Angular Distribution of Particles Sputtered with Energetic Heavy Ions ◇

H.D. Mieskes and W. Assmann

Sputtering yields with energetic heavy ions of pure metals have been measured using the UHV setup which has been described in detail in Ref. [1,2]. The experiments were aiming on a systematic study of electronic energy loss effects in sputtering of conductors where only scarce data exist. In order to extract total sputtering yields from a differential yield measurement – at 90° to the target surface in our experiments – one needs to know the angular distribution of the sputtered particles. Almost no data were available for sputtering with ions in the 100 MeV range therefore we had to measure the angular distribution at least for some typical cases. Furthermore it was found in sputtering at lower energies that surface roughness effects can strongly influence the angular distribution. This could be even more a problem for higher energies where large surface modification have been observed due to high electronic energy loss. We have developed a program to simulate the influence on the angular distribution caused by the surface micro-geometry. In this contribution we report on measurements and computer simulations of the angular distribution of some selected metals.

In our measurements we used a circular arrangement of Si–catchers covering an angle range of ±40° in order to ensure similar sticking efficiency for different exit angles of the sputtered particles. The catcher analysis was performed with heavy ion RBS using a 1.5 MeV carbon beam from the small tandem accelerator at the University of Augsburg (Prof. Stritzker). The measured angular distributions (see fig. 1) are symmetric to the surface normal within the experimental errors. The angular shape can be fitted by a cos–distribution but, opposite to a pure isotropic distribution, with a higher power of cos only. This "over-cosine" behavior has also been found in sputtering with ions energies of a few MeV.

The second question was related to the influence of the target surface roughness on these distributions. Due to the low sputtering yield at these high energies a high fluence was necessary to accumulate enough sputtered particles on the catcher which resulted in unavoidable surface modifications. If this would change the angular distribution, wrong total sputtering yields would be extracted from the measured differential yield value. A simulation program was developed to study the influence of the surface roughness on the angular distribution. In fig. 2 an example is presented of a simulation with three different roughness values using a flat surface distribution of $\cos(\theta)^{2.6}$. Only in case of mean roughness values of more than about 300 nm a shift of the yield maximum has been found leading to asymmetric distributions. Thus the influence of the surface roughness on the angular distribution can be controlled by limiting the flux for one irradiated spot. This result was verified in measurements of samples with different surfaces roughnesses.

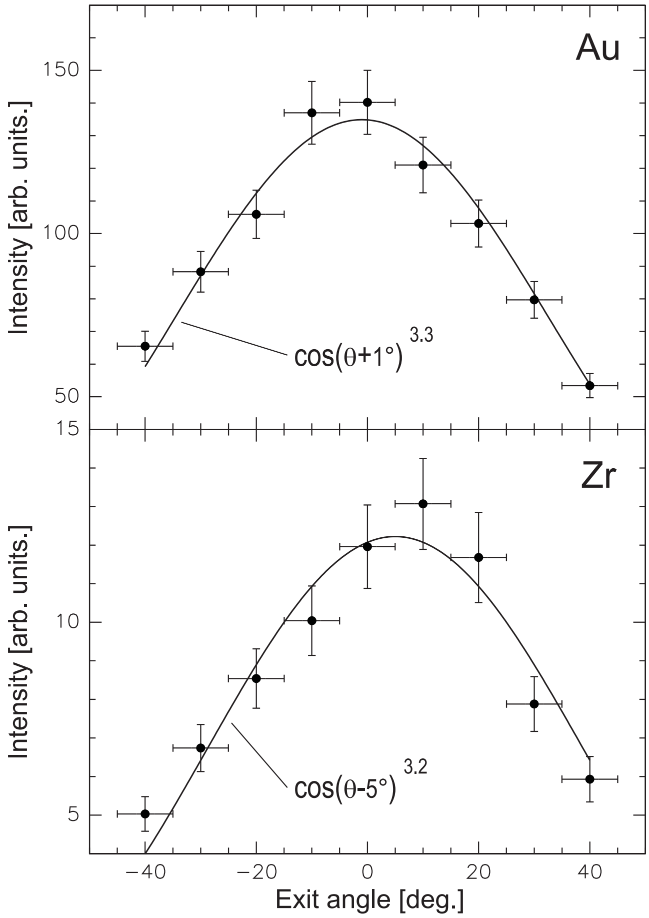

Fig. 1: Angular distribution of Au and Zr particles sputtered with 230 MeV Au ions incidenting at 70° and corresponding cos–fits.

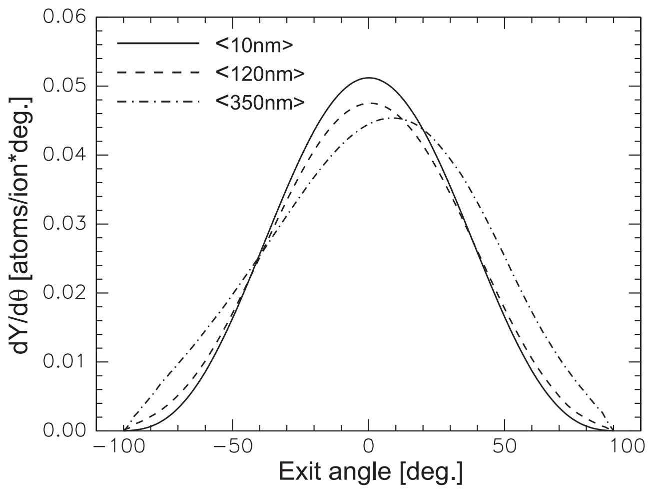

Fig. 2: Computer simulation of angular distributions of sputtered particles for different surface roughness.

References

[1] H.D. Mieskes *et al.*, Jahresbericht 1997, p. 104
[2] H.D. Mieskes *et al.*, Nucl. Instr. Meth. **B146** (1998) 117

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