

Summary of the 3rd Workshop

University of Tsukuba Forum on Power Electronics Tomorrow (UTOP)

“SiC Wafer, Devices and Application to Trains”

Time & Date: 1:20-5:40pm, July 10, 2015

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

Program:

Mediator: Noriyuki Iwamuro, Professor, Institute of Applied Physics, University of Tsukuba

13:20 “Recent topics at Power Electronics Laboratory, Tsukuba University”

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

13:30 “Complementary inverter and its gate driving circuit; prototype preparation and operation analysis”

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

14:20 “Application of SiC power devices to electric railroads”

Youichi Kono, Railway Operations Headquarters, East Japan Railway Co.

15:10 - 15:25 Coffee break

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

15:25 “Latest technology trends of SiC devices, Fuji Electric’s challenges”

Masato Otsuki, Electric Devices Business Group, Fuji Electric Co., Ltd.

16:15 “Development status of SiC single crystal – Phenomenon analysis and product quality enhancement on the sublimation-recrystallization process”

Tatsuo Fujimoto, Advanced Technology Research Laboratories, Nippon Steel and Sumitomo Metal Corp.

17:00 Panel Discussion “Aiming for SiC power devices with greater availability”

Mediator: Prof. Ryuichi Shimada, Institute of Applied Physics, University of Tsukuba

17:40 Closing Address

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

Prof. Hiroshi Tadano, 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 up to six faculty staffs and twenty-two students.

The laboratory consists of two donation-based courses and



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. Complementary inverter and its gate driving circuit; prototype preparation and operation analysis

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

Basic switching mechanisms in a power conversion circuit were discussed, followed by those on gate-driving circuits and their required performances.

Dominant power conversion circuits are shifting from IGBT to SiC-MOSFET with the advent of SiC devices. Prof. Isobe proposed a complementary inverter, in which N-ch and P-ch switching devices are paired. A prototype of this inverter was prepared at the lab and checked its performance. A practical P-ch power device is expected using SiC-MOSFET.



3. Application of SiC power devices to electric railroads

Youichi Kono, Railway Operations Headquarters, East Japan Railway Company

Status of railway transportation business, mechanism and features of electric railcars, inverter drive with induction motor are presented. 1,500V-DC power feeding and 20,000V-DC feeding are employed to drive JR trains. Recent development of power electronics promoted the inverter drive system with AC-motors.

Application of SiC power devices to the inverter system was discussed. Low-loss and high-frequency SiC devices have a lot of advantages, resulting in energy saving driving systems. East JR has developed prototype railcars with SiC power devices and checked their performances, followed by DC driven train, type E235, test operation.



4. Latest technology trends of SiC devices, Fuji Electric's challenges

Masato Otsuki, Electric Devices Business Group, Fuji Electric Co., Ltd.

Fuji Electric is expanding its business in the energy and environment sectors based on the power electronics technologies. SiC products are widening their families and the application is extending in the variety of industrial fields.

Low cost SiC devices are manufactured by using 6-inch wafers and automated process

lines. Those devices can contribute to reducing system cost at users because of their advantages of low-loss and high-frequency, which leads to reduction in cost for L, C and structural materials in the systems. A hybrid module of SiC and IGBT is also possible, which can provide inverters having low-loss and high-frequency features. A full SiC module could reduce the loss by 50% or more. However, advanced packaging technology is required for this module in order to secure applications at the high temperature of 170°C-200°C.



5. Development status of SiC single crystal – Phenomenon analysis and product quality enhancement on the sublimation-recrystallization process

Tatsuo Fujimoto, Advanced Technology Research Laboratories, Nippon Steel and Sumitomo Metal Corp.

A sublimation-recrystallization process was developed by Nippon steel and Sumitomo Metal Corp. The process requires precise control at every step of sublimation, transport and recrystallization. A Si-C phase diagram was very important for the process development. An excess Si addition was tried to stabilize the composition of the sublimated gas in order to minimize dislocation defects. Epitaxial defects along the polishing flaws are also important, which was revealed by observing the crystal surface closely.



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

Prof. Shimada had charge of moderator; Messrs. Kono, Otsuki and Fujimoto took part in the discussion. Prof. Shimada proposed a smart switch with SiC-MOSFET, which could be useful for many applications such as PV, EV, DC network, HVDC breaker, etc. The panel discussed on its possibilities.

