Walter H. Schottky

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(Redirected from Walter Schottky)

Walter Hans Schottky (23 July 1886 – 4 March 1976) was a German physicist who played a major early role in developing the theory of electron and ion emission phenomena,[1] invented the screen-grid vacuum tube in 1915 and the pentode [citation needed] in 1919 while working at Siemens, co-invented the ribbon microphone and ribbon loudspeaker along with Dr. Gerwin Erlach in 1924 [2] and later made many significant contributions in the areas of semiconductor devices, technical physics and technology.

Walter H. Schottky	
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Born	23 July 1886 Zürich, Switzerland
Died	4 March 1976 Pretzfeld, West Germany
Residence	Germany
Nationality	German
Fields	Physicist
Institutions	University of Jena University of Würzburg University of Rostock Siemens Research Laboratories
Alma mater	University of Berlin
Doctoral advisor	Max Planck Heinrich Rubens
Notable students	Werner Hartmann
Known for	Schottky effect Schottky barrier Schottky contact Schottky anomaly Screen-grid vacuum tube Tetrode Ribbon microphone Ribbon loudspeaker Theory of Field emission Shot noise
Notable awards	Hughes medal (1936) Werner von Siemens Ring (1964)

Contents

Early life

Schottky's father was mathematician Friedrich Hermann Schottky (1851–1935). Schottky's father and mother had one daughter and two sons. His father was appointed professor of mathematics at the University of Zurich in 1882, and Schottky was born four years later. The family then moved back to Germany in 1892, where his father took up an appointment at the University of Marburg. [citation needed]

Schottky graduated from the Steglitz Gymnasium in Berlin in 1904. He completed his B.S. degree in physics, at the University of Berlin in 1908, and he completed his Ph.D. in physics at the University of Berlin in 1912, studying under Max Planck and Heinrich Rubens, with a thesis entitled: *Zur relativtheoretischen Energetik und Dynamik*.

Career

Schottky's postdoctoral period was spent at University of Jena (1912–14). He then lectured at the University of Würzburg (1919–23). He became a professor of theoretical physics at the University of Rostock (1923–27). For two considerable periods of time, Schottky worked at the Siemens Research laboratories (1914–19 and 1927–58).

Inventions

In 1924, Schottky co-invented the ribbon microphone along with Gerwin Erlach. The idea was that a very fine ribbon suspended in a magnetic field could generate electric signals. This led also to the invention of the ribbon loudspeaker by using it in the reverse order, but it was not practical until high flux permanent magnets became available in the late 1930s.[2]

Major scientific achievements

Possibly, in retrospect, Schottky's most important scientific achievement was to develop (in 1914) the well-known classical formula, now written $-q^2/16\pi\varepsilon_0 x$, for the interaction energy between a point charge q and a *flat* metal surface, when the charge is at a distance x from the surface. Owing to the method of its derivation, this interaction is called the "image potential energy" (image PE). Schottky based his work on earlier work by Lord Kelvin relating to the image PE for a sphere. Schottky's image PE has become a standard component in simple models of the barrier to motion, $M(x)$, experienced by an electron on approaching a metal surface or a metal–semiconductor interface from the inside. (This $M(x)$ is the quantity that appears when the one-dimensional, one-particle, Schrödinger equation is written in the form

$$\frac{d^2}{dx^2}\Psi(x) = \frac{2m}{\hbar^2}M(x)\Psi(x).$$

Here, $\hbar$ is Planck's constant divided by 2π, and m is the electron mass.)

The image PE is usually combined with terms relating to an applied electric field F and to the height h (in the absence of any field) of the barrier. This leads to the following expression for the dependence of the barrier energy on distance x, measured from the "electrical surface" of the metal, into the vacuum or into the semiconductor:

$$M(x) = \ h - eFx - e^2/4\pi\epsilon_0\epsilon_r x \ .$$

Here, e is the elementary positive charge, ε_0 is the electric constant and ε_r is the relative permittivity of the second medium (=1 for vacuum). In the case of a metal–semiconductor junction, this is called a Schottky barrier; in the case of the metal-vacuum interface, this is sometimes called a Schottky–Nordheim barrier. In many contexts, h has to be taken equal to the local work function φ.

This Schottky–Nordheim barrier (SN barrier) has played an important role in the theories of thermionic emission and of field electron emission. Applying the field causes lowering of the barrier, and thus enhances the emission current in thermionic emission. This is called the "Schottky effect", and the resulting emission regime is called "Schottky emission".

In 1923 Schottky suggested (incorrectly) that the experimental phenomenon then called autoelectronic emission and now called field electron emission resulted when the barrier was pulled down to zero. In fact, the effect is due to wave-mechanical tunneling, as shown by Fowler and Nordheim in 1928. But the SN barrier has now become the standard model for the tunneling barrier.

Later, in the context of semiconductor devices, it was suggested that a similar barrier should exist at the junction of a metal and a semiconductor. Such barriers are now widely known as Schottky barriers, and considerations apply to the transfer of electrons across them that are analogous to the older considerations of how electrons are emitted from a metal into vacuum. (Basically, several emission regimes exist, for different combinations of field and temperature. The different regimes are governed by different approximate formulae.)

When the whole behaviour of such interfaces is examined, it is found that they can act (asymmetrically) as a special form of electronic diode, now called a Schottky diode. In this context, the metal–semiconductor junction is known as a "Schottky (rectifying) contact'".

Schottky's contributions, in surface science/emission electronics and in semiconductor-device theory, now form a significant and pervasive part of the background to these subjects. It could possibly be argued that – perhaps because they are in the area of technical physics – they are not as generally well recognized as they ought to be.

Awards

He was awarded the Royal Society's Hughes medal in 1936 for his discovery of the Schrot effect (spontaneous current variations in high-vacuum discharge tubes, called by him the "Schrot effect": literally, the "small shot effect") in thermionic emission and his invention of the screen-grid tetrode and a superheterodyne method of receiving wireless signals.

In 1964 he received the Werner von Siemens Ring honoring his ground-breaking work on the physical understanding of many phenomena that led to many important technical appliances, among them tube amplifiers and semiconductors.

Controversy

The invention of superheterodyne is usually attributed to Edwin Armstrong. However, Schottky published an article in the Proceedings of the IEEE that may indicate he had invented something similar.[*citation needed*]

- 1939: first p–n junction

Legacy

Walter Schottky Institute (Germany) was named after him. The Walter H. Schottky prize is named after him.

Books written by Schottky

- *Thermodynamik*, Julius Springer, Berlin, Germany, 1929.
- *Physik der Glühelektroden*, Akademische Verlagsgesellschaft, Leipzig, 1928.

See also

- Schottky defect

References

1. ^ Welker, Heinrich (June 1976). "Walter Schottky" (http://www.physicstoday.org/resource/1/phtoad/v29/i6/p63_s1?bypassSSO=1). *Physics Today* **29** (6): 63–64. doi:10.1063/1.3023533 (http://dx.doi.org/10.1063%2F1.3023533).
2. ^ [a] [b] "Historically Speaking" (http://www.hi-fiworld.co.uk/loudspeakers/66-knowledge/152-historically-speaking-part-ii.html). Hifi World. April 2008. Retrieved April 2012.

External links

- Walter Schottky (http://www.tf.uni-kiel.de/matwis/amat/def_en/kap_2/advanced/t2_1_3.html)
- Biography of Walter H. Schottky (http://www.webcitation.org/query?url=http://www.geocities.com/bioelectrochemistry/schottky.htm&date=2009-10-25+19:12:49)
- Walter Schottky Institut (http://www.wsi.tum.de/)
- Walter H. Schottky (https://portal.d-nb.de/opac.htm?query=Woe%3D118759183&method=simpleSearch) in the German National Library catalogue
- Reinhard W. Serchinger: Walter Schottky – Atomtheoretiker und Elektrotechniker. (http://www.gnt-verlag.de/de/?id=88) Sein Leben und Werk bis ins Jahr 1941. Diepholz; Stuttgart; Berlin: GNT-Verlag, 2008.
- Schottky's nndb profile (http://www.nndb.com/people/438/000172919/)
- Schottky's math genealogy (http://genealogy.math.ndsu.nodak.edu/id.php?id=55830)

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