

1-100 mbar near-ambient photoemission catalysis experiments at BESSY using a multi-stage differential pumping unit

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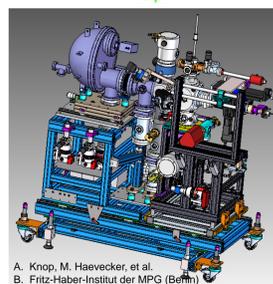
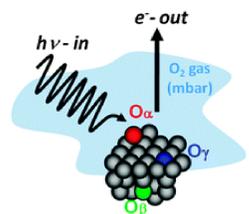
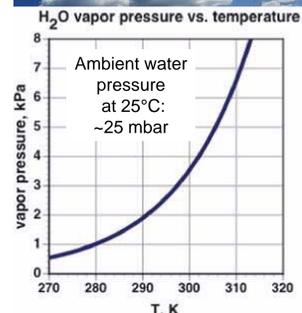
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ABSTRACT: In order to cope with a pressure difference of several orders of magnitude between an ambient-pressure photoemission chamber and a preceding ultra-high vacuum synchrotron beamline a compact differential pumping unit (DPU) has been constructed. This multi-stage pumping unit is designed to enable photoemission experiments up to 1 mbar (3-stage) and finally up to 100 mbar (4-stage, starting mid 2021) while keeping a pressure of $<1 \times 10^{-8}$ mbar in the adjoining refocusing mirror chamber of the BelChem beamline (UE56-2/PGM-1) at BESSY II. It will be used for ambient pressure XPS and XAS studies of catalytic surfaces and interfaces at BelChem.

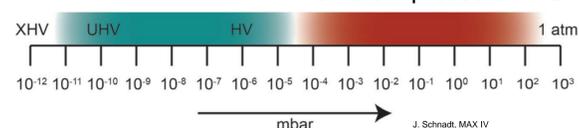
MOTIVATION

The study of chemical reactions under realistic conditions becomes more and more attractive in synchrotron research. Catalytic processes on surfaces, at interfaces and in the liquid phase are key research areas which demand for experiments under ambient conditions, e.g. atmospheric pressure. Photoemission experiments using soft-X-ray photons, as provided by BESSY, are sensitive to ultra-high vacuum conditions due to strong atomic photoionization cross sections of about 1-100 Mbarn and a short mean free path of the emitted photoelectrons. Therefore an efficient differential vacuum stage has to be installed between the high-pressure experimental chamber and the ultra-high vacuum parts of the soft X-ray beamline. Pressure differences of several orders of magnitude have to be overcome at short distance in order to keep within the focal length of the beamline optics.

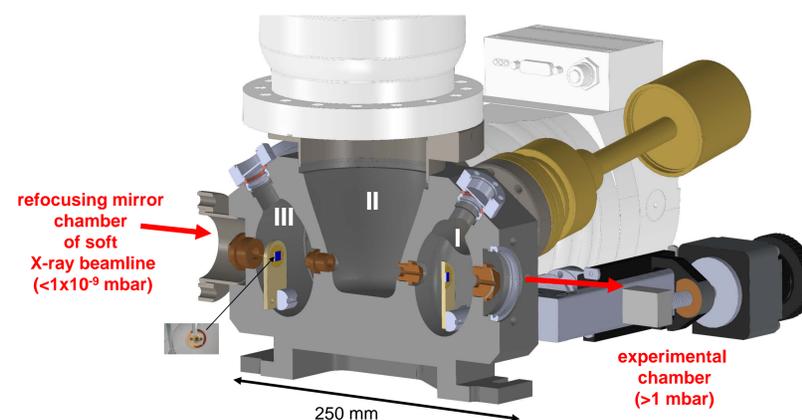
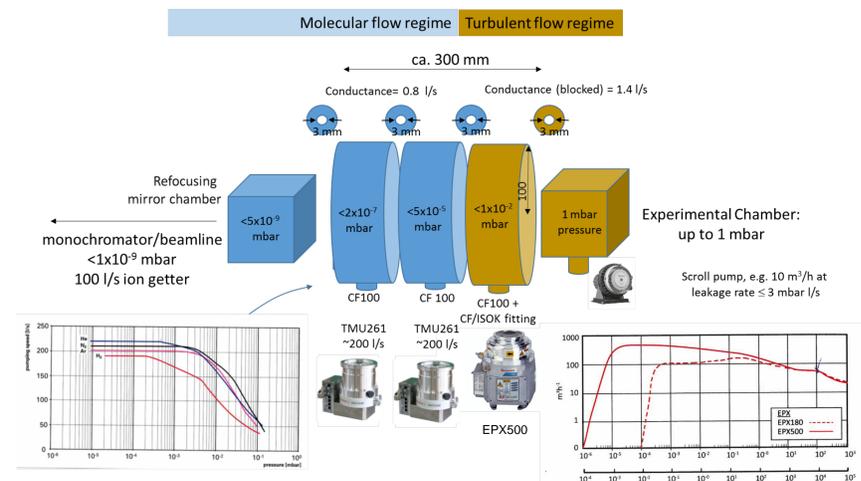


conventional XPS

ambient pressure XPS



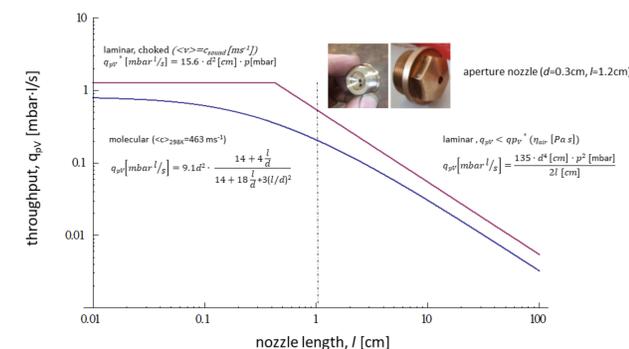
METHODS



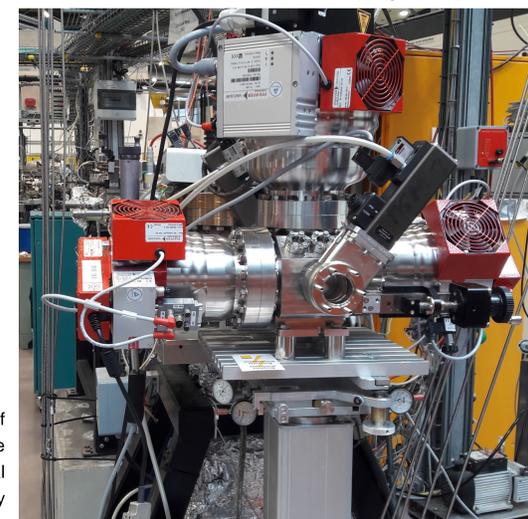
3-stage differential pumping unit. The differential vacuum chambers (I,II,III) are separated by apertures of variable opening (<3 mm). A phosphor screen (P43) and photodiode (GaAs, see inset) can be moved into the beam for alignment and X-ray beam characterisation. Chamber I, which immediately follows the experimental chamber, is pumped by a high-vacuum turbopump (500 m³/h). Chamber II and III are pumped by ordinary ultrahigh vacuum turbomolecular pumps (230 l/s).

RESULTS

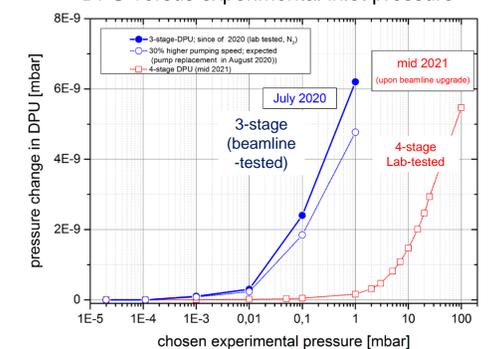
Gas flow simulation (air) using 3-mm aperture at $p_{exp} = 1$ mbar



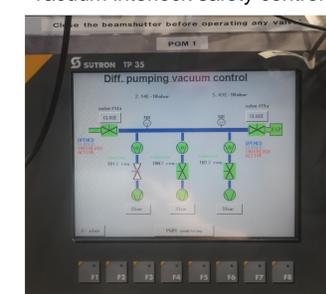
Triple differential pumping stage at UE56-PGM1-Beamline (Aug. 2020)



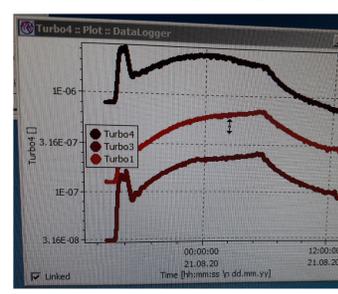
Pressure measurement in final chamber of DPU versus experimental inlet pressure



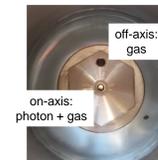
Software-controlled pressure & pumping speed monitor as well as vacuum interlock safety control



Vacuum-monitoring during bakeout



double-hole inlet tube nozzle (diameter: 3mm, length: 12mm)



In-vacuum GaAs-diode (movable) for alignment



Level gauge indicator for lateral position and azimuth angle of UHV-chamber versus X-ray beam

