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In Half a Century of Research Career What did I explore?

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In 1945-46, we physics students were really fascinated by the introduction of the revolutionary knowledge of "Quantum Mechanics" which had not yet been widely disseminated. I was interested in putting the new knowledge of quantum mechanics to practical use. In 1947, I moved on to life as a researcher in the electronics industry, where I explored the possibility of creating quantum electron devices. Coincidentally, 1947 was the year in which the epoch-making transistor was invented.

In 1956, I initiated the investigation of the quantum mechanical tunneling in narrow Ge p-n junctions at SONY, Tokyo. We first obtained a backward diode. When the junction width narrowed down to about 10 nanometers, the current-flow mechanism was convincingly tunneling not only in the reverse direction but also in the low-voltage range of the forward direction, giving rise to a prominent current-peak. Since the current-peak associated with a negative resistance had never been predicted, the Esaki Tunnel diode - the very first quantum electron device - came as a total surprise in 1957.

In 1969, Esaki and Tsu at IBM T.J. Watson Research Center, New York, proposed a semiconductor superlattice, a "man-made periodic quantum structure" which is engineered by applying the advanced growth technique of MBE, after designing the periodic structure in accordance with the principles of quantum theory in such a way as to exhibit unprecedented electronic properties. The proposal is based on Bloch's golden rule that "the periodic potential in the crystal lattice determines its electronic properties". The lattice constant of this proposed superlattice is in the range of 1-10 nanometers, substantially longer than that of the host crystal, but shorter than the electron phase-coherent length.

Esaki and his coworkers' pioneering research on superlattices and quantum wells in the 1970s and 1980s triggered a wide spectrum of experimental and theoretical investigations resulting in not only the observation of a number of intriguing phenomena, but also the emergence of a new class of transport and optoelectronic devices.