Awards

SSDM Award

The SSDM Award is awarded to researchers who contributed an outstanding paper at the past SSDM conferences.

Presented at the 16th International Conference on Solid State Devices and Materials (1984), Kobe

High Voltage Bipolar-Mode MOSFET with High Current Capability

Akio Nakagawa, Hiromichi Ohashi, and Tsuneo Tsukakoshi

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The Insulated Gate Bipolar Transistor (IGBT) is currently the leading power semiconductor device. During initial development, however, the IGBT had an intrinsic problem. Latch-up phenomena, which were caused by the thyristor structure inherent in the device, narrowly limited the Safe Operating Area (SOA) for voltage and current. This paper proposed and demonstrated the first tangible solution in the world to this problem. The concept became the theoretical guideline for designing IGBTs commercialized in countries around the world. It can be said that this paper was the starting point for such practical implementation.

Around 1980, research was actively being pursued on the MOS-controlled thyristor which an MOS gate turns on and off, to be the power semiconductor that would globally succeed the high-voltage bipolar transistor. Among those efforts, the discovery that a horizontal MOS thyristor could operate the transistor (1978) prompted greater interest in development of a device structure that would realize the operation. However, these attempts were unable to solve the problem of the thyristor easily latching up on account of the PNPN structure with its alternating P-type and N-type layer arrangement, which was essentially inherent in the device structure. As such, no practically applicable device ever resulted. Amid the focus of much research on the flow of electrons, this paper showed that it was possible to formulate conditions triggering latch-up by focusing on the hole current supplied by P-type layer on the back surface of the chip and that, based on this, a design which would prevent latch-up could be worked out. The outcome of this paper was that the SOA of the IGBT expanded significantly up to a practical level, opening the way for commercialization as well as developing rapidly on high power IGBTs for industrial motors and other applications.

Currently, the IGBT has been developed to handle even higher current densities (for home appliances) and its high performance has been realized at overwhelmingly low cost. This has made it a core device in fields applying power semiconductors. It has also been projected the IGBT will be a key device in CO2 reduction and renewable energy adoption. The IGBT market continues to grow 10% annually and could conceivably reach 1 trillion yen.

As explained above, the results of the research published in this paper have made a substantial contribution from a fundamental perspective to the development of industrial applications for the IGBT, the most important power device of our day, and the paper's great contribution has also been acknowledged from the standpoint of constructing device design guidelines that fully utilize numerical simulations. Therefore, the SSDM Award is presented to the authors of this paper in recognition of their achievements.

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Akio Nakagawa

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Akio Nakagawa received the B.Sc. and M.Sc. degrees in physics in 1972 and 1974, and the Ph.D. degree in electrical engineering in 1984, all from Tokyo University. In 1974, he joined Toshiba R&D Center, where he was engaged in the development of various power devices. In 1984, he developed world first non-latch-up IGBTs. From 1981 to 1983, he was a visiting scholar in the Electrical & Computer Engineering Dept. of the Univ. of Mass., Amherst. He published over 150 technical papers. He received Okochi Memorial Technology Prize in 1990 and IEEE William E. Newell Power Electronics Award in 2010, all for development of non-latch-up IGBTs, and received ISPSD Award in 1998 for his paper of high voltage SOI technology. He was granted over 190 U.S. patents and over 100 Japanese patents. He retired from Toshiba Corp. in 2009, and is currently President of Nakagawa Consulting Office, LLC. Dr. Nakagawa is a life senior member of IEEE, and a fellow member of IEE Japan.

Hiromichi Ohashi

Corporation Aggregates, NPERC-J (Next generation power electronics and system research consortium Japan)

He received M.S. degree in electronics from Sophia university in 1969 and Ph. D degree from Tohoku University in 1990. From 1969 to 2002, he joined Research and Development Center, Toshiba Corporation, Kawasaki Japan. After being involved in sensor system development for Artificial-satellite, he engaged in research activities for a novel power device and Its application technologies. From 2002 to 2004, he was a professor of the Tokyo Institute of Technology. From 2003 to 2013, he was working for the Power electronics Center of AIST as an invited researcher. From 2014 to 2019, he was director of the Green Electronics Research Center of City Kitakyushu. From 2014, he has been president of the NPERC-J. He was General Chairman of the 1995 ISPSD (International Symposium on Power Semiconductor Devices and ICs). In 1999, He received the Purple Ribbon Award from Japan Government.

Tsuneo Tsukakoshi

Tsuneo Tsukakoshi Joined Toshiba Central Research Laboratory (former Toshiba Research & Development Center) in 1965. In 1968, he engaged in the development of compact color imaging tubes. Since 1973, engaged in the development of power semiconductor devices such as 600V 100A GTO, high voltage power MOSFETs, 6000V 2500A Light Triggered Thyristor, and high voltage IGBTs. In 2002, he retired from Toshiba Research & Development Center. In 1997, he received Oyama Matsujiro Award for his contribution to the development and commercialization of IGBTs.

History of the SSDM Award

SSDM Paper Award (PA)