Summary of the 7th Workshop

University of Tsukuba Forum on Power Electronics Tomorrow (UTOP)

"Application of SiC-MOSFET Devices to EV"

Time & Date: 1:20-5:40pm, July 6, 2018

Venue: Bunkyo School Building, Tokyo Campus, University of Tsukuba

Participants: 80

Program:

Mediator: Takanori Isobe, Associate Professor, Institute of Applied Physics, University of Tsukuba

13:20 "Recent topics at Power Electronics Laboratory, Tsukuba University"
Prof. Noriyuki Iwamuro, Institute of Applied Physics, University of Tsukuba

13:30 Presentation (1), Power Electronics Laboratory, Tsukuba University in FY2018
"Investigation of near-interface traps in 4H-SiC MOS devices"
Xufang Zhang, Ph. D student

13:55 Presentation (2), Power Electronics Laboratory, Tsukuba University in FY2018
"Non-power operation of MOSFET body-diode by Z-source inverter - Utilization of device property by circuit behavior -
Ryuji Iijima, Ph.D. degree student

14:20 "Rare-earth free motor for EV (SR motor)"
Akira Chiba, Professor, Department of Electrical & Electronics Engineering, Tokyo Institute of Technology

15:10 - 15:25 Coffee break

Mediator: Hiroshi Yano, Associate Professor, Institute of Applied Physics, University of Tsukuba

15:25 "Nissan's EV strategy (including power electronics technology)"
Haruyoshi Kumura, Fellow, Nissan Motor Co., Ltd.

16:15 "SiC trench MOSFET with built-in SBD (SWITCH-MOS)"
Yusuke Kobayashi, Advanced Power Electronics Research Center, National Institute of Advanced Industrial Science and Technology (AIST)

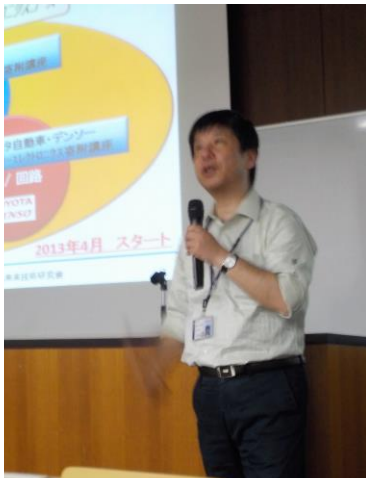
Mediator: Prof. Hiroshi Tadano, Institute of Applied Physics, University of Tsukuba

17:10 Panel Discussion "How can SiC devices contribute to EV technology?"

17:40 Closing Address

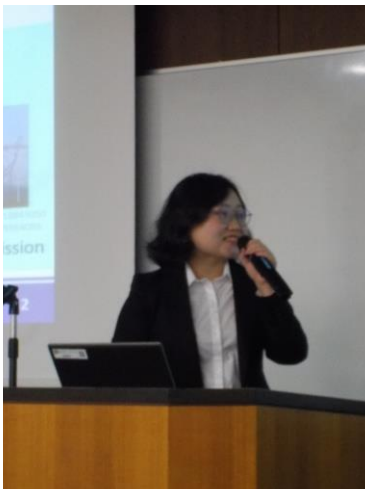
1. Recent topics at Power Electronics Laboratory, University of Tsukuba

Prof. Noriyuki Iwamuro, Institute of Applied Physics, University of Tsukuba



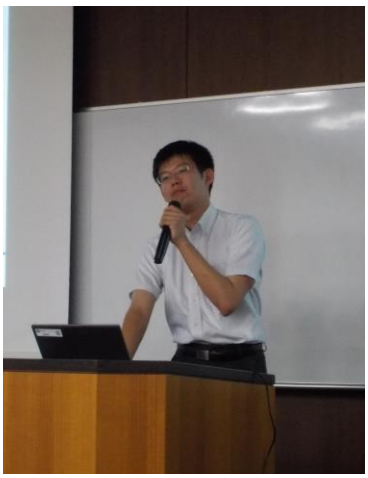
Outline of activities at Power Electronics Laboratory, which was founded in April, 2013, was presented including those as a member of Tsukuba Innovation Arena (TIA) - nano.
The laboratory has been expanded steadily and been operated by thirty-seven (37) members of faculty staff, bench scientists and students in FY2018. Two students were graduated from the laboratory for the first time in FY2015, and approximately ten (10) students follows every year. The laboratory members have been actively working, including presentations at the international and domestic conferences, two of which are scheduled to be presented at this workshop.
The laboratory consists of two donation-based courses and is jointly managed sharing one office room, in which frank discussions can easily take place. Its missions include to produce researchers having multi-specialized domains through these education and research system.

2. Presentation (1), Power Electronics Laboratory, Tsukuba University in FY2018
"Investigation of near-interface traps in 4H-SiC MOS devices"
Xufang Zhang, Ph. D student



A distributed model has been applied for 4H-SiC MOS capacitors to investigate the near-interface traps (NITs), taking the electron tunneling into account.
The modified distributed model was successfully explained the C-f and G-f characteristics with an assumption of exponentially decaying distribution of NITs. The density distribution of NITs changed significantly by NO passivation. NIT density increases with increasing oxide thickness.
In order to solve the problems of 4H-SiC MOSFETs of low channel mobility and threshold voltage instability, it is necessary to know the reasons concerning NITs.

３．Presentation (2), Power Electronics Laboratory, Tsukuba University in FY2018
"Non-power operation of MOSFET body-diode by Z-source inverter - Utilization of device property by circuit behavior – "
Ryuji Iijima, Ph.D. degree student



No current operation at body diode was proposed for MOS-FET Z-source invertor by having short-circuit behavior.
Possibility of SiC-SBD-less MOSFET was discussed through characteristics of the device and the circuit.
SJ-MOSFET is a promising device for invertor systems because of the higher efficiency than conventional ones.
MOSFET is a very convenient device for invertor system, but the current through the body-diode is not preferable.
Short-circuit behavior could avoid this unfavorable current.

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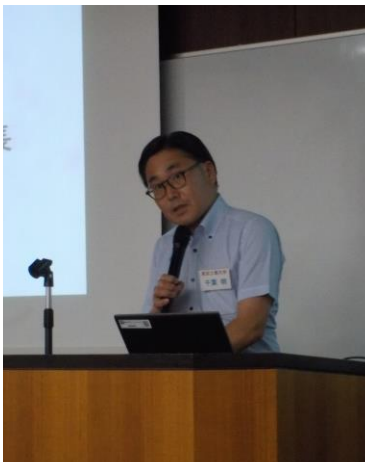
４．"Rare-earth free motor for EV (SR motor)"
Akira Chiba, Professor, Department of Electrical & Electronics Engineering, Tokyo Institute of Technology

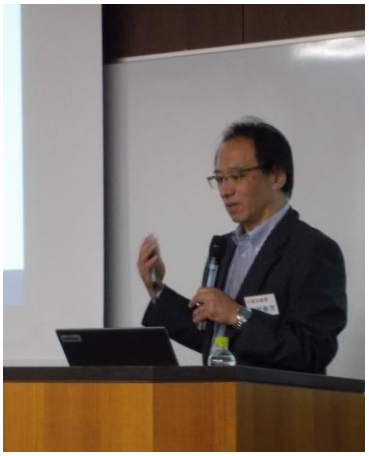


Rare-earth metal prices are hiking along with the growth of EV production. A motor used for present EV is mostly permanent magnetic (PM), which contains Neodymium (Nd) and Dysprosium (Dy) and their cost account for more than half of the total cost of motor itself.
The rare-earth metal problem could be solved by applying an advanced switched reluctance motor (SR motor), which does not use rare-earth metals.
The SR motor has disadvantages in its weight and vibration, however, those problems could be solved by improving its structure (of magnetic poles) and electric current wave, etc.
The improved SR motor showed the similar performance in torque and efficiency as PM motors, and wider power output range of speed.

５．"Nissan's EV strategy (including power electronics technology)"
Haruyoshi Kumura, Fellow, Nissan Motor Co., Ltd..

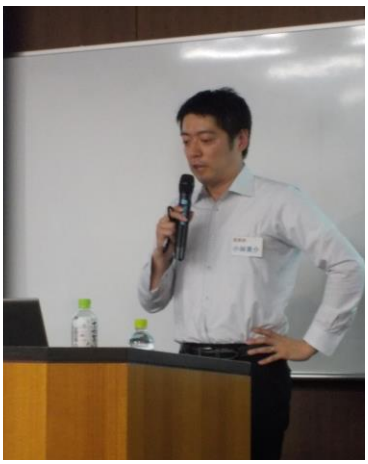
A moving distance per capita increases with the economic growth, and number of automobiles follows. Problems like energy supply, global warming, traffic congestion and accident enlarges at the same time.

Nissan Motor has settled its challenges to Zero-emission and to Zero-vehicular-death. The technical approaches consist of Electricity-powered system and Artificial intelligence. Nissan is strongly driving e-Pedal and e-Power in order to accelerate Electricity-powered system. In terms of Artificial intelligence, it aims at the perfect auto-driving system (Level-5) which will appear in 2022. We should consider about the power source for EVs when they widely spread around the world. Power electronics technologies would take important roles at that time.



6．“SiC trench MOSFET with built-in SBD (SWITCH-MOS)”
Yusuke Kobayashi, Advanced Power Electronics Research Center,
National Institute of Advanced Industrial Science and Technology (AIST)

Si-MOSFET is expected to be employed as an efficient device at 1.2kV range used in trains, EVs, etc. In order to make SiC-MOSFET more efficient and compact, it is necessary to lower the loss and to remove the outside Shottky diode (SBD).
Trench MOS structure is very effective to lower the device resistance, and SBD built-in structure works for removing outside SBD. Those measures resulted in the development of SWITCH-MOS. Additionally halo structure helped drastically lower the threshold voltage.



7．Panel Discussion “How can SiC devices contribute to EV technology?”

Prof. Tadano reviewed the market and application of SiC devices. Base on the understanding of the present status, a discussion was made on expected applications of SiC devices in the field of EV technology.