Summary of the 6th Workshop

University of Tsukuba Forum on Power Electronics Tomorrow (UTOP)

"SiC MOSFET Devices with Trench Gate Structure and their Applications"

Time & Date: 1:20-5:40pm, March 3, 2017

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

Participants: 81

Program:

Mediator: Dai Okamoto, Assistant 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 FY2016 @ EPE 2016 ECCE, Karlsruhe, Germany (Sep 2016)
"A dead-time minimized inverter by using complementary topology and its experimental evaluation of harmonics reduction"
Kazuma Okuda, 2nd -year master's degree student

13:55 Presentation (2), Power Electronics Laboratory, Tsukuba University in FY2016 @ IEEE IEDM 2016, San Francisco, USA (Dec 2016)
"Experimental demonstration of -730V vertical SiC p-MOSFET with high short circuit withstand capability for complementary inverter applications"
Junjie An, 2nd -year Ph.D. degree student

14:20 "Development of SiC V-groove trench MOSFET and its applications"
Yasuki Mikamura, Department Head, Design and Engineering Department, Power Device Division, Sumitomo Electric Industries Ltd.

15:10 - 15:25 Coffee break

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

15:25 "SiC device with trench structure and its applications"
Takashi Nakamura, General Manager, Research and Development Division, Rohm Co., Ltd.

16:15 "Development of SiC modules and Inverters with SiC module"
Atsuhiko Kuzumaki, Scientist, Power Electronics Technology Group, Electrical/ Mechanical Systems and Power Electronica R&D Dept., Power and Industrial Systems R&D Center, Toshiba Corporation Energy Systems & Solution Co.

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

17:10 Panel Discussion "Aiming for SiC power devices with greater availability"

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 with nine (9) faculty staff, two (2) bench scientists, four (4) doctoral students from industry and twenty-nine (29) students in FY2016. Two students were graduated from the laboratory for the first time in FY2015. 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 FY2016

@ EPE 2016 ECCE, Karlsruhe, Germany (Sep 2016)

"A dead-time minimized inverter by using complementary topology and its experimental evaluation of harmonics reduction"

Kazuma Okuda, 2nd -year master's degree student

A research result on a complementary inverter with dead-time minimization and harmonics reduction was presented. Higher efficiency, downsizing and lower output deformation are required for power electronics products. When enhancing frequency in the usual circuit, a dead-time is necessary for preventing short-circuit. In this research, a new circuit was proposed enabling no dead-time and a very shot feedback time. The proposed circuit was fabricated and successfully tested at 400W single-phase system with a low output deformation.

３．Presentation (2), Power Electronics Laboratory, Tsukuba University in FY2016
@ IEEE IEDM 2016, San Francisco, USA (Dec 2016)
"Experimental demonstration of -730V vertical SiC p-MOSFET with high short circuit withstand capability for complementary inverter applications"
Junjie An, 2nd -year Ph.D. degree student

The very first SiC p-MOSFET was fabricated in response to requirement of higher frequency switching for power electronics products.
A vertical SiC MOSFET with high short-circuit withstand capability for complementary inverter system was fabricated and successfully tested at up to -730V, 16.1J/cm^2.
The fabricated p-MOSFET has a high avalanche ability as well as a stable gate oxide layer.

４．"Development of SiC V-groove trench MOSFET and its applications"

Yasuki Mikamura, Department Head, Design and Engineering Department, Power Device Division, Sumitomo Electric Industries Ltd.

Sumitomo Electric Industry Ltd. has been working on development of non-silicon semiconductor materials, devices and modules.
It has developed SiC V-groove trench MOSFET utilizing (0338) facet which has high mobility of electron. Thermo-chemical etching was used for making V-groove trench gate which showed a low on-resistance of 2mΩcm^{-2}.
A module having a low impedance was fabricated using the MOSFET device, and its high speed switching was confirmed by testing it. A compact battery system also was fabricated using the module, and it delivered an excellent performance of high efficiency.
A grounding structure in the device will be modified in order to upgrade its performance in the research activities.

５．"SiC device with trench structure and its applications"

Takashi Nakamura, General Manager, Research and Development Division, Rohm Co., Ltd.

Rohm Co., Ltd. has been manufacturing SiC wafer, discrete devices and modules in its

integrated system of production.

It has proposed a new trench structure SBD and produces it on a commercial basis. It also developed the very first SiC back-current preventing MOSFET for bidirectional switches. In the module manufacturing, it has launched new products onto the market, such as compact and low cost modules utilizing transfer molding, very compact modules for inverters on EV and PHV, highly thermostable 6in1 TMP for on-board applications.

SiC devices and modules are recently expected to apply to accelerators for their downsizing, for example, a new BNCT (Boron Neutron Capture Therapy) multi-gate accelerator would be possible, which could provide very efficient treatment in the cancer therapy. (A development plan in US)

6．“Development of SiC modules and Inverters with SiC module”

Atsuhiko Kuzumaki, Scientist, Power Electronics Technology Group, Electrical/ Mechanical Systems and Power Electronica R&D Dept., Power and Industrial Systems R&D Center, Toshiba Corporation Energy Systems & Solution Co.

SiC power devices are expected to apply to the on-board and power grid equipment of the next generation.

Lowering the parasitic inductance (Ls) is very important for the large-current and high-speed switching.

A new all-SiC module of 1.7kV-400A MOSFET/SBD could provide a very lowered inductance by 40% compared to the conventional products. The new module could also decrease the switching loss by 89% comparing with Si-IGBT.

A similar performance was observed with newly fabricated 3.3kV-1000A products. When applying to the high-speed trains, the module could deliver a saving-energy effect by 66% comparing to the Si-IGBT, by 40% comparing to the hybrid SiC module.

SiC hybrid module of 4.5kV-150A was tested in the PMSM drive system. A drive system having PMSM and SiC hybrid main circuit was selected for the 1000 series new train of Tokyo Metro Ginza line, which showed very good energy saving effect by 37% reduction comparing to the 01 series train having IM drive system. A new Shinkansen bullet train N700S will carry SiC devices in the plan of JR Tokai (Central Japan Railway Company).

７．Panel Discussion “Aiming for SiC power devices with greater availability”

Prof. Tadano showed present problems of SiC devices, and also their growth projection in the power electronics market. Base on the understanding of those problems and projection, a discussion was made on expected applications of SiC devices and their problems to be solved.