

THE CHARGE ON NICKEL OXIDE IN ELECTRON-STIMULATED NEUTRAL MOLECULE DESORPTION

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A study has been made of the charging mechanism for nickel oxide in electron-stimulated neutral-molecule desorption. It has been found that the charging is not related either to the electron-stimulated desorption of positive ions or to the trapping of the bombarding electrons at traps in the surface. A charging mechanism is proposed.

A mechanism has been proposed [1] for the interaction of a bombarding electron with an adsorbed molecule of carbon monoxide, which implies that the excited or dissociating molecule leaves a valency electron at the adsorption center, which should lead to negative charging in electron-stimulated desorption (ESD) of neutral molecules. Also, a negative surface charge is possible in ESD of positive ions and when the electrons are trapped in the oxide.

To elucidate the charging mechanism for nickel oxide in ESD, it is of interest to examine the charging under the following conditions:

- 1) in the absence of positive-ion ESD,
- 2) in the absence of neutral-molecule ESD, and
- 3) after removal of the adsorbed molecules.

Adsorbed molecules are retained on the oxide for several days at room temperature at a pressure of 10^{-9} Torr [1]. One therefore assumes that the charge localized at adsorption centers from neutral-molecule or positive-ion ESD will persist there for a long time. As regards the charge localized at traps in the oxide, we know [2] that this persists at room temperature for several days. This all indicates that ultraslow surface states should make a measurable contribution to the charging.

MEASUREMENT METHODS

The method of measuring the ESD for neutral molecules has been described previously [1]. The charging and charge loss in surface states was measured by a standard method [3] based on displacement of the voltage-current characteristics (VCC). The positive-ion ESD occurring during neutral-molecule ESD was measured with a VK-2-16 electrometer. There was a point rhenium cathode at the center of two nickel hemispheres coated with oxide. One of the hemispheres was the positive-ion collector, while the neutral-molecule ESD occurred at the other one. In some experiments, we used two rings instead of the hemispheres.

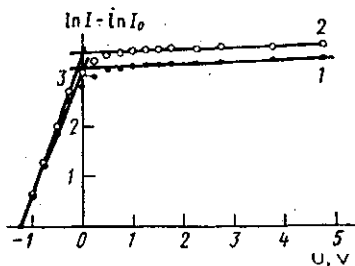


Fig. 1

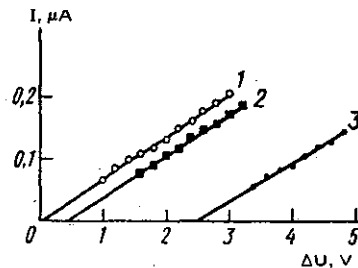


Fig. 2

RESULTS AND DISCUSSION

Figure 1 shows the VCC for the initial nickel oxide surface measured with various heater currents for the rhenium cathode (220 mA for curve 1 and 230 mA for curve 2). The points of inflexion show that the initial oxide surface was uncharged [3]. To measure the change in surface potential in neutral-molecule ESD, we use the VCC shift method, in which the VCC is recorded in turn from two identical anodes differing only in that neutral-molecule ESD had been performed on one anode, while no ESD had been performed on the other.

Figure 2 shows that neutral-molecule ESD (75% CO₂ and 25% CO) at an electron energy of 13 eV leads to negative charging. Before the ESD, the potential difference between the test and control specimens was zero (curve 1). After ESD, the nickel oxide was charged negatively, and the potential difference between the two specimens was 2.5 V (curve 3). We also examined the leakage of the accumulated charge. The surface potential after ESD was measured at various times, and it was found that the discharging was fairly slow: the potential difference in a vacuum of 10⁻⁹ Torr changed from 2.5 to 0.4 V in seven days at room temperature (curve 2).

Figure 3 shows how the probability W of neutral-molecule ESD varies with electron energy (curve 1, $W \approx 10^{-2}$) and the same for positive-ion ESD (curve 2, $W \approx 10^{-7}$). The peak neutral-molecule ESD occurs at ~13 eV, and this appears much earlier than the ion ESD, which begins at a threshold of 20 eV. Figure 3 thus indicates that the charging in neutral-molecule ESD at 13 eV is not associated with positive-ion ESD, since the latter does not occur at this energy.

To establish whether traps participate in the charging, we examined the charging on exposing the nickel oxide to electrons of energy 4 eV. This is insufficient to produce neutral-molecule and positive-ion ESD. No charging was then observed, i.e., we did not find traps on the outer surface.

Only such traps are relevant, since electrons of energy ~10 eV do not penetrate into the oxide. The decisive factor in the charging appears to be inelastic interaction between the electrons and the adsorbed molecules. We consider that an electron converts an adsorbed CO molecule into an excited state and is trapped by it. The resulting bound excited negative CO ion on conversion to a neutral molecule leaves a valency electron attached to the adsorption center and is desorbed as a neutral molecule, leaving the surface negatively charged.

The ESD mechanism for CO₂ is evidently related to oxidation of adsorbed CO molecules in the dissociation of adsorbed oxygen molecules produced by the bom-

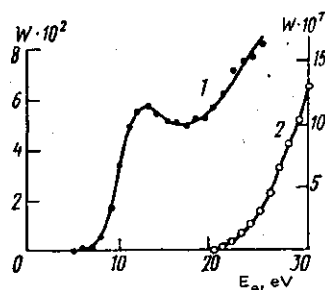


Fig. 3

barding electrons. In particular, that dissociation may produce a negative atomic oxygen ion bound to the adsorption center in an excited state, which participates in oxidation and leaves an electron attached to the adsorption center, thereby charging the surface.

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