C-8

Pioneering Study on Tunnel Diodes

Leo Esaki (1925－) started the study of PN junction diodes as a chief scientist in the diode research laboratory at Tokyo Communication Industry Co., Ltd., (currently Sony). After trial and error for about one year, he discovered the fact that when making the width of the PN junction of germanium as thin as 10 nm, negative resistance—the higher the voltage, the lower the current, contrary to conventional knowledge—occurred because its current-voltage properties were dominated by the impact of tunnel effects.

This discovery was the first example of verifying the tunnel effect of quantum mechanics in the diode and the birth of new electronic devices—tunnel diode (or Esaki diode)—in electronic engineering as well. Then in 1973, L. Esaki was awarded the Nobel Prize for Physics together with Ivar Giaever who made the achievement of tunnel effects in ultrahigh conductors.

Initially, the tunnel diode was made from germanium, however, now it is also made from gallium arsenide and silicon. It has also been used for various electronic circuits, e.g., oscillation circuits, amplifying circuits, frequency converters, and detector circuits.

C-9

Study on Static Induction Transistors (SIT)

In 1950, Junichi Nishizawa (1926－) developed the static induction transistor (hereinafter, SIT) applying the perfect crystal growth technique and high purity crystal growth technique originated by himself. He introduced a transistor having a rising property into the field of conventional transistors, where the properties of both the bipolar transistor and the field-effect transistor (FET) were limited to only the property of current saturation to increase in voltage. In other words, the property of the triode valve became obtainable by making it possible to control the current potential shape of the boundary between the source and the channel using the static induction effect, which was derived by means of the elimination of the negative feedback effect by making the channel short and decreasing the concentration so as to reduce the channel resistance to the utmost limit.

This finding discredited the globally established theory—FET property is saturation form. Introducing a new conductivity theory by correcting errors in Dr. Shockley's theory, he made it clear that field-effect transistor could be either SIT or FET of saturation form, and then established the design standard to separate them.

Regarding conventional saturation form transistors, output impedance was very large, so for its application to the circuit, various types of measures were required. However, SIT developed by J. Nishizawa had the merits of small drive power and simple circuit construction which were characteristics of high input impedance drive voltage devices of the conventional FET, while showing the rising property of current increasing as voltage increased. In addition, this made it possible to flexibly design the output impedance covering a wide area ranging from 1 Ω to tens Ω by changing the structure and impurity distribution. Accordingly, it was favorably applicable to various circuits and equipment such as power amplifier construction with simple circuits.

In 1975, the Institute of Electronics, Information and Communication Engineers (IEICE) gave an achievement award to Junichi Nishizawa for this technology.