

## LETTER TO THE EDITOR

### **Sputtering of copper single crystals bombarded with $A^+$ , $Kr^+$ and $Ne^+$ ions with energies ranging from 300 - 2000 eV.**

The ejection pattern of the atoms sputtered from a monocrystalline metal surface bombarded with positive rare gas ions shows some preferential directions <sup>2)3)4)</sup>. The relation between the lattice structure of the bombarded metal and the ejection pattern of the atoms sputtered from the surface can easily be determined if this surface is a flat, low index, lattice plane.

The ejection patterns that appear if a Cu (111)- and Cu (110) surface are bombarded with normally incident  $Ne^+$ ,  $A^+$  and  $Kr^+$  ions of energies ranging from 100-350 eV have been published previously <sup>2)3)</sup>. In this paper the ejection patterns formed by bombardment of Cu (100), (110) and (111) surfaces with rare gas ions of energies ranging from 300-2000 eV will be described.

If a Cu (100) surface is bombarded with ions of energies below 200 eV four preferential ejection directions, corresponding to the four (110) directions, are found. If the ion energy increases, the (100) direction normal to the bombarded surface also becomes a preferential ejection direction (fig. 1).

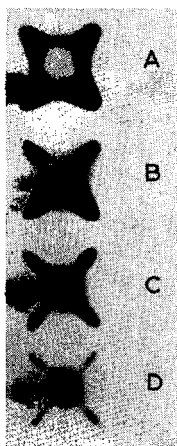


Fig. 1. Ejection pattern of atoms sputtered from a Cu (100) surface bombarded with  $Kr^+$  ions.

A, B, C and D are photographs of glass plates placed parallel to the bombarded surface. The dark spots correspond to preferential sputtering directions. The central spot in B, C and D corresponds to the surface normal of the bombarded electrode. A is made at 500 eV ion energy, B at 1000 eV, C at 1500 eV and D at 2000 eV.

In figure 2 the ratios of the sputtering yields in the (100) direction normal to the surface and in the four (110) directions for a copper (100) surface bombarded with normally incident  $Ne^+$ ,  $A^+$  and  $Kr^+$  ions are shown as a function of ion energy. This sputtering yield is the mean number of atoms sputtered in the directions of investigation per incident ion.

If a Cu (111) surface is bombarded with ions of 75–1000 eV energy a pattern of six preferential ejection directions appears. Three of them are (110) directions and three probably correspond to the (114) directions. Wehner <sup>4)</sup>, in the case of a Cu (111) surface bombarded with  $Hg^+$  ions at 100 eV energy, found only a preference for the three (110) directions; at 200 eV he also found six directions. The three non (110) directions disappeared in his experiments with  $Hg^+$  ions of 400 eV energy when the crystal under bombardment was heated. Contrary to Wehner's results with  $Hg^+$ , in our experiments with  $Kr^+$  ions the pattern of six directions was found for all ion energies below 1000 eV; a heating of the crystal up to 500°C did not measurably change the pattern. At higher ion energies (1500–2000 eV) the ejection pattern consisted only of the three (110) directions, although the surface temperature was about 100°C. Similar results can be expected for  $Ne^+$  and  $A^+$ .

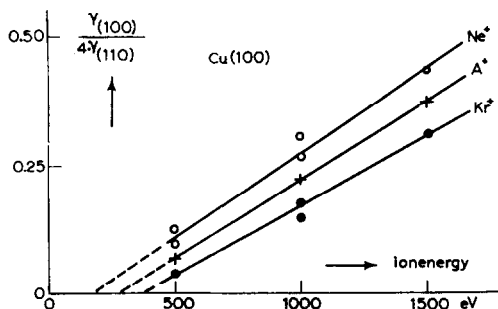


Fig. 2. Ratio of the sputtering yields  $\gamma$  in the (100)- and in the four (110) directions together. The surface under bombardment corresponds to a (100) lattice plane. The sputtering yield is the mean number of atoms sputtered in the direction of investigation per incident ion. This number is found by integrating over the whole spot in fig. 1.

Increasing the energy of the ions bombarding a Cu (110) surface results in a more pronounced ejection of the atoms in the (110) direction normal to the surface under bombardment. At ion energies of 2000 eV, this direction seems to be the only preferential one.

More quantitative sputtering data will be published later. From our experiments it is evident that the ejection pattern of the atoms sputtered from a monocrystalline surface depends on the kind of ion as well as on the ion energy. No important changes of the pattern are found in our experiments if the metal surface is heated to 500°C.

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