Investigation on New Coatings and an In-situ Bake-out for the SIS18 Beam Loss Collimators [◇]

H. Kollmus [a], M. Bender [a], W. Assmann, R. Dörner [b], C. Halfpap [a], B. Kindler [a], A. Krämer [a], B. Lommel [a], and H. Reich-Sprenger [a]

[a] GSI Darmstadt, Germany [b] Universität Frankfurt, Germany

1. Introduction

For optimal functionality and high durability of the planned SIS18 beam loss collimators a low ion-induced desorption yield of the collimator material is required. Gold coated copper was found to be the material of choice: copper has a high thermal conductivity, a high specific heat and can be produced with high purity for reasonable prizes. The gold layer prevents the copper from oxidation. The influence of the oxidation on the desorption yield was reported to be significant [1]. But we have also shown that copper and gold diffuse during a typical UHV bake-out cycle [2]. In 2007 we have studied nickel diffusion barriers using Rutherford Backscattering Spectroscopy (RBS). As reported [3] desorption turned out to be predominately a surface effect with a strong link to the bulk properties. Additionally there was always cleaning observed of the target under ion irradiation. The total amount of desorbed gas corresponds to roughly one surface monolayer. To observe best cleaning of the target with 1.4 MeV/u Xe ions a flux of a few $1 \cdot 10^{13}$ ions per cm^2 is necessary. Since a beam cleaning of the loss regions in SIS18 is not possible we have tried to minimize the surface coverage by a special bake-out treatment of the target. The idea is to keep the target during UHV bake-out always higher in temperature compared to the environment in order to minimize the re-adsorption of gas on the surface.

2. Nickel Diffusion Barrier

To avoid diffusion of gold and copper, which is stimulated by the UHV bake-out procedure, nickel diffusion barriers were investigated using RBS. The measurements were performed with 1.4 MeV/u C ions. Using RBS we gain sensitivity to heavy elements compared to ERDA. Additionally, sensitivity and depth resolution are increased by a comparatively heavy projectile like C with the disadvantage, however, to lose any information about low Z target components. Fig. 1 shows the RBS spectra for a nickel-gold coating on copper before and after bake-out. The gold layer thickness is around 400 nm and the nickel layer is about 1 μm. Because of the total layer thickness of 1.4 μm the copper substrate is not seen in RBS before bake-out (Fig. 1, blue spectrum) due to the limited penetration depth of the C ions.

The red spectrum shows the same sample after bake-out. Essentially the shape of the nickel distribution is changed since copper starts to diffuse across the nickel layer to the sample surface indicated by the dashed line. Additionally, the gold layer is broadened due to the diffusion of gold into nickel. However, the diffusion is strongly reduced compared to samples without diffusion layer [2].

Complementary ERDA measurements with 1.4 MeV/u Xe ions have shown, that under UHV conditions and without heating, a gold layer on copper will not be contaminated be copper in-diffusion. The desorption yield of this sample was measured to be initially 100 molecules per incoming ion, decreasing to less than 20 after an ion flux of about $1 \cdot 10^{13}$ ions per cm^2.

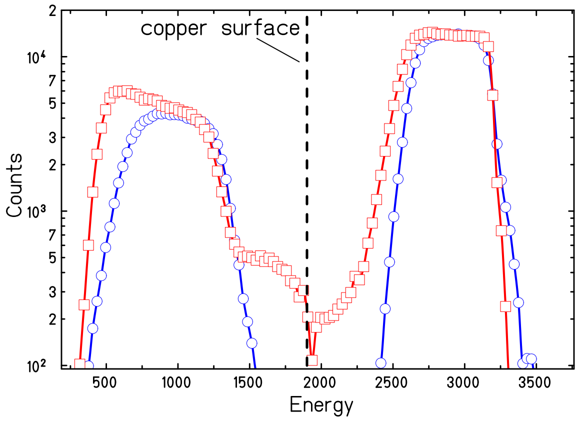

Fig. 1: RBS profiles of a gold coated copper with a nickel diffusion barrier before (○) and after (□) a bake-out for 17h at 250°C and 2.5h at 350°C.

3. In-situ Bake-Out

As a complement to gold, rhodium coatings have been investigated. Like gold, rhodium does not oxidize with the advantage that the diffusion with copper is strongly reduced. Additionally we have tested if the initial surface coverage of the samples can be reduced by a special bake-out procedure. Therefore, two rhodium coated copper samples have been prepared identically but one was *in-situ* heated up to 350°C in an UHV environment and the other was kept at room temperature. Afterwards the desorption yields of both samples were measured. For the unbaked sample a desorption yield of around 1000 was observed, whereas the yield of the baked sample was reduced to 260 molecules per ion, resulting in essentially two consequences: First, rhodium is not suitable for a beam loss region due to the high desorption yield. Nevertheless, an *in-situ* bake-out of the loss regions in a good UHV environment can minimize the desorption similar to a cleaning by the ion beam. Therefore, one can expect to reduce the initial desorption of gold coated copper to around 20 molecules per incoming 1.4 MeV/u Xe ion. First SIS18-tests with a gold coated copper collimator seem to support this expectation.

References

[1] M. Bender *et al.*, NIM **B256** (2007) 387
[2] M. Bender *et al.*, GSI Scientific Report 2006 (2007) 94
[3] H. Kollmus *et al.*, Vacuum **82** (2007) 402

[◇] We acknowledge the support of the European Community-Research Infrastructure Action under the FP6 "Structuring the European Research Area" program (DIRACsecondary-Beams, contract number 515873)