2014 International Conference on Solid State Devices and Materials
= Short Course A =
Trends for Future Power Devices
September 8, 2014 Tsukuba International Congress Center, Ibaraki, Japan

Organizer

Prof. Shizuo Fujita (Kyoto University)

Speakers

13:00-14:20 "Basic Requirements and Physics of Power Devices"

Prof. Jun Suda (Kyoto University)

Fundamentals of power semiconductor devices will be reviewed. Requirements from the system side, such as low on-resistance, high breakdown voltage, high switching speed and high operation temperature will be explained together with basic power electronics circuits, such as a buck converter, a boost converter and an inverter. Then, semiconductor device physics which determine these characteristics will be presented. Several device structures, such as Schottky barrier diodes, MOSFETs, PiN diodes and IGBTs will be mentioned. The advantages of wide-band-gap semiconductors will be discussed based on the discussions. The lecturer would like to show you a comprehensive view of power semiconductor devices.

Break (10 min.)

14:30-15:30 "Trends in the development of SiC power devices by manufacturers"

Prof. Hidekazu Yamamoto (Chiba Institute of Technology)

Today, nearly 100% of power devices are manufactured using Si. Although Si power devices have a different structure and a somewhat different manufacturing process to other types of Si integrated circuits, they are compatible with most manufacturing equipment. As a result of ongoing development of Si integrated circuits, their performance has rapidly improved, and mass-production systems have been developed. However, Si power devices are now considered to be approaching their performance limit, and for this reason, expectations are growing for next-generation power devices based on wide-gap semiconductors (WGSs) such as SiC and GaN, which have superior characteristics. In contrast to Si power devices, there are many challenges to be faced before WGS power devices can enter genuine mass production. The present article reviews the various issues that must be addressed by device, materials, and equipment manufactures.

Break (10min.)

15:40-16:40 "High-speed switching operation of wide band-gap semiconductor and its circuit application"

Prof. Nobuo Satoh (Chiba Institute of Technology)

In DC power supplies, the switching operation with high-speed can decrease the amount of energy treated in one cycle operation. This promotes the downsizing of the passive elements of the inductor and the capacitor. On the other hands, parasitic impedances of the circuit decide limitation of high-speed switching operation. The switching loss occurs because of the surge voltage, the tail current, and ringing phenomena originated in both circuit patterns and valve-device parasitic component. In this short course lecture, two types of power MOSFET were examined as the valve device: those are a silicon (Si) power-device and a silicon carbide (SiC) one. We investigated transient behaviors of the flyback converter at the switching operation. Finally, we showed a flyback converter of 50W output-class with a snubber circuit beyond 1MHz as high-speed switching operation.

16:40-17:20 "Gallium oxide-based electronics: Present status and future prospects"

Dr. Masataka Higashiwaki (NICT)

A new widegap oxide compound semiconductor, gallium oxide (Ga_2O_3), has excellent material properties for power and high-temperature device applications mainly due to a large band gap of about 4.8 eV. Another important advantage of Ga_2O_3 over other widegap semiconductors such as SiC, GaN, and diamond is that large-area single-crystal wafers can be fabricated from a melt-grown bulk crystal, which is high quality, requires neither a high-temperature nor a high-pressure environment, and uses less source material. Here, after the introduction of Ga_2O_3 material properties and envisioned markets for Ga_2O_3 devices, I will talk about the current status of R&D on Ga_2O_3 transistors and the future prospects. The experimental results on Ga_2O_3 MESFETs and MOSFETs will be given in the talk as practical examples.