

LETTER TO THE EDITOR

Sputtering of a polycrystalline silver surface bombarded with monoenergetic argon ions of low energy (40-240 eV)

A silver surface has been bombarded with normally incident Ar^+ ions at several well defined energies ranging from 40-240 eV (the energy spread has a half width of 8 eV). The ions were extracted from a plasma created by an electron beam in argon gas at low pressure (fig. 1). The electron beam was kept together by an axial magnetic field (ca 800 oerstedt). The energy of the Ar^+ ions was controlled by adjusting the potential difference of the silver surface and the plasma; the energy distribution was measured by a special probe system. The argon pressure within the apparatus was such that the mean free path of the sputtered atoms was large compared to the tube dimensions so that back diffusion was negligible. The silver atoms sputtered within a certain well defined solid angle were collected on a glass plate (fig. 1). Measurements and calculations have indicated, in a first approximation, that the mass ratio of the silver deposited on the glass plate to the total amount of sputtered silver is independent of the energy of the argon ions.

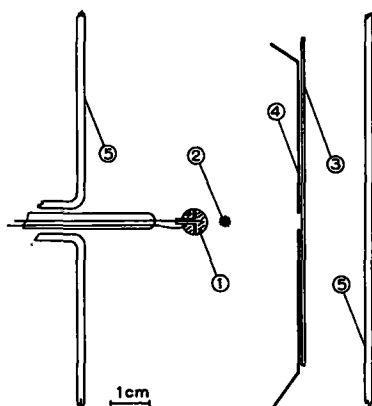


Fig. 1. Cross section of apparatus for investigation of cathode sputtering, viewed in a plane perpendicular to the direction of electron beam and magnetic field.

- ① sputtering electrode,
- ② electron beam,
- ③ movable glass plate,
- ④ shield (Ni-Cr),
- ⑤ tube wall (glass).

The ions created by the electron beam ② bombard electrode ①. This electrode consists of two parts, each having the same potential (to prevent disturbance of normal ion incidence at the edge of the electrode). The ion current to the part facing the electron beam has been measured. The sputtering yield has been derived from the thickness of the silver layer deposited on the glass plate ③.

The number of silver atoms per square centimeter on the glass plate was determined from the optical transmission of the layer measured at 5470 Å (and also at 6700 Å as a check). It was assumed that none of the silver atoms was reflected from the glass plate or from the silver layer upon it. In a special experiment, evaporating silver atoms on a glass plate, the fraction of silver atoms reflected was found to be less than the error in the measurement (0.5%). The sputtering experiments have confirmed the assumption that under the circumstances in question (slight ion bombardment) the structure of the metal deposit and therefore its optical transmission is independent of the time (10–100 min.) during which the layer has been built up⁴).

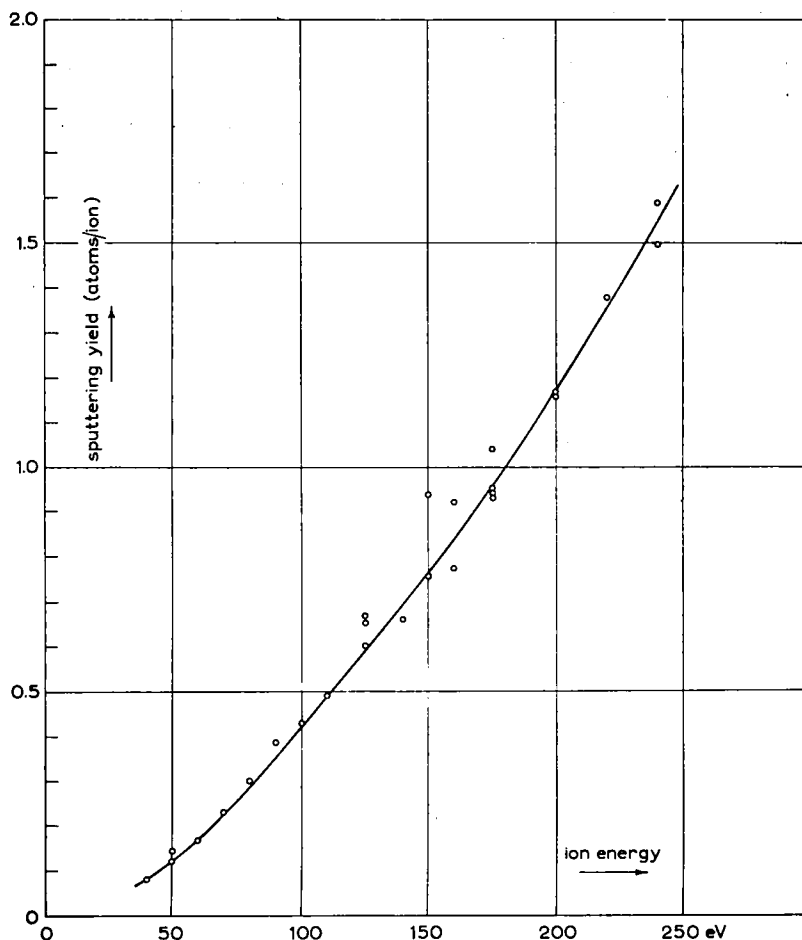


Fig. 2. Sputtering of a polycrystalline silver surface bombarded with Ar^+ ions at normal incidence. Curve of sputtering yield versus ion energy.

The number of sputtered silver atoms per incident ion, *i.e.*, the yield, was calculated from the number of collected silver atoms on the glass plate and the product of sputtering time and ion current (600–900 μA). This yield was measured for different ion energies (fig. 2).

The relation of the yield to the ion energy does not indicate a real sputtering thresh-

hold energy, contrary to Wehner's ⁴⁾ prediction 48 eV for Ar^+ on Ag. According to our measurements any threshold value should lie below 20 eV. This result is comparable with those of Bradley ³⁾ who has found thresholds under 10 eV for K and Na surfaces bombarded with inert gas ions, using a very sensitive detection method for the sputtered atoms. In a recent paper Wehner ⁴⁾ has revised his previous conclusions regarding threshold energies.

Extrapolation of our yield curve to an ion energy of 300 eV gives a yield of 2.3; Keywell ²⁾ has determined a yield of 3.0 for 300 eV and the same gas-metal combination.

Wehner ³⁾⁴⁾ has bombarded several metals with Hg^+ ions. His yield-versus-ion energy curves show the same relationship as ours and the yield values have the same order of magnitude as those presented in this paper.

With Kr^+ ions on Ag we obtained similar results. Measurements on other gas-metal combinations are in progress.

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REFERENCES

- 1) Bradley, R. C., Phys. Rev. **93** (1954) 719.
- 2) Keywell, F., Phys. Rev. **97** (1955) 1611.
- 3) Wehner, G. K., Phys. Rev. **102** (1956) 690.
- 4) Wehner, G. K., Phys. Rev. **108** (1957) 35.