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LETTER TO THE EDITOR

Sputtering of copper single crystals bombarded with monoenergetic ions of low energy (50 - 350 eV).

A copper plate made of single crystal material, whose surface coincides with one of the lattice planes, was bombarded with normally incident ions of variable energy. The sputtered copper atoms were collected on a glass plate placed parallel to the bombarded surface at a distance of 2.5 cm from it. From the "thickness" of the metal film at different places on the glass plate the directional distribution of the sputtered atoms can be determined. The film "thickness" (the number of atoms per cm^2 in the film) was derived from the measured optical transmission [1]).

If the bombarded surface coincides with a (111) lattice plane, six directions are found in which the copper atoms prefer to leave the surface: these directions are perpendicular to the (110), (011), (101), (114), (411) and (141) lattice planes (see fig. 1). Similar results have been found by Wehner who bombarded Cu (111) with Hg^+ ions [2]). We found such a directional distribution for all ion energies applied.

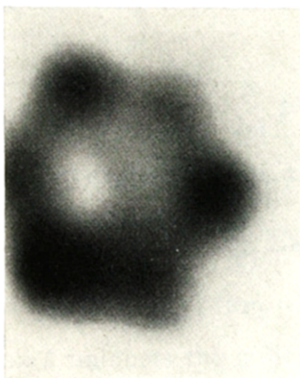

Fig. 1. Photograph of a glass plate that had been placed parallel to a small copper plate made of single crystal material and bombarded with normally incident ions. The surface of the copper plate coincided with a (111) lattice plane. The three dark spots on the glass plate, corresponding to preferential sputtering directions, agree with (110), (101) and (011) lattice orientations. The three less dark spots agree with the (141), (114), (411) lattice orientations. The photograph is a positive; a black spot corresponds to a relatively thick copper layer at that place.

If the bombarded surface coincides with a (110) lattice plane, the sputtered atoms have a strong preference to leave the surface in the direction perpendicular to it. This (110) direction was also preferential when we bombarded the (111) plane. Except for this we found no other pronounced preferential directions of the atoms sputtered from the (110) plane. However, the film thickness in the non-preferential directions shows traces of a pattern (see fig. 2).

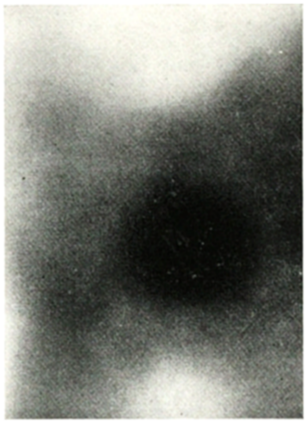

Fig. 2. Photograph of a glass plate that had been placed parallel to a bombarded copper surface coinciding with a (110) lattice plane. The dark spot corresponds to the normal direction.

Bombarding a copper surface coinciding with a (110) lattice plane with normally incident Kr^+, Ar^+ or Ne^+ ions of several energies ranging from 50 to 350 eV, we determined the number of atoms sputtered per incident ion in the (preferential) normal direction in dependence on the ion energy. The metal spot on the glass plate (fig. 2) has approximately the same diameter as the bombarded surface; the number of sputtered atoms, mentioned above, was determined by integrating over that spot. Fig. 3 gives the results.

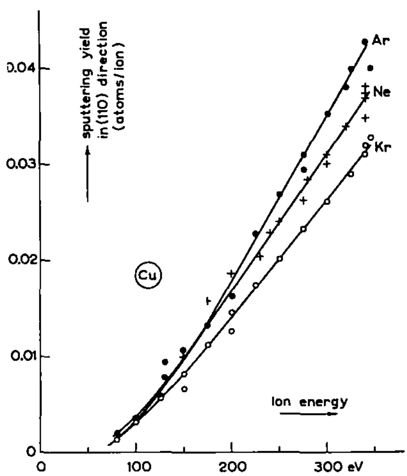

Fig. 3. Sputtering of a copper single crystal. The bombarded surface coincides with a (110) lattice plane. The curve gives the number of sputtered atoms integrated over the central spot of fig. 2, per incident ion, as a function of the ion energy.

For comparison with the curves of fig. 3, and to complete the measurements discussed in the reference[1]), the sputtering yield (total number of sputtered atoms per incident ion) as a function of ion energy was determined for a polycrystalline silver surface bombarded with Kr^+, Ar^+, Ne^+ and He^+ ions (see fig. 4).

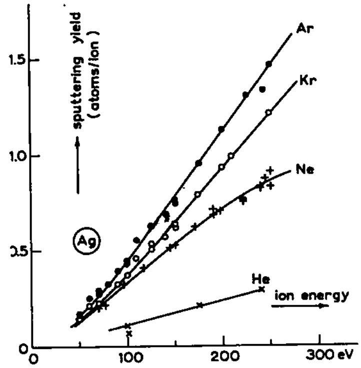

Fig. 4. Sputtering of a polycrystalline silver surface bombarded with normally incident ions. Curve of the sputtering yield, this is the total number (integrated over all directions of emission) of sputtered atoms per incident ion, *vs* ion energy.

All experiments were done with the apparatus described in an earlier paper[1]). Experiments with other monocrystalline metals, as well as determinations of the influence of the temperature of the sputtering surface on the directional distribution of the sputtered atoms, are in preparation.

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1) Koedam, M., Physica **24** (1958) 692.
2) Wehner, G., Report 3rd International Conference on Ionization Phenomena in Gases (1958).