Session 8: Power Devices - Advances in Silicon Carbide and Gallium Oxide Silicon Power Devices
Monday, December 3, 1:30 PM
Continental Ballroom 7-9
Co- Chairs: S. Ekkanath Madathil, University of Sheffield
S. Harada, AIST

1:35 PM - 2:00 PM
8.1 0.63 mΩcm^2 / 1170 V 4H-SiC Super Junction V-groove trench MOSFET, *T. Masuda, Y. Saito, T. Kumazawa, T. Hatayama, and S. Harada, National Institute of Advanced Industrial Science and Technology*

4H-SiC super junction, 0.63 mΩcm^2 and 1170 V, V-groove trench MOSFETs (SJ-VMOSFET) were demonstrated. The specific on-resistance (Ron, sp) of the SJ-VMOSFET is the lowest ever among all the reported SiC-MOSFETs with the blocking voltage (Bv) over 600 V. Superior electrical properties were realized with the structural combination of the V-groove MOS channel and the charge balance at super junction area. The $R_{on, sp}$ analysis of SJ-VMOSFET was carried out after mounted on a TO-268 5pin package having a Kelvin source terminal. The V-groove {03 8} channels could keep a high inversion mobility even in increasing doping concentration over 1x10^{18} cm-3. The excellent-static and –dynamic performances of SJ-VMOSFET were allowed to realize the ultra-low loss switching applications.

2:00 PM - 2:25 PM
8.2 First Demonstration of Dynamic Characteristics for SiC Superjunction MOSFET Realized using Multi-epitaxial Growth Method, *S. Harada, Y. Kobayashi, S. Kyogoku, T. Morimoto, T. Tanaka, M. Takei, and H. Okumur, AIST*

A 1.2 kV-class superjunction (SJ) UMOSFET was realized using a multi-epitaxial growth method. The dynamic characteristics were characterized, and the potential of a product level device was identified for the first time. The switching characteristics with Schottky barrier diode showed no degradation in spite of the large drain-source capacitance (CDS). The reverse recovery characteristics of the body diode exhibited a soft recovery which may originate from the large CDS and the short lifetime of minority carrier. A high short circuit capability comparable to a non-SJ device was demonstrated.

2:25 PM - 2:50 PM
8.3 Channel engineering of 4H-SiC MOSFETs using sulphur as a deep level donor, *M. Noguchi, T. Iwamatsu, H. Amishiro, H. Watanabe, K. Kita* and N. Miura Mitsubishi Electric Corporation, *The University of Tokyo*

We demonstrated Si-face 4H-SiC MOSFETs using sulphur as a deep level donor in channel region, for the first time. The natures of sulphur in 4H-SiC, that is a donor with large ionization energy, realized lower channel resistance and higher threshold voltage compared with the channels using conventional shallow level donors.

2:50 PM Coffee Break

3:15 PM - 3:40 PM
8.4 Demonstration of 1200V Scaled IGBTs Driven by 5V Gate Voltage with Superiorly Low Switching Loss, *T. Saraya, K. Itou, T. Takakura, M. Fukui, S. Suzuki, K. Takeuchi, M. Tsukud*, Y. Numasawa**, K. Satoh***, T. Matsudai#, W. Saito#, K. Kakushima^, T. Hoshii^, K. Furukawa^, M. Watanabe^, N. Shigyo^, K. Tsutsui^, H. Iwai^, A. Ogura**, S. Nishizawa^^, I. Omura^^, H. Ohashi#, and T. Hiramoto, The University of Tokyo, *Green Electronics Research Institute, **Meiji University,*

****Mitsubishi Electric Corp., #Toshiba Electronic Devices & Storage Corp., ^Tokyo Institute of Technology, ^^Kyushu University*

Functional trench-gated 1200V-10A class Si-IGBTs, designed based on a three dimensional (3D) scaling concept, were fabricated, and 5V gate voltage switching operation has been demonstrated for the first time. 33% reduction of turn-off loss and 100mV improvement of onstate voltage were achieved, while keeping 1.2kV forward blocking voltage.

3:40 PM - 4:05 PM

8.5 2.44 kV Ga2O3 vertical trench Schottky barrier diodes with very low reverse leakage current,

W. Li, Z. Hu, K. Nomoto, R. Jinno, Z. Zhang, T. Q. Tu**, K. Sasaki**, A. Kuramata**, D. Jena and H. Grace Xing, Cornell University, *Kyoto University, **Novel Crystal Technology, Inc.*

High-performance beta-Ga2O3 vertical trench Schottky barrier diodes (SBDs) are demonstrated on bulk Ga2O3 substrates with a halide vapor phase epitaxial layer. A breakdown voltage (BV) of 2.44 kV, Baliga's figure-of-merit (BV2/Ron) of 0.39 GW/cm2 from DC measurements and 0.45 GW/cm2 from pulsed measurements are achieved, all of which are the highest among beta-Ga2O3-based power devices. A lowest reverse leakage current density below 1 uA/cm2 until breakdown is observed on devices with a fin width of 1-2 um, thanks to the reduced surface field (RESURF) effect provided by the trench SBD structure. The specific on-resistance is found to reduce with increasing area ratio of the fin-channels following a simple relationship. The reverse leakage current agrees well with simulated results considering the barrier tunneling and barrier height lowering effects. The breakdown of the devices is identified to happen at the trench bottom corner, where a maximum electric field over 5 MV/cm could be sustained. This work marks a significant step toward reaching the promise of a high figure-of-merit in beta-Ga2O3.