IPNO-DRE--87-33(7) FR8900075

Contribution to the Conferenceon Ion Formation from Organic Solids, Munster (RFA), Sept. 21-22, 1987

4 pages

EXPERIMENTS ON SECONDARY ION EMISSION WITH MULTICHARGED keV ION BOMBARDMENT

S. DELLA NEGRA, J. DEPAUW, H. JORET, Y. LE BEYEC, E.A. SCHWEIKERT*

Institut de Physique Nucléaire, BP n° 1, 91406 ORSAY - France
*Department of Chemistry, College Station TEXAS & M University TX 77843 USA

An electron cyclotron resonance ion source has been used to study the influence of the incident charge state of keV ions on the secondary ion emission. The experiments were run with 18 keV Arn+ (1 < n < 11) beams produced by the minimafios ECR source at CEN Grenoble (1) (2). Various types of targets have been bombarded by the ion beam and the sputtered ionized species were identified with time of flight mass spectrometry. We describe in this short paper the experimental arrangement and give some preliminary results.

EXPERIMENTAL

Fig. 1 shows a schematic view of the experimental set up which has been installed on line with the ECR source. The beam line includes 2 einzel lenses to focus the beam to a spot of ≈ 1.5 mm in diameter at the entrance of the reaction chamber where a collimator with a hole of 2 mm was positioned. In this chamber the target and the microchannel plate detectors were mounted on a common platform which could be rotated from outside the chamber to change (with a precision of 0.5 degree) the angle of incidence of the primary beam.

A voltage of 1 kV was applied in 30 nsec on deflection plates (see figure 1) so that the primary beam was swept rapidly through the collimator.

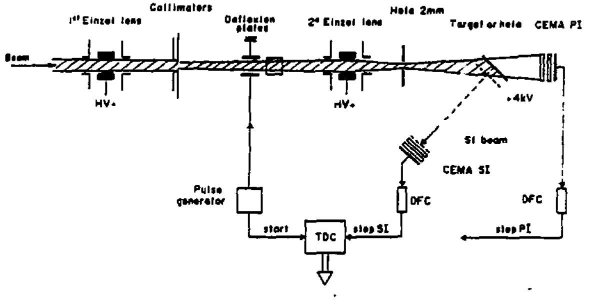

Fig. 1 Schematic view of the beam line and the time of flight chamber

The start signal for the secondary ion time of flight was given by the pulse generator. In order to measure the secondary ion yield it was necessary to know the exact number of primary ions hitting the target per pulse. When there is no target at the center of the chamber, the primary beam could hit directly a set of microchannel plates. It was thus possible to measure the time of flight of the beam and to reduce the beam intensity so that for each pulse either none or only one ion did hit the detector (and therefore the target). We have for this purpose used a beam with less than 2 ions/10 pulses. Since the beam from the ion source is extremely stable the number of ions bombarding the target is for a given time, directly proportional to the total number of pulses delivered by the generator. Thus this was an event by event counting experiment, similar to MeV ion experiments (3).

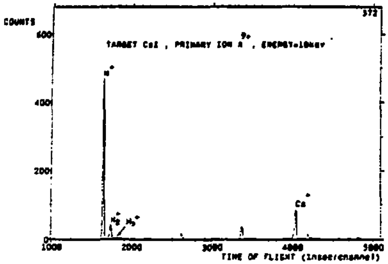

Fig. 2 Time of flight spectrum measured with a CsI target bombarded by Ar^{8+} at 18 keV. Note the importance of the H^+ peak

An example of a secondary time of flight spectrum is presented in Fig. 2.

The target was an evaporated CsI target (2000 angstroms of CsI on Al backing). The mass resolution, because of the beam spot, size was low ($M/\Delta M$ = 150) but sufficient to resolve the mass in the mass range of interest for this first experiment.

The accelerating voltage for the secondary ions was kept constant at a value of 4 kV. An additional post acceleration voltage of 3 KV was applied for the secondary ion detection. In order to have a fixed bombarding energy of the primary beam it is necessary to apply different acceleration voltages at the ion source (according to the desired charge state). If U1 is the accelerating voltage of the primary ions and U2 the accelerating voltage for the secondary ions, the bombarding energy Eb is Eb = n(U1 - U2), n being the charge state. Another parameter is the angle of impact on the target surface θ (impact) which depends on the angle of incidence θ with respect to the normal (see fig. 3) and

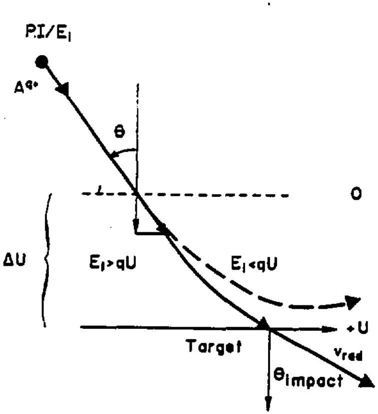

Fig. 3 Primary ion beam trajectories in the accelerating region for secondary ions delimited by the target plane and the grid. The angle of impact θ is a function of (E), θ and n).

■ Cs^+ ion □ H^+ ion

also on the primary energy $E_i = nU_1$. We have verified the influence of the angle of impact on the secondary ion yield as follows. For a given bombarding energy we have measured the secondary ion yield of Cs^+ (for a CsI target) and the molecular ion MH^+ (from a phenylalanine target) as a function of the angle of incidence θ. θ (impact) is deduced by the relation θ_{impact} :

$$\theta_{(impact)} = \mathrm{Arccotg}\sqrt{\mathrm{cotg}^2\theta - \frac{q\,u}{E_b \sin^2\theta}}$$

Fig. 4 shows the measured angular distribution : the secondary yield is constant and decreases rapidly when θ (impact) becomes larger than 60 degrees. This limit corresponds to the case where the primary beam is entirely deflected in the region between the grid and the target. The measurements of the secondary ion yields have always been made in the plateau region.

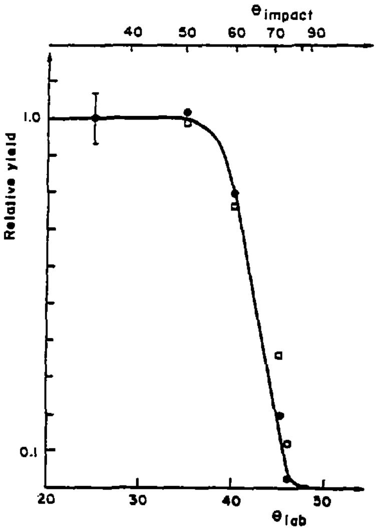

Fig. 4 Secondary ion yield as a function of the angle of impact on the target and the angle of incidence with the grid (beam of Ar^{3+} 18 keV).

A cryogenic pump was used to maintain the vacuum in the time of flight chamber (~ 5 x 10^{-7} mbar). By changing the potential voltage on the target, it is easy to verify the purity of the beam in terms of charge state. We had, for the highest charge state used Ar^{11+}, less than 1% of contamination with lower charge states.

RESULTS

Several targets have been bombarded : SiO2, evaporated CsI and phenylalanine layers on Al backing. Contradictory measurements have been reported on Si (4–6). We have found a constant yield of Si^+ as a function of the charge states of the primary ion with an energy of 18 keV. A similar behaviour is observed for Cs^+ emitted from the CsI target.

The yield for the molecular ion MH^+ from the phenylalanine target remains also fairly constant between 1^+ and 9^+. The only remarkable behaviour is due to H^+ ions which exhibit a strong yield dependence on the incident charge state (yield $H^+ \alpha q_i^3$) a situation similar to the one prevailing with multicharged MeV ions (3) obtained recently. More complete results will be presented soon (7).

We wish to acknowledge S. Dousson and D. Hitz for their efficient and kind collaboration during this experiment at CEN Grenoble and E. Davanture for her patience towards the physicists.

REFERENCES

1. R. GELLER and B. JACQUOT, Physica Scripta T_3, 19 (1983)

2. S. BLIMAN, N. CHAN-TUNG, S. DOUSSON, B. JACQUOT, D. WAN HUTE, Phys. Rev. A 21, 1856 (1980)

3. S. DELLA-NEGRA, O. BECKER, R. COTTER, Y. LE BEYEC, B. MONART, K. STANDING, K. WEIN, J. Phys. 48 (1987) 151

4. I.S. BITENSKII, M.N. MURAKHMETOV, E.S. PARILIS, Sov. Phys. Tech. Phys. 24 (1979) 618

5. A.J. ECCLES, J.A. VAN DEN BERG, A. BROWN and J.C. VICKERMAN, Appl. Phys. Lett. 49, 4 (1986) 188

6. S.T. de ZWART, T. FRIED, D.O. BOERMA, R. HOEKSTRA, A.G. DRENTJE and A.L. BOERS, Surface Science 177 (1986) L-939-L946

7. S. DELLA-NEGRA, J. DEPAUW, H. JORET, Y. LE BEYEC, E.A. SCHWEIKERT, to be published