Height of the Potential Barrier in Barrier Layer Cells

Measurements of the zero resistance of a number of barrier-layer cells[1] over a wide range of temperatures have shown that the theoretical expression:

$$R_0 = AT \exp (\varphi/T), \qquad (1)$$

where A and φ are regarded as constants, is not obeyed over the whole range of temperatures. The power of T appearing outside the exponential in equation (1) depends on the assumptions made in the theoretical treatment; values ranging from $+ 3/2$ to $- 1/4$ [2–5] have been obtained, but these do not significantly alter the shape of the curve. Accordingly, the value of unity has been used in this work. It is the purpose of this communication to put forward a possible explanation of the observed departure from equation (1).

In the case of selenium rectifiers, the existence of weak spots has been postulated to explain breakdown phenomena[3], and in germanium the multicontact theory[5] has been proposed to explain the forward characteristics of point-contact diodes. By a simple mathematical analysis of these postulates, it is possible to account for the zero resistance measurements. The barrier layer is considered as being made up of a number of elements in parallel, to each of which equation (1) applies. The parameter φ is assumed to have a normal distribution among the elements about a mean value $\bar{\varphi}$ with standard deviation S. Then it is easy to show that, for the whole cell,

$$\frac{R_0}{T} = \frac{2A}{N(1 + \operatorname{erf} x)} \exp \left[\frac{\bar{\varphi}}{T} - \frac{S^2}{2T^2}\right], \qquad (2)$$

where N is the number of elements, and

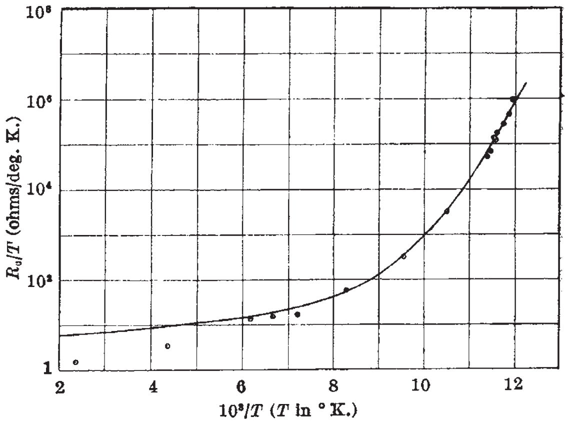
$$x = \frac{1}{S\sqrt{2}} \left(\bar{\varphi} - \frac{S^2}{T}\right).$$

Equation (2) has been fitted to the results for a selenium rectifier, and the theoretical curve and experimental points are shown in the accompanying graph. A similar fit has been obtained with a commercial selenium photocell and germanium and silicon point diodes. Values of $\bar{\varphi}$ and S obtained by fitting equation (2) to the experimental results are shown in the table.

	$\bar{\varphi}$ (eV.)	S (eV.)
Selenium rectifier	0·69	0·09
Selenium photocell	0·86	0·12
Germanium rectifier	1·13	0·13
Silicon rectifier	0·47	0·07

It is clear from the experimental results that equation (1) cannot be used as a reliable method for the determination of φ, but $\bar{\varphi}$ and S obtained from equation (2) will give some indication of the uniformity of the barrier layer.

The above calculations can be modified by allowing for an upper and lower limit for the distribution of φ; the shape of the curve is found to be sensitive to the lower, but very insensitive to the upper, limit. This is in agreement with the multicontact theory, where it is shown that it is the low-value tail of the distribution which is of primary importance. The upper limit may be less than $\bar{\varphi}$, so that the occurrence of $\bar{\varphi}$ greater than the width of the energy gap in



the semiconductor need not imply that the individual barrier heights exceed this value ($\bar{\varphi}$ for germanium, 1·13 eV.; width of energy gap, 0·72 eV.). Detailed calculations of this sort were not considered worth while, as the data so far available do not justify the inclusion of yet another parameter.

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Molecular Weight Determination by Thermistors

A thermistor is a resistance body which has a high negative temperature coefficient of resistance, and is a valuable circuit element with a large variety of applications. Thermistors can be used as sensitive thermometers in cryoscopic measurements[1] and also in place of thermocouples for measuring the lowering of vapour pressure of aqueous colloidal solutions[2]. At a condition of steady state, the droplets of solution and solvent deposited on the tips of the thermistors have a constant difference in temperature which can be measured as a difference of resistance in an A.C. bridge circuit. The construction and operation of a simple A.C. thermistor bridge, used for measuring the osmotic activities of aqueous solutions, has been described by McGee and Iyengar (submitted for publication elsewhere).

A pair of matched thermistors can also serve as a sensitive element for determination of molecular weights of compounds in organic solvents. The resistance differential ΔR set up per unit molal difference in concentration between the drops of solvent and solution ($k = \Delta R/m$) is generally much higher for organic solvents than for water; for example, $k = 12 \cdot 1$ ohms/mol. for water and $40 \cdot 1$ ohms/mol. for toluene in the case of a pair of Western Electric thermistors (Type 14B, resistance about 2,000 ohms at 25°). Thus, organic solvents increase the sensitivity of measuring the small difference of vapour pressure between the drops of solution and solvents.