UHV Setup for Materials Research with High Energetic Heavy Ion Beams

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Surface properties are of great importance both in basic research and technological applications. Chemical or physical processes at the surface are very sensitive to the surface conditions and can be studied in an UHV environment only. Therefore, to measure heavy ion induced irradiation effects on materials surfaces an UHV setup has been developed and installed at an existing beam line. Elsewhere in this report experiments are described which made use this new installation for sputter measurements with high energetic heavy ions [1].

The requirements on this setup were as follows: basic vacuum of 10^{-10}mbar with beam in the UHV chamber, all components bakeable to 250 °C, UHV compatible materials only, surface cleaning possibility, in-situ surface analysis method available. To fulfill the first requirement a 2-step differential pumping system had to be introduced between the UHV chamber and the beam line which has a vacuum of 10^{-7}mbar typically. It consists of a 1500 l/s cryopump followed by a special designed cryobaffle (fig.1a). This second stage is a copper cylinder with 18–25 mm diameter aperture inserts which are centered to the beam position. The inside of the copper cylinder is coated with activated carbon, the outside is polished to reduce heat absorption. The cylinder is coupled by a copper rod to the 20 K stage of a modified cryopump. A heat shield connected to the 80 K stage of the cryopump surrounds the 20 K parts. After several days bake out at temperatures of 100–150 °C a vacuum pressure of 3×10^{-10} mbar can be reached at the second stage.

The UVH chamber itself was made from stainless steel by VAb (Vakuumanlagenbau, Elmshorn) using CF sealed flanges only. The chamber was not vacuum annealed afterwards but cleaned by sand blasting. A baffle plate is mounted inside to avoid contamination of the upper part during surface preparation by sputter cleaning in the lower part (see fig. 1b). Samples can be moved by a 300 mm linear rotary drive from the irradiation position to the cleaning position through a narrow channel which is blocked for direct particle path by the sample holder. For out-baking of the whole system two halogen lamps (500 W and 300 W) are installed inside the chamber. Heating is supported from outside by heater tapes and aluminum foil wrapping. The UHV chamber is pumped by a 520 l/s turbo pump with magnetic bearings assisted by a titanium sublimation pump. UHV chamber and differential pumping system are separated by a all-metal gate valve. After 3 days bake out at around 250 °C a vacuum in the 10^{-11} mbar range can be reached. The residual gas components can be measured by a HIDEN HAL2000 quadrupole mass spectrometer. The main components at this vacuum level are H_2, H_2O and CO. With valves open to the beam line and beam in the UHV chamber the pressure increases to the 10^{-10} mbar range.

In order to prepare the sample surfaces in–situ a home made saddle-field ion source is mounted in the lower part of the chamber which is operated at 8 kV using Xe gas of 99.998 % purity. At the sample position a usable beam spot of about 10 mm diameter and 5 particle μA current is available from this source which corresponds to 20–40 nm sample material removed by sputter etching after 20 min.

As important as cleaning is monitoring of the surface condition during the measurement. Here we can make use of the irradiating beam itself, at least for oblique incidence where elastic recoil detection of surface atoms is possible. For this purpose a position sensitive detector telescope has been developed consisting of a ΔE–gas ionization and an E_{rest}–solid state detector. The position in the scattering plane is measured by the ratio of the cathode to the anode signal and used for kinematic correction to improve the depth resolution [2]. The detector is mounted at a scattering angle of 35^o and has a solid angle of 1.8 msr with 12 mm diameter entrance window.

A critical part in this UHV setup is the entrance foil of the ionization detector which has to separate up to 100 mbar detector gas pressure and 10^{-10} mbar chamber vacuum. The usual solution with at least 5 μm Havar foil cannot be accepted because of the corresponding high energy threshold and energy resolution worsening. We have chosen as entrance foils two differentially pumped Maylar foils each coated with 100 nm Al, one of 0.9 μm thickness at the UHV-side and one with 1.5 μm on the high pressure side. A mild bake-out without detector gas at about 80 °C was essential to remove the water from the UHV-side. Without grid support this window can withstand a gas pressure of 100 mbar. Using 230 MeV Au projectiles a final energy resolution for O or C ions with kinematic correction of about 0.8 % has been achieved.

The sample holder has 5 positions for 1x1 cm^2 samples with 0.5 mm thickness and an additional position for a CsI scintillator to adjust the beam spot. For use in sputter measurements a completely shielded box with rotatable positions for 15 catcher foils has been mounted opposite to the sample holder. The catcher foils can be loaded through a view port without opening of the main chamber flange. This whole assembly can easily be removed to install other analytical devices for surface characterization if required.

References

[1] H.D. Mieskes *et al.*, this report p.43

[2] W. Assmann *et al.*, Nucl. Instr. Meth. **B89** (1994) 131

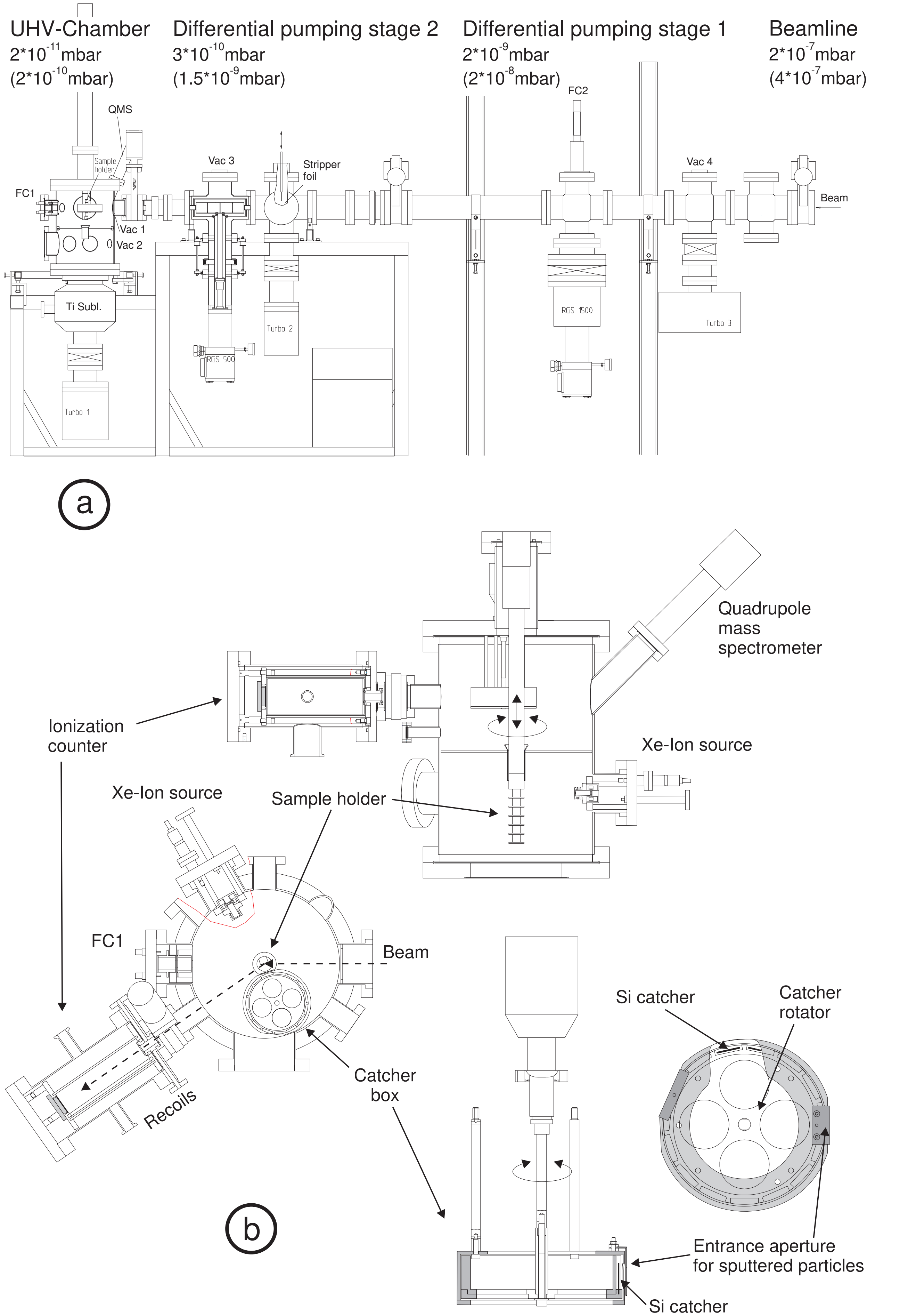

Fig. 1: (a) Layout of the UHV setup, vacua with valve to the beam line closed and open (in brackets) (b) UHV chamber in detail