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September 25, 2017

Dr. Hiroyuki Matsunami, Professor Emeritus, Kyoto University Received the Honda Prize 2017 for Contribution to Pioneering Research on Silicon Carbide (SiC) Power Devices and its Practical Applications

Honda Foundation, a public-interest incorporated foundation created by Soichiro Honda, the founder of Honda Motor Co., Ltd. and his younger brother, Benjiro Honda, and currently headed by Hiroto Ishida, is pleased to announce that the Honda Prize 2017 will be awarded to Dr. Hiroyuki Matsunami, Professor Emeritus, Kyoto University who has made tremendous contributions to pioneering research on "silicon carbide (SiC) power devices" and its practical applications.

Established in 1980, the Honda Prize is Japan's first international award in the field of Science and Technology. It is awarded annually to an individual or group to recognize accomplishments in the field of ecotechnology*[1], which works to advance human achievement while concurrently preserving the natural environment. Dr. Matsunami has been a world pioneer in conducting research on utilizing a material called "silicon carbide (SiC)," which realizes highly efficient power control, for semiconductor elements called "power devices," used for power control. Through his research, SiC power devices have been put into practical use and are contributing to the reduction of power loss occurring in the control process during power supply, that Dr. Matsunami's endeavor is recognized by the award of the Honda Prize.

Dr. Matsunami is the 38th Honda Prize laureate. The award ceremony will be held at the Imperial Hotel in Tokyo, Japan on November 16, 2017. In addition to the prize medal and the diploma, the laureate will be awarded 10 million yen.

<Dr. Matsunami's SiC Power Devices>

Throughout the process from electric power generation at power plants to the use of generated power as energy, this electric power is subject to various controls such as voltage boosting and dropping, conversion between alternating current and direct current, and electric energy regulation. Semiconductor elements used in the course of power control are called "power device" and silicon (Si) is used as its main material. When electric current flows into the power device, it consumes electric power as power control is performed, and some of the electric power turns to heat, causing an energy loss. Therefore, while worldwide efforts have been made to redesign the power device structure, the development of a new material substitute for Si that is compatible with the power devices is anticipated in order to promote resource and energy conservation.

As a new materials, research on “silicon carbide (SiC)” started in mid 1950s in the United States. SiC is a compound of Si and carbon (C), which is an exceedingly hard material exemplifies the diamonds. The research on SiC aimed for realization of the development of electronic devices for electronics, that is operable in a high-temperature environment has spread on a global scale. Dr. Matsunami had an interest in SiC from early on, and started basic research from the late 1960s to develop electronic devices utilizing SiC’s excellent physical properties—high-temperature operability and radiation resistance.

While Si has a characteristics of a single crystal with a regular diamond structure, SiC is a hard-to-handle material as performing crystal growth with few defects was difficult. Also SiC has 200 different types of crystal structure states (crystal polymorphism), the most appropriate crystal polymorphism for commercialization was not yet determined. Furthermore, with a robust structure as hard as diamond, SiC makes its processing extremely difficult and challenging. Although many research institutes attempted to realize SiC’s practical applications, none overcame the difficulties in processing and most of them withdrew from the project.

Dr. Matsunami continued basic research on SiC and, about 20 years from the commencement of his research, in 1987, he published a method called “Step-Controlled Epitaxy*[2],” enabling production of homogeneous SiC thin membrane with uniformed crystal polymorphism by tilting the surface of a substrate a few degrees. Around 1990, as Si power devices were facing their performance limit, thanks to this discovery, the SiC utilization came under the world’s spot light and development of the SiC power devices dramatically advanced.

Around 2010, practical applications of SiC power devices has started. Utilizing SiC in power devices led to a tremendous reduction in power loss, enabling high-speed, high-efficiency power control. Likewise, as SiC has high-voltage resistance and high-temperature resistance characteristics, cooling systems became more compact, leading to downsizing of power control mechanisms. In 2013, SiC power devices were introduced to Tokyo Metro subway and registered a 30% energy reduction compared to the amount of energy required by conventional train cars. In recent years, SiC power devices have been installed on such as suburban trains, high-speed elevators, power conditioners for solar batteries, fuel cell vehicles, and experiments for installation on hybrid cars and the Tokaido Shinkansen have been started as well.
Although there are still some challenges in dissemination of SiC power devices including establishment of mass-production technology, cost reduction, and so forth, its application to electric vehicles is also expected when further reduction in power consumption, space-saving through downsizing of the devices, and cost reduction are achieved.

Starting with Step-Controlled Epitaxy developed through long years of Dr. Matsunami’s research, SiC production method and the technologies enabling the practical applications of SiC to power devices have paved the way for new possibilities for SiC as a novel material. As realization of the practical uses of SiC power devices would also lead to resolution of a rapid increase in fossil fuel consumption and the amount

of waste from power generation accompanied by a surge in power consumption on a global scale, his accomplishments were considered appropriate for the Honda Prize recognition.

*1 Ecotechnology: Coined from “ecology”—the house of civilization—and “technology.” It has been put forward since 1979 as the guiding philosophy for a better symbiosis between technology-driven civilization and nature.

*2 Epitaxy: Phenomenon where on the surface of a crystal, crystals with aligned axes or other crystals of similar structures grow. This is applied to the production process of diodes and transistors.

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You may also contact Honda Motor’s Coporate PR Department via phone at +81-3-5412-1512.

Dr. Hiroyuki Matsunami

Professor Emeritus, Kyoto University

Date of Birth

June 5th, 1939

Biography

1962: Department of Electronic Engineering, Faculty of Engineering, Kyoto University
1964: Master's Degree, Graduate School of Engineering, Kyoto University
1964: Research Associate, Kyoto University
1970: Doctor of Engineering, Kyoto University
1971: Assistant Professor, Kyoto University
1976–1977: Visiting Associate Professor, North Carolina State University, U.S.A.
1983: Professor, Kyoto University
2003: Mandatory retirement from Kyoto University and appointed as Professor Emeritus
2004–2012: Director, Innovation Plaza Kyoto, Japan Science and Technology Agency

Academic Society/Association Activities

President, SiC Alliance, General Incorporated Association (2015–)
The Japan Society of Applied Physics; The Institute of Electronics, Information Science and Communication Engineers; The Institute of Electrical Engineers of Japan; The Japanese Association for Crystal Growth; IEEE (The Institute of Electrical and Electronics Engineers, Inc.)

Selected Publications

Silicon Carbide Vol. I, II (Akademie Verlag, 1997)
Silicon Carbide—Recent Major Advances— (Springer, 2003)
Semiconductor SiC Technology and Applications (Nikkan Kogyo Shimbunsha, 2003)
Semiconductor SiC Technology and Applications Second Edition (Nikkan Kogyo Shimbunsha, 2011)
Wide Gap Semiconductors—From Dawn to the Frontlines—(Baifukan, 2013)

Awards and Honors

2001: The 1st Yamazaki-Teiichi Prize (in the field of semiconductors and semiconductor devices), Foundation for Promotion of Material Science and Technology of Japan
2002: The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology in 2002 (Research Contribution Award)
2004: The 4th (2003) Research Achievement Award, The Japan Society of Applied Physics
2004: The 41st (2003) Research Achievement Award, The Institute of Electronics, Information Science and Communication Engineers
2005: The SSDM Award-2005
2013: The 2012 Asahi Prize (pioneering research of power semiconductor silicon carbides)
2016: The IEEE David Sarnoff Award
2017: The Academia Prize
Also, appointed to Fellow of the Japan Society of Applied Physics, Fellow of the Institute of Electronics, Information and Communication Engineers, and Life Fellow of the IEEE