Desorption Yield Measurements of Copper with UHV-ERDA ◇

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Ion-induced desorption is a serious luminosity limitation for high current and low charge state heavy ion accelerators [1]. In order to find low desorbing materials for the loss regions of SIS18 a dedicated experimental program was started at GSI measuring desorption yields of different materials, which can be *in-situ* well characterized using UHV Elastic Recoil Detection Analysis (ERDA).

Two targets with size of 50 x 50 mm^2 were cut out of the same piece of 99.95% oxygen free high conductivity (OFHC) copper. Target (A) was lapped in the target laboratory of GSI using a ceramic (Al_2O_3) paste and cleaned in HNO_3 acid in order to remove a possible oxide layer and polishing grains. After preparation the sample was mounted in the UHV-ERDA chamber with minimal exposure to air. Target (B) was polished with a standard polishing paste (Fe_2O_3, grain size $\leq 10\mu$m in a Stearin matrix) which is used for copper coated accelerator cavities. After polishing the target was cleaned in an ultrasonic bath, flushed with demineralized water and dried under atmosphere for 4 h at 250° C.

The desorption yield was measured by the pressure rise and the surface contamination by UHV-ERDA at the high charge state injector (HLI) of GSI using a 1.4 MeV/u $^{136}Xe^{21+}$ beam. From raw ERDA data, compare [2], element specific depth distributions can be derived using the KONZERD code [3] as shown in Fig. 1. Here the depth distributions of copper, oxygen and carbon for the both samples are shown: whereas sample (A) is a pure metallic copper with only minor oxygen contamination on the surface, target (B) has a highly oxidized surface. For both the targets carbon contaminations is below 1 %. The thickness of the Cu_2O oxide layer on target (B) is around 450 nm. The corresponding pressure rise under ion bombardment is shown in Fig. 2. A significant higher pressure rise was observed for target (B). At the end of each desorption yield measurement we have applied a positive or negative bias voltage to the target in order to measure the influence of secondary, charged particles (electrons and ions) to the pressure rise. A pressure increase is clearly visible and is slightly more pronounced for a positive bias voltage. Here secondary ions emitted from the target gain 2000 keV kinetic energy in the electric field and are accelerated towards the chamber wall resulting in a low energetic ion stimulated desorption. The effective desorption yield for sample (A) was measured to be $\eta_{eff} \approx 360$ and for sample (B) $\eta_{eff} \approx 1500$ taken from the peak maximum. For more details see [4].

Hence, the desorption yield of the oxidized copper is around 4 times higher compared to an almost clean copper. This result and the measured $(dE/dx)^2$ dependency reported in [1] show that desorption is directly linked to electronic sputtering: the higher the sputter rate of the target the higher the desorption yield of the adsorbed gas. The higher sputter yields for the oxidized copper can be explained by the Thermal Spike Model [5]. Since the copper oxide is an insulator the mobility of the electrons and therefore the thermal conductivity is strongly reduced compared to a metal.

Results and interpretation have clear consequences for materials and material treatments used for accelerator beam tubes or beam loss collimators: It should be a highly conductive material with very little impurities and very low surface adsorption rate. Favorably it should be made out of a low Z material to minimize the electronic energy loss and hence the sputter yield. Perpendicular impact would in addition reduce the sputter yield. The initial amount of adsorbed gas should be kept at a minimum, e.g., by a special bake out procedure.

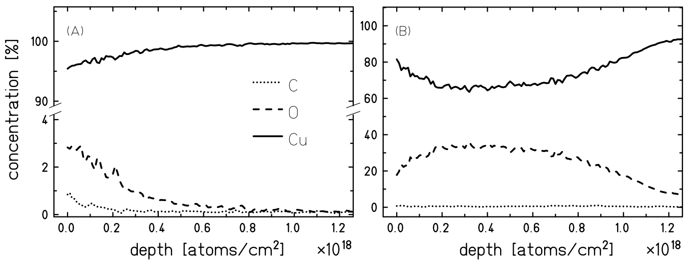

Fig. 1: Depth distribution of copper, oxygen and carbon for sample (A) and (B).

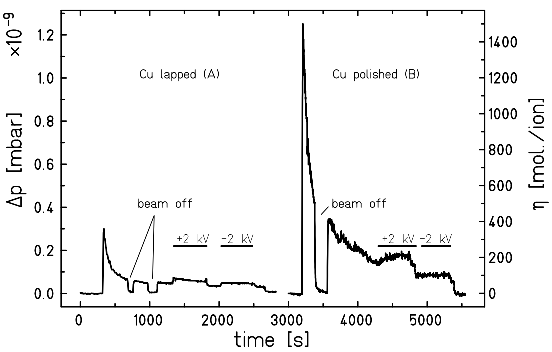

Fig. 2: Desorption yield measurement of both targets.

References

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