ANALYSIS OF COMPOSITE SPECTRAL–SENSITIVITY FUNCTIONS*

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In measurements of the photoelectric effect on semiconductors two types of relationship have been found between the frequency of incident radiation ν and the observed photoelectric current I_{obs}. In one type, the plot of log I_{obs} against ν fits the theoretical Fowler curve (Fowler 1931) ; in other cases, however, a curve is obtained which is in two parts, each of which can be fitted to a separate Fowler curve. Thus Suhrmann, Wedler, and Dierk (1958*a*, 1958*b*) obtained "composite" curves from bismuth films, and we have found both types of behaviour with evaporated nickel films undergoing stepwise oxidation. The problem of interpreting such composite curves is quite a general one.

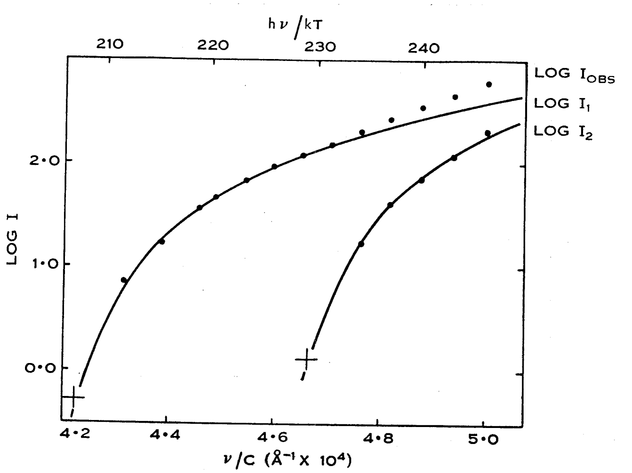

Fig. 1.—Fowler-type plot for photoelectric emission from a partially oxidized nickel surface; curves are computed from Fowler's equation. The work functions are 5·21 eV ($4 \cdot 23 \times 10^{-4}$ Å^{-1}) and 5·76 eV ($4 \cdot 67 \times 10^{-4}$ Å^{-1}).

A composite curve may be interpreted in terms of two emitting mechanisms which act independently. The observed photoelectric current is then the sum of the individual currents, so that

$$\begin{aligned}\log I_{obs} &= \log (I_1 + I_2) \\ &= \log \{A_1\varphi(\nu-\nu_1)+A_2\varphi(\nu-\nu_2)\},\end{aligned}$$

where φ is the Fowler function and ν_1 and ν_2 are the two threshold frequencies. Such a relationship, in a restricted range of frequency, gives a very good fit to two Fowler curves intersecting at a frequency slightly above that of the higher threshold ν_2. (The exact point of intersection for lines of best fit depends on the

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value of A_1/A_2 and on the ratio of the frequency range employed to the interval between the two threshold frequencies.)

The value of ν_2 may be obtained from a second plot of log $(I_{obs}-I_1)$ against ν, where I_1 is obtained by extrapolation of the first Fowler curve ; the method is illustrated in Figure 1, using some of our (unpublished) results. We have usually found it more convenient, however, to use a different method based on the fact that $\varphi(\nu-\nu')$ approaches $0 \cdot 5(\nu-\nu')^2$ as $(\nu-\nu')$ increases : when $(\nu-\nu')$ is greater than $5kT/h$, the discrepancy is usually small compared with the experimental error, and in this region a plot of $I_{obs}^{\frac{1}{2}}$ against ν can be readily fitted to a pair of intersecting straight lines. The value of ν_2 can be calculated from the parameters of these lines ; alternatively, values of I_2 can be obtained numerically and a third straight line can be drawn which is extrapolated to determine ν_2, as shown in Figure 2.

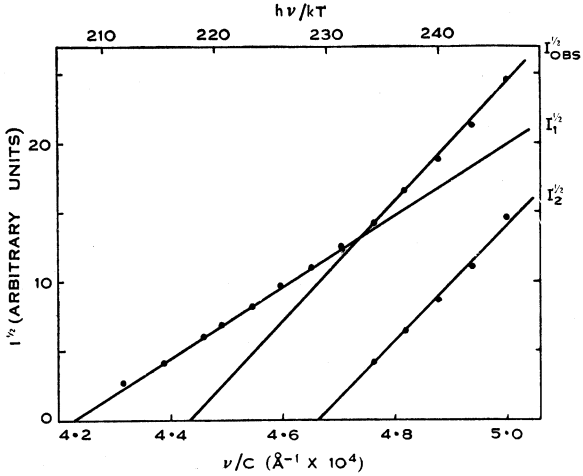

Fig. 2.—Square-root plot for the results in Figure 1.

The values of ν_2 are not the same as the values of second threshold frequency derived by the method of Suhrmann, Wedler, and Dierk. On the basis of a particular band model which is not fully elaborated in their papers, these authors have applied a graphical analysis of Fowler plots which differs from our method. For a typical set of their results (Suhrmann, Wedler, and Dierk 1958*a*, p. 101, Fig. 4) their analysis leads to threshold values of 4·25 and 4·37 eV ; when treated by our method (which assumes the operation of two independent types of emitting region) the same experimental results give threshold values of 4·25 and 4·6 eV, so that the separation is changed by a factor of three. Likewise, the value of A_1/A_2, which is 0·6 according to the analysis of Suhrmann, Wedler, and Dierk, becomes unity in our method. It is therefore necessary in any such case to consider results in relation to a particular model.

References

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Suhrmann, R., Wedler, G., and Dierk, E.-A. (1958*a*).—*Z. Phys.* **153** : 96.

Suhrmann, R., Wedler, G., and Dierk, E.-A. (1958*b*).—*Z. Phys. Chem.* N.F. **18** : 255.