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A Note on Electron Transfer to Exoelectron Emission Sources from Scratched Aluminum

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In a previous paper[1] we proposed a 'two-process' model for interpreting the observed transient response of PSEE (photostimulated exoelectron emission) from scratched aluminum. According to this model, there are two excitation processes during PSEE; one is the photo-excitation of the electrons at the exo-active sites and the other is the activation of the exo-inactive sites, or electron supply to the sites lacking in electrons. In the latter, we have so far assumed that the process is in principle the thermal excitation of electrons. The present study was performed to examine the validity of this assumption.

After scratching Al specimens in vacuum (10^{-6} Torr), we determined β, the rate of activation of the exo-inactive sources as a function of temperature by using a simplified method reported earlier.[2] The results are shown in Fig. 1. Contrary to our expectations, β was found to be practically temperature-independent.

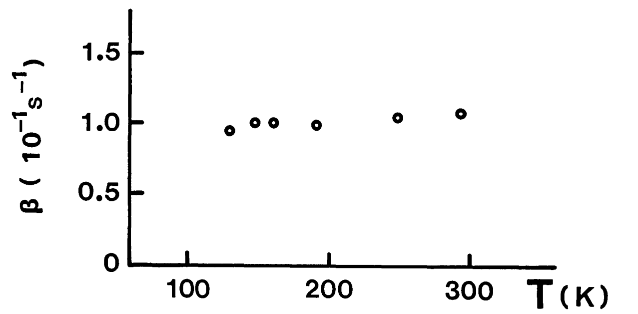

Fig. 1. Exo-activation rate β determined as a function of temperature.

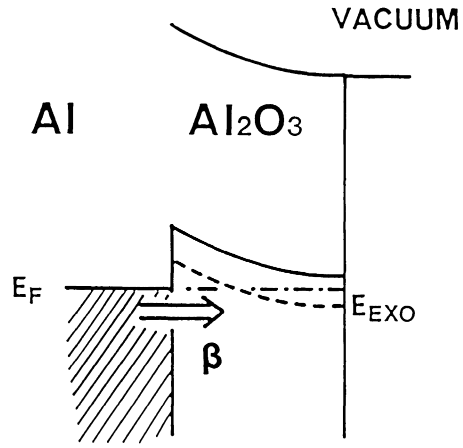

Fig. 2. Energy-level model for Al/Al_2O_3 interface.

Since the height of the energy barrier for the interface between Al and Al_2O_3 is known to be about 1 eV,[3] it is very unlikely for a temperature change from 120 to 300 K to exert no influence on β, the activation rate of exo-inactive sources (which should exist in the oxide layer), if electrons are supplied from the bulk aluminum to the sources as a result of thermal excitation. Regarding electron supply to the sources, therefore, we have altered our 'two-process' model as follows:

Scratching can create trap levels (represented by the dashed line in Fig. 2) for electrons in oxide layers. Because of the electron transfer from the trap levels to the bulk aluminum, equalizing the Fermi levels of both sides, band bending and vacuum-level lowering of Al_2O_3 will result. It is the trap levels below the Fermi level in the aluminum oxide layer that are considered responsible for exoelectron emission.* When these levels are deficient in electrons, i.e., the sites are in the exo-inactive state, electrons will be transferred from the metal side to the sites not by thermal excitation but by quantummechanical tunneling at the rate of β. This view is believed to be consistent with the results obtained in the present study.

*When the photon energy for stimulating scratched Al was varied, the PSEE intensity peak was observed at 3.7 eV. Taking into account that the electron affinity of Al_2O_3 is about 3.2 eV, we estimate the activation energy of the exo-centers to be about 0.5 eV, a value not very different from the value of 0.7 eV obtained from photoluminescence or photoconductivity studies of Al_2O_3.[4-6]

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