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To cite this version:
J. Biersack, E. Santner. SPUTTERING OF ALKALI HALIDES BY 70 TO 300 keV H, He, Ar IONS. Journal de Physique Colloques, 1976, 37 (C7), pp.C7-541-C7-542. <10.1051/jphyscol:19767125>. <jpa-00216848>

HAL Id: jpa-00216848
https://hal.archives-ouvertes.fr/jpa-00216848
Submitted on 1 Jan 1976

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SPUTTERING OF ALKALI HALIDES
BY 70 TO 300 keV H, He, Ar IONS

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Résumé. — Les expériences de sputtering ont été faites avec KCl et KI, à l’aide des ions H\textsuperscript{+}, He\textsuperscript{+} et Ar\textsuperscript{+}. Les échantillons étaient sous forme de couches polycristallines de 600-2 500 Å déposées sur l’aluminium et le carbone. L’effet de variation de la température des cibles dans le domaine de 50 °C et 300 °C a été étudié. La diminution de l’épaisseur des couches est contrôlée pendant l’irradiation par le backscattering de Rutherford.

Nous avons observé : (i) Un sputtering préférentiel des atomes d’halogènes, (ii) une énergie d’activation de 0.2 eV du taux de sputtering, (iii) une proportionnalité entre le taux de sputtering et la puissance de freinage nucléaire, (iv) un rendement de sputtering supérieur aux précisions de la théorie des cascades par plusieurs ordres. Contrairement aux résultats antérieurs obtenus par divers autres auteurs à la température ambiante et aux basses énergies, les observations présentées indiquent clairement que le sputtering n’est pas dû aux cascades de collisions mais s’interprète plus probablement par un processus de Pooley, avec une migration consécutive des atomes interstitiels d’halogène à la surface.

Abstract. — The present sputter experiments are performed with 70 to 300 keV H\textsuperscript{+}, He\textsuperscript{+}, and Ar\textsuperscript{+} ions impinging on KCl and KI. The alkali halide samples are prepared as polycrystalline layers of 600-2 500 Å, deposited on carbon-aluminium backings. During the ion bombardment the targets are kept at elevated temperatures between 50° and 300 °C, in order to study the temperature dependence. The decrease of layer thickness is monitored during the irradiation by Rutherford backscattering.

The present observations are (i) preferential sputtering of the halogene atoms, (ii) temperature dependent sputter rates with 0.2 eV activation energy, (iii) sputter rates proportional to the electronic stopping power, rather than the nuclear stopping power, and (iv) sputter yields orders of magnitude higher than estimated by elastic collision cascade theories. In contrast to earlier results obtained by various other authors at room temperature and low ion energies, the present findings indicate clearly that the sputtering does not result from collision cascades, but is more likely interpreted by a Pooley process with subsequent migration of the interstitial halogen atom to the surface.

DISCUSSION

K. S. SONG. — With regard to the possible role of the self-trapped exciton (STE) in the sputtering mechanism of these materials, there is a theoretical calculation of the upper and lower limit for the thermal activation energy of the jumps of the STE in alkali fluoride and chlorides (1). According to this work, the energies are situated between the corresponding values for the V\textsubscript{r}-centre and about one third of the same. There is also some systematic quantitative, trend in their variation with the ion. It would be of interest to try a correlation between these values and the observed activation energies in the sputtering yield.

J. P. BIERSACK. — If the diffusion of self-trapped excitons to the surface would be responsible for the sputtering, we would expect close agreement between our activation energies (e. g. \approx 0.15 eV for KCl) and your calculated values (0.44 eV for KCl). Unfortunately, we could not find such agreement.

J. DAVENAS. — Have you considered the energy dependence of sputtering? Because at low energies collision processes may be more important.

J. P. BIERSACK. — The lowest energy we have used, was 70 keV Ar\textsuperscript{+} on KCl. In this case we obtained sputter yields of \( S = 4...30 \) atoms/ion (dependent on temperature). These sputter yields are still above the value predicted for elastic collision sputtering.

M. C. WINTERSGILL. — (i) Firstly I would like to remark that results produced at the University of Sussex also indicate that both anions and cations are removed from the surface. The cation distribution is of

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a cosine form indicating evaporation from the surface whilst anions exhibit a spatial distribution compatible with ejection due to a collision sequence.

(ii) Therefore, secondly, I would suggest that the results presented here may also be explained by the model of Townsend et al. in which exciton diffusion precedes de-excitation either (a) radiatively giving luminescence or (b) non-radiatively, resulting in the sputtering due to anion collision sequences intersecting the surface of the crystal.

J. P. Biersack. — (i) With regard to your first remark, I am glad to hear about the close compatibility of experimental results of your group and ours.

(ii) Concerning the interpretation of data, we feel at present unable to decide whether exciton diffusion anion collision sequences or H-center diffusion to the surface precedes the ejection of halogen atoms. Energy spectra of sputtered halogen atoms were observed by Könneken et al. at FOM Amsterdam; they found mainly a thermal distribution (compatible with H-center diffusion to the surface), but little indication of a 5 eV peak which would be more typical for non-radiative de-excitation of an exciton near the surface or anion collision sequences.