Supplementary Sputtering Calculations

DON E. HARRISON, JR.
University of Louisville, Louisville, Kentucky
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The theoretical curves of a preceding paper have been recalculated using the sputtering threshold values predicted by Wehner. The parameters of the new calculation follow a more regular pattern, and the numerical values are more realistic. Although the new curves differ from those previously reported, the variations are hardly significant.

IN a preceding paper,[1] the author presented a theory of the process by which cathodes are eroded in a gaseous discharge. Four parameters characterize the resulting theoretical expression: μ, the mass ratio; h, the trapping parameter; η, the mean free path ratio; and E_T, the threshold energy for sputtering.

At that time, only the first parameter was accurately known. Recently Wehner has predicted values for all of the sputtering thresholds in this series of data.[2] Thus it seemed advisable to repeat the calculations using only h and η as fitting parameters.

Figure 1 indicates the type of variation in fitting of the theoretical curves produced by the recalculation. Considering the present experimental data, the new fitting is not significantly poorer than those previously reported.

Figures 2, 3, and 4 show the new theoretical fitting

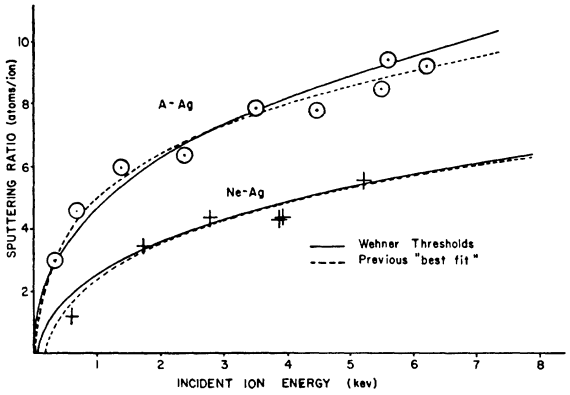

FIG. 1. Here the old and new fittings are compared for the A—Ag and Ne—Ag systems, using Keywell's data. (See the first paper of this series for references.) These curves indicate the types of modifications required by the recalculation. The new fitting parameters are listed in Table I.

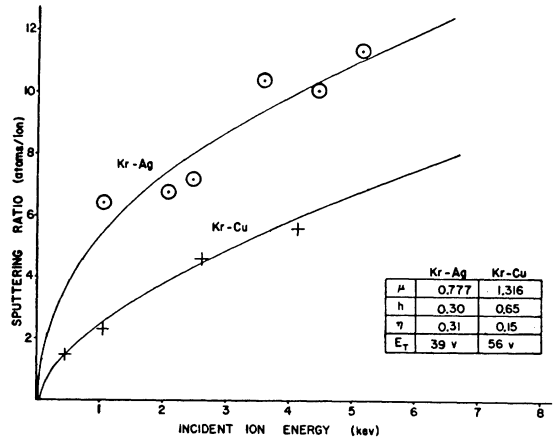

FIG. 2. Comparison of the recalculated theory and experiment for Kr—Ag and Kr—Cu. Both of these curves are especially questionable because the experimental data are so incomplete.

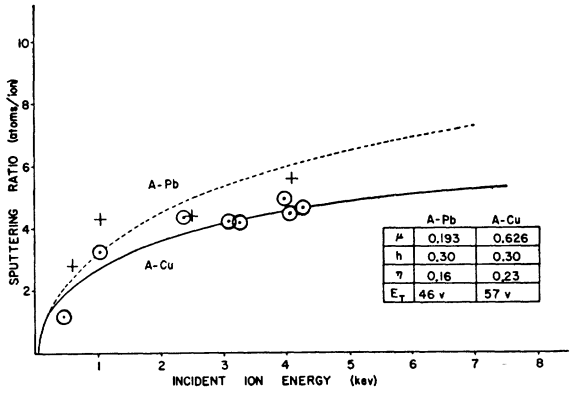

FIG. 3. Comparison of theory and experiment for A—Pb and A—Cu. The system A—Pb is hardly useful, but A—Cu is one of the better sets of data. Unfortunately it does not extend into the higher energy range.

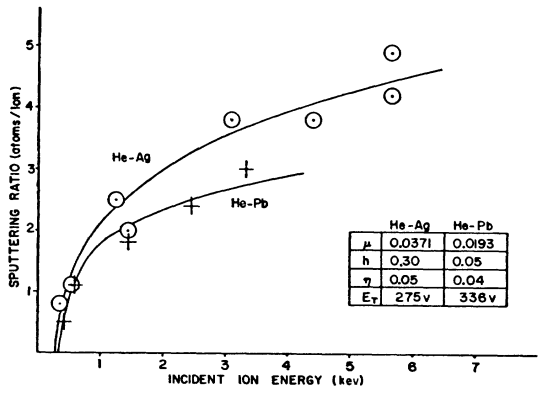

FIG. 4. Comparison of theory and experiment for He—Ag and He—Pb. Note the change of scale. The fitting is reasonable for He—Ag, but fails quite badly for He—Pb when compared to systems of higher mass ratio.

[1] Don E. Harrison, Jr., Phys. Rev. **102**, 1473 (1956).

[2] Gottfried K. Wehner, Phys. Rev. **102**, 690 (1956).

TABLE I. Comparison of the parameters for the eight available atomic systems. μ is the mass ratio, h the trapping parameter, η the macroscopic cross section or mean-free-path ratio, and E_T the sputtering threshold as predicted by Wehner. Note the internal consistency of h, except for systems of large and small mass ratio. In the new calculation η seems to increase with the mass ratio, rather than remain constant as previously reported.

System	μ	h	η	E_T (ev)
He−Pb	0.0193	0.05	0.04	336
He−Ag	0.0371	0.30	0.05	275
Ne−Ag	0.1871	0.30	0.16	72
A−Pb	0.1926	0.30	0.16	46
A−Ag	0.3700	0.30	0.26	48
A−Cu	0.6264	0.30	0.23	57
Kr−Ag	0.7766	0.30	0.31	39
Kr−Cu	1.3155	0.65	0.15	56

for the remaining sets of data in this series. For convenience the new parameters are tabulated in Table I. We note that a single value of h applies over a considerable range in the mass ratio. This effect is somewhat more pronounced here than it was in the earlier calculations. The value of h is larger, but 0.30 seems a more realistic value for $\sigma_s/(\sigma_s+\sigma_t)$ than the value 0.10 previously reported. As we would expect, the cross section for trapping is considerably reduced when the mass ratio exceeds unity, and the value of h increases.

Except for the system A−Cu, the mean free path ratio shows a steady increase with the mass ratio for values of μ less than unity.

There is no apparent correlation of either h or η with the velocity of sound or elastic constants of the metals.

As before, the system He−Pb requires special treatment. The fitting is not as satisfactory because the "constant h" approximation fails in the manner described in I. The degree of failure is about the same in each calculation.

In conclusion, it appears that there is no significant change in the theoretical interpretation, but the new parameters are slightly more realistic.

ACKNOWLEDGMENTS

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Hall and Drift Mobilities; Their Ratio and Temperature Dependence in Semiconductors

F. J. BLATT
Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan
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It is shown that the Hall and drift mobilities in the temperature range in which scattering by ionized impurities dominates should exhibit a temperature dependence less rapid than $T^{\frac{3}{2}}$. This conclusion is in agreement with experimental observation. Furthermore, the mobility ratio, μ_H/μ_d, is not equal to $315\pi/512$ nor is it independent of temperature. Instead, μ_H/μ_d only approaches $315\pi/512$ at very high temperatures and decreases monotonically to $3\pi/8$ as the temperature is lowered.

INTRODUCTION

IN a recent paper[1] it was shown that at *low temperatures* the usual expression for the mobility in the range where ionized impurity scattering predominates is not valid because it is based on the Born approximation. This approximation was shown to fail at low temperatures. Moreover, it was found in I that even at *higher temperatures* where the Born approximation *is* valid the Hall and drift mobilities, which were calculated by numerical integration of the relaxation times over the distribution function, did not obey the generally accepted $T^{\frac{3}{2}}$ dependence. Instead, the calculated mobilities followed no simple power law behavior, although at high temperatures a $T^{\frac{3}{2}}$ law appeared to be approached. Over the entire range of temperature investigated the mobilities increased with temperature less rapidly than $T^{\frac{3}{2}}$, $d(\log\mu)/d(\log T)$ increasing monotonically with temperature and approaching the value $\frac{3}{2}$ asymptotically.

It was suggested in I that the $T^{\frac{3}{2}}$ dependence is generally obtained theoretically because certain factors which depend on temperature and carrier energy have not been considered in sufficient detail in the past. In particular, it was thought that the difference between the $T^{\frac{3}{2}}$ and the true temperature dependence of the mobility may be due to a certain approximation which is commonly employed when performing the necessary integrations over the distribution function.

In order to clarify this point we have performed detailed calculations of the mobilities in the impurity scattering range using the Born approximation. We have carried out the necessary integrations exactly for a particular case and have compared the results with those obtained by a slightly modified form of the usually accepted expression for the mobility.

In I, curves of the mobility ratio as a function of

[1] F. J. Blatt, Intern. J. Phys. Chem. Solids (to be published); hereafter referred to as I.