Ion-induced gas desorption from tungsten targets irradiated with 4.8 MeV/u gold ions

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The release of gas into vacuum, triggered by impinging heavy ions is a critical issue concerning beam losses and was investigated in the past at GSI and CERN [1]. For room temperature targets, the amount of desorbed gas per projectile ion (defined by the desorption yield η) is described by a pure surface process. However, under ion beam exposure, track formation and related thermal spike effects come into play. When a high-energetic ion impacts a target, the material around the ion trajectory is exposed to a short thermal spike, which increases locally the temperature resulting in enhanced thermal desorption. Several experiments with different beams and targets provided desorption yields which are in good quantitative agreement with thermal spike model calculations [2]. Desorption effects are of concern when highest beam intensities are involved, e.g., at the SPIRAL-2 accelerator that will deliver some 10^{14} ions per second on a production target for rare isotopes. Even if the desorption yield is low, the high beam current will lead to enormous gas loads in the range of 10^{-3} mbar l s^{-1}. At the production target special rods are attached which stop the primary beam upon separating the rare isotopes. For thermal reasons the rods have to be made from a high melting material such as tungsten.

The desorption yields of three different tungsten samples were measured at the UNILAC beamline M1. For the irradiation 4.8 MeV/u Au ions with charge states 26+ and 53+ and respective currents of 3e-9 A and 3e-10 A were used. The pulse rate was 2 Hz and the pulse length 1.2 ms. The beam spot had a diameter of 6 mm. The samples stem from the same batch of original rod material. They were brazed onto a Cu block as thermal substrate. The sample thickness was 5 and 3 mm which both is much larger than the projected range of the Au projectiles ($\approx 17\ \mu m$). The base pressure in the irradiation chamber was 1.8 e-8 mbar. During beam exposure, the dynamic vacuum, i.e., the total and partial pressures were recorded. The yields were calculated from the pressure increase inside the vacuum chamber during irradiation.

Figure 1 presents the results of the total desorption yield as a function of the accumulated fluence (top) and the partial pressure evolution for the 3 mm tungsten target irradiated with Au^{26+} ions (bottom). The overall uncertainty is estimated to be around 30% due to the large errors of the pressure and pumping speed measurements. Note that the beam current for the 53+ beam was one order of magnitude less than for the 26+ beam. Hence, within a fixed beamtime, much less fluence is accumulated. For a given sample, the higher charge state leads to higher desorption yields due to the higher energy loss of the 53+ beam [2]. The desorption yield tends to slightly decrease with increasing fluence due to beam scrubbing (cleaning of the surface with the ion beam). However, there are other effects which may increase the desorption yield (see H_2O in Fig. 1, bottom). After the irradiation, the corresponding thick sample contained many macroscopic cracks where gas could be released under beam exposure. The composition of the desorbed gas is predominately H_2, CO and CO_2 (see Fig. 1, bottom) as observed so far for any sample and beam condition. The desorption yields measured for these tungsten samples are surprisingly high compared to earlier measurements using Au or Cu targets [3].

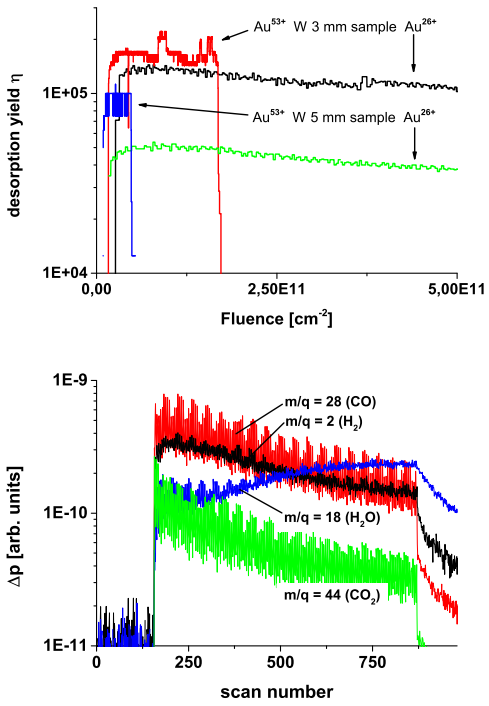

Figure 1: Desorption yield measurement of tungsten samples. Top: yield vs. fluence, bottom: partial pressures of 3 mm tungsten irradiated with Au^{26+}.

References

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