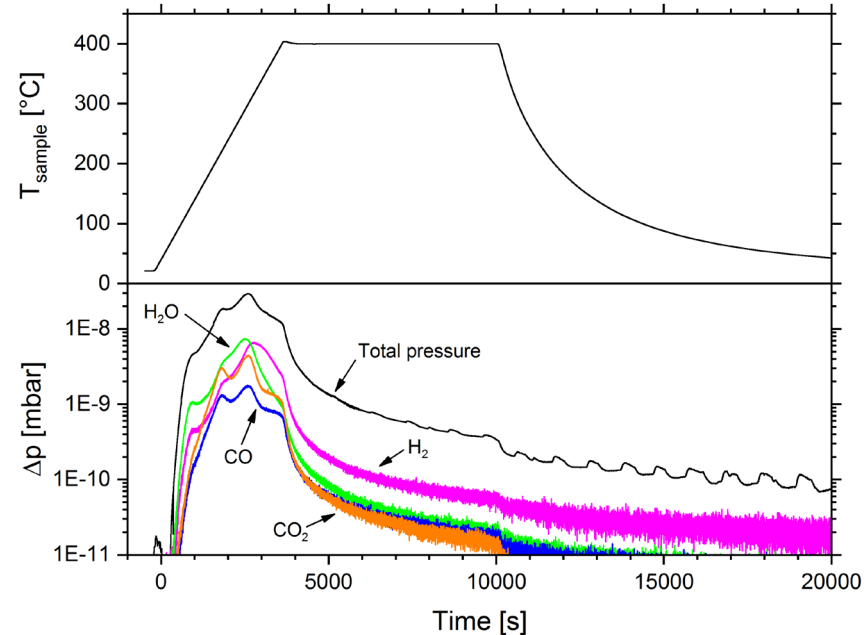


OFCu lapped + polished
(size 15x13 mm)



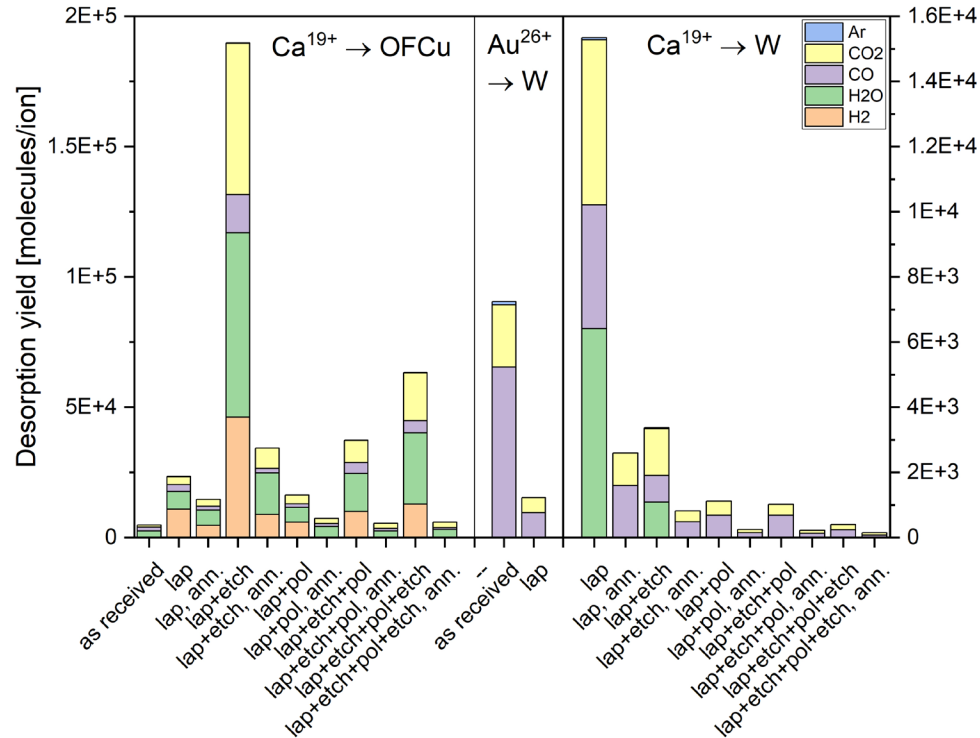
W and Cu with different treatments
(samples size 18x15 mm)

- Ex-situ annealing in separate setup
- Final temperature: 400 °C
- UHV conditions ($p_0 = 10^{-11}$ mbar)
- Duration of annealing process is determined by pressure evolution (typically ~4h)
- Effect persists for at least several month



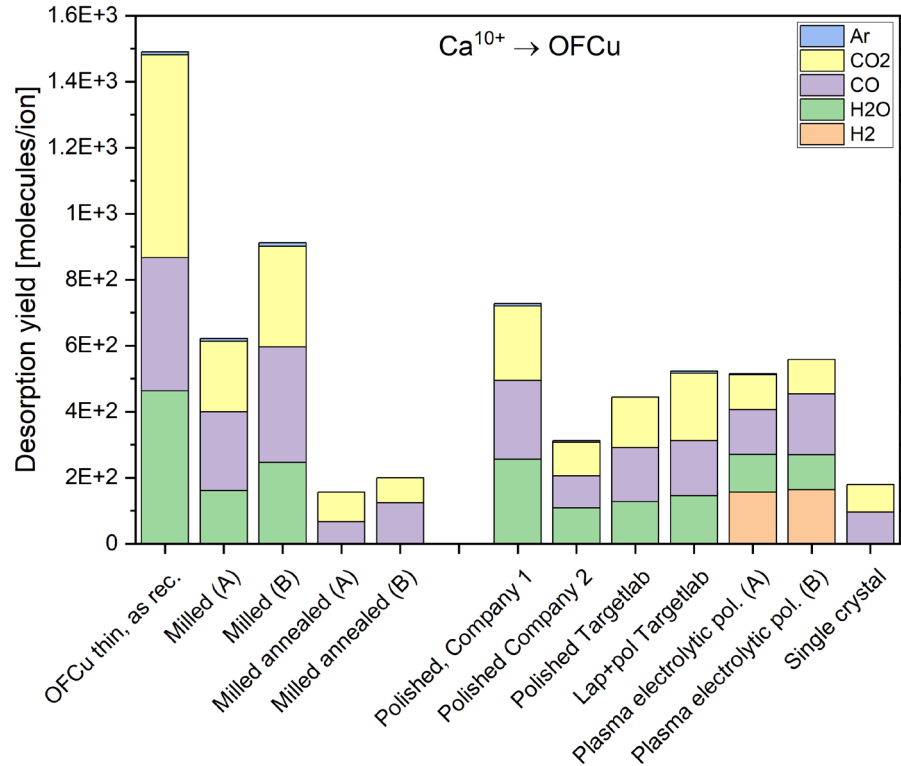
V. Velthaus et al. *Vacuum* 194 (2021) 110608

Results Surface Treatment (1)

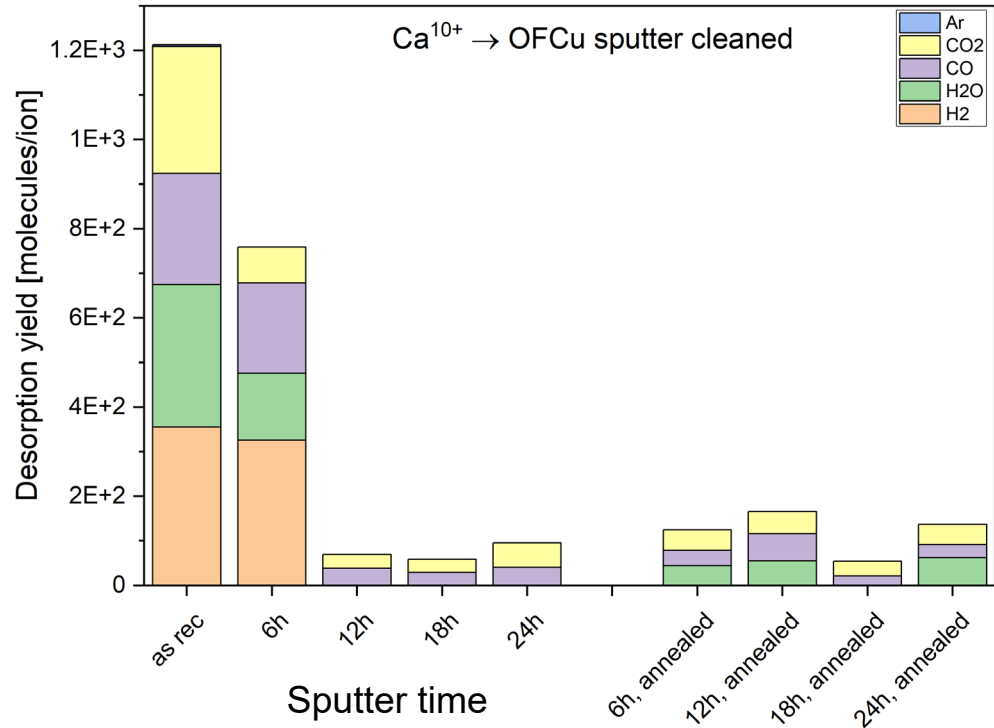


- Main gases: CO, CO₂, H₂, H₂O
- Other components: Ar, CH₄, C₂H_x and C₃H_x
- Annealing reduce desorption significantly
- Enlarged desorption yields for pretreated OFCu
- Reduced desorption for pretreated tungsten

Results Surface Treatment (2)

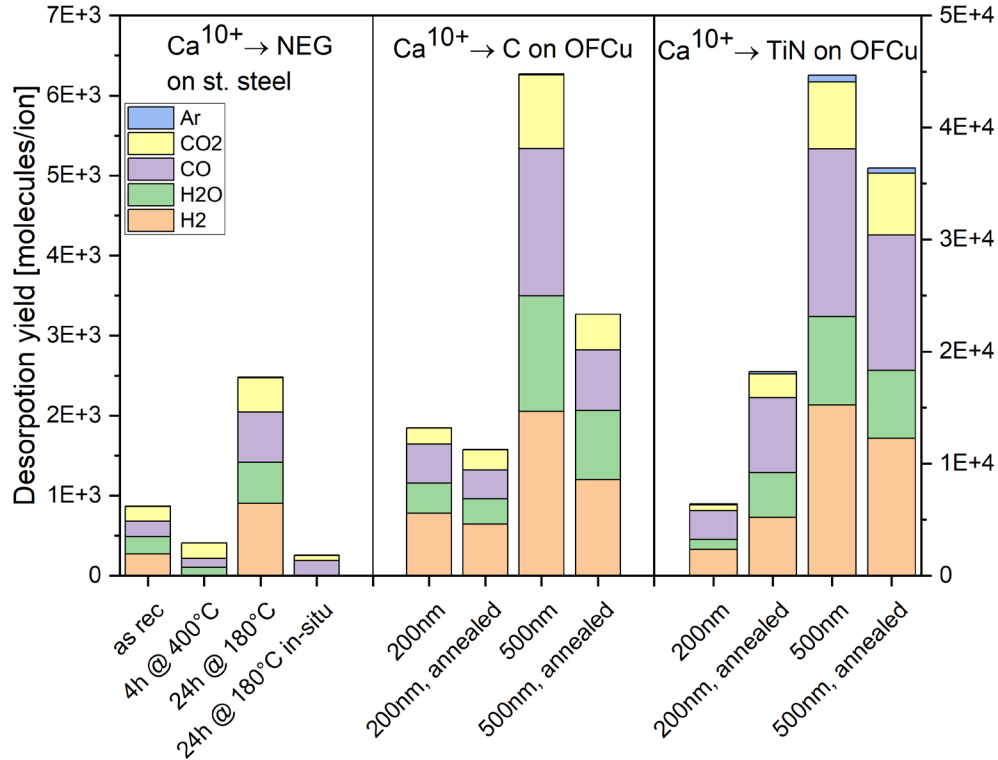


- Samples (t = 4 mm) milled from thicker plate (t = 6.35 mm)
- No effect of different polishing methods

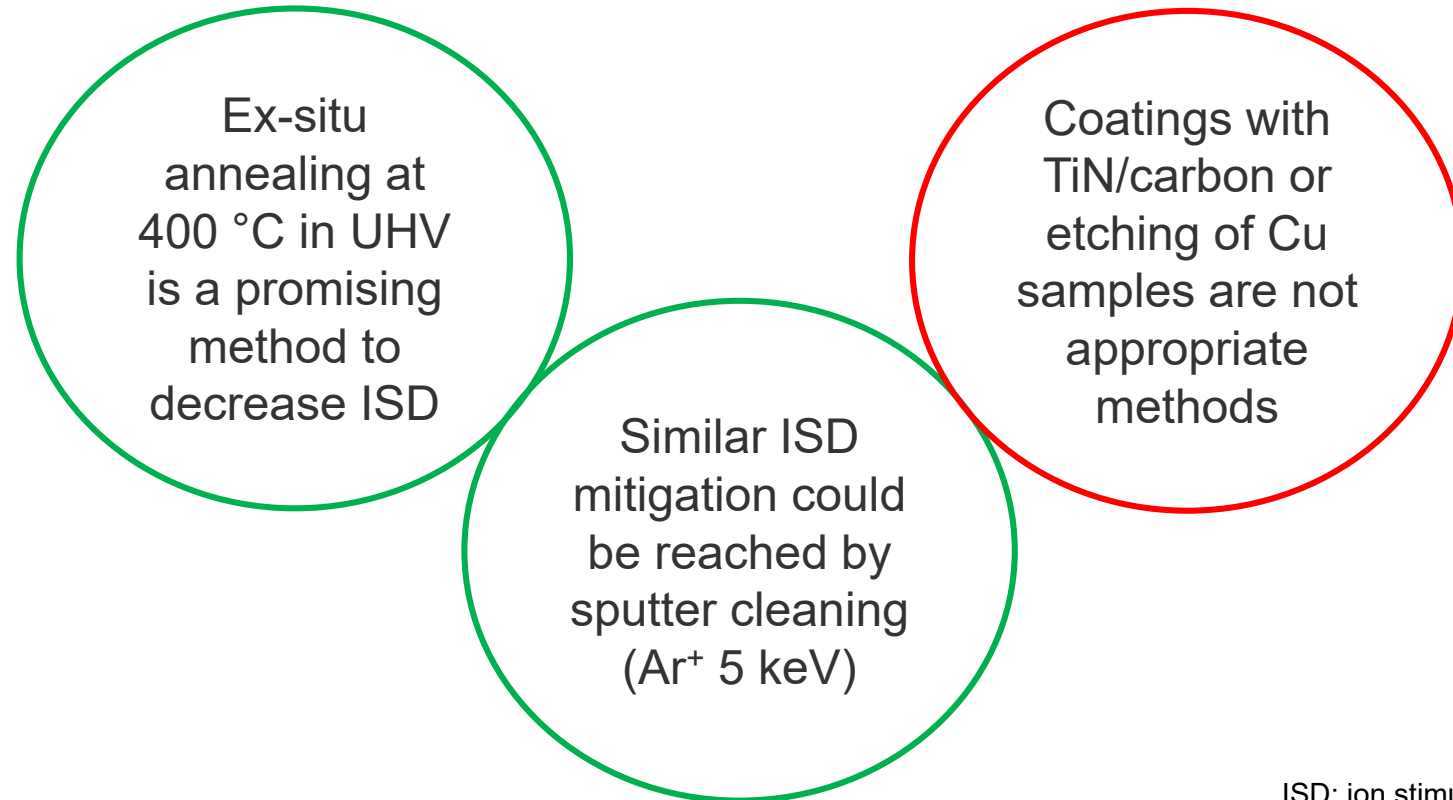


- Sputter cleaning (Ar⁺ 5 keV) produces very low yields
- Yields decrease with increasing sputter time and saturate for >12 h
- No argon desorption

Results Coated samples



- Low desorption for NEG coating (TiZrV) after ex-situ annealing at 400 °C
- Comparable to in-situ baked sample
- TiN and carbon sputter coatings not suitable to reduce ion-stimulated desorption



ISD: ion stimulated desorption

Acknowledgment



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STIFTUNG
GIERSCH



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