Reports of the Academy of Sciences of the USSR

Academician of the Academy of Sciences of the Uzbek SSR U. A. ARIFOV, D. D. GRUICH, Kh. MIRRAKHIMOVA

1962

SovietRxiv

Abstract

Full Text

Reports of the Academy of Sciences of the USSR

1962. Vol. 143, No. 1

PHYSICS

Academician of the Academy of Sciences of the Uzbek SSR U. A. ARIFOV, D. D. GRUICH, Kh. MIRRAKHIMOVA
and S. Z. MUZHAVIROV

INVESTIGATION OF SECONDARY PROCESSES CAUSED BY FAST NEUTRAL ATOMS OF ALKALI METALS

Up to the present time, very few studies have been carried out on secondary emission during the bombardment of metals by fast neutral atoms. The small number of such works is due to the absence of a reliable method for registering the number of fast neutral atoms (⌒1).

To elucidate the mechanism of secondary ionic and electronic emission, it is of great interest to study the secondary processes occurring when targets are bombarded by neutral atoms and to compare them with the secondary processes obtained under ion bombardment of targets. For this purpose, a method has been developed for obtaining beams of fast neutral atoms of alkali metals, controllable in energy and intensity. A method is proposed for measuring the intensity of beams of neutral atoms. By the method of double modulation (^{2}-4), secondary emission from a Ta target under the action of fast neutral Na atoms was investigated.

The experimental apparatus consisted of a source section, where a beam of fast neutral atoms was formed, and a receiving section—a hemispherical collector 85 mm in diameter, at the center of which was located a Ta target with dimensions of the central region 10 × 10 mm. The working vacuum in the receiving section was $5 \cdot 10^{-7}$ mm Hg.

To obtain fast neutral atoms, resonant charge exchange of Na^{+} ions was used in a beam of Na vapor directed perpendicular to the ion beam. The directed Na beam was obtained from an evaporator heated by a nichrome spiral. When necessary, the beam could be cut off by a shutter.

The intensity of the beam of fast neutral Na atoms reaching the target was determined by two measurements: first, with the shutter in the receiving section of the apparatus closed, the current of the primary ions I_{Σ}^{+} was measured; then,

Fig. 1

Figure 1: Fig. 1

with the shutter open, the current of ions of the primary beam that had not undergone charge exchange, $I_\Sigma^{+\prime}$, was measured; the intensity of the beam of fast neutral atoms I_Σ^0 was determined by the difference of these two currents

$$I_\Sigma^0 = I_\Sigma^+ - I_\Sigma^{+\prime}.$$

It is assumed that, at the Na vapor pressures used by us, attenuation of the primary ion beam occurs mainly only by neutralization, while attenuation due to scattering of the primary ion beam by the directed beam of Na vapor, which could introduce an error into the determination of I_Σ^0, is negligible. The method we propose for measuring the intensity of a beam of fast neutral atoms eliminates the errors introduced by the method of collecting slow ions (^1), since the currents actually reaching the target are measured.

Figure 1 presents the results obtained in the interaction of neutral Na atoms with energy 1250 eV with a Ta target. Oscillogram 1 in this figure represents the current of the primary ions I_Σ^+, oscillogram 2—the current of ions of the primary beam that had not undergone charge exchange, I_Σ^0. The difference in heights

these two oscillograms gives the intensity of the fast neutral atoms reaching the target, I_Ω^0. Oscillograms 3—11 were obtained by cine photography; the frames were taken at equal time intervals. Along the abscissa axis are plotted the potentials on the collector. Between the target and the collector a sawtooth voltage of amplitude ~ 150 eV was applied. The left-hand parts of these oscillograms, when there is a negative potential on the collector, represent retardation curves of negative secondary emission; the right-hand parts, when a positive potential is applied to the collector, represent retardation curves of secondary positive ions.

Fig. 1

Oscillogram 3 was obtained with a cold Ta target, after it had been heated at high temperature (2200° K). Some amount of residual-gas atoms had already had time to be adsorbed on the surface of the target, but the target was still sufficiently clean. From its right-hand part it is evident that the secondary positive ions have large energies.

In oscillograms 4 and 5 a decrease in the current of secondary positive ions is observed, owing to an increase in the coverage of the Ta target by a film of alkali metal and to a lowering of the work function of the surface. In the subsequent oscillograms 6—11 the positive secondary ions disappear completely, and negative emission begins to appear, consisting of secondary electrons and negative ions.

Fig. 2

Figure 2: Fig. 2

From oscillograms 10 and 11 it is clearly seen that some of the secondary particles possess large energies, which greatly exceed the possible energies of secondary electrons (^{5}). This indicates the presence of negative ions in the composition of the secondary negative emission.

Figure 2 shows the dependence of the scattering coefficient of secondary Na^+ ions, when a clean Ta target is bombarded by fast neutral Na atoms, in the energy range from 1500 to 2500 eV. The individual points of the graph were obtained after heating the Ta target at 2200° K during its cooling, which ensured sufficient cleanliness of the surface at the moment of measurement.

Fig. 2

The results we obtained on secondary emission in the interaction of fast neutral Na atoms with a Ta target that is clean and covered with a film of residual gases allow us to draw an analogy with the secondary emission obtained in the interaction of positive Na^+ ions with a Ta target.

With a clean Ta target bombarded by fast neutral Na atoms, as in the case of Na^+ ions, scattered positive ions with large energies are observed (oscillogram 3, Fig. 1). From the subsequent oscillograms of the same figure it is seen that, as in the case of ion bombardment, because of the decrease in the work function of the target surface due to adsorption of alkali-metal atoms, the number of scattered positive ions decreases and the negative emission greatly increases; this emission contains a large number of negative ions. However, the dependence we obtained of the scattering coefficient K_p' of fast neutral atoms in the form of ions (Fig. 2) does not quantitatively coincide with the same dependence

in the interaction of Na^+ ions with a Ta target. Other conditions being equal, the value of the scattering coefficient in the form of ions when the surface is bombarded by neutral atoms is greater than when it is bombarded by ions.

Institute of Nuclear Physics
Academy of Sciences of the Uzbek SSR

Received
17 VI 1961

REFERENCES

1. H. W. Berry, *J. Appl. Phys.*, **8**, 1219 (1958).

2. U. A. Arifov, A. Kh. Ayukhanov, S. V. Starodubtsev, *Dokl. AN UzSSR*, **1**, 13 (1953); *ZhTF*, **6**, 714 (1954).

3. U. A. Arifov, A. Kh. Ayukhanov, S. V. Starodubtsev, *ZhETF*, **4** (10), 845 (1957).
4. U. A. Arifov, A. Kh. Ayukhanov, S. V. Starodubtsev, Kh. Kh. Khadzhimukhamedov, *DAN*, **124**, No. 1, 60 (1959).
5. U. A. Arifov, Dzh. A. Tashkhanova, *Izv. AN SSSR, ser. fiz.*, **24**, No. 6, 664 (1960).

Note: Figure translations are in progress. See original paper for figures.

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.