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Defect Analysis of Schottky Diode based 4H-SiC n-type substrate using Deep Level Transient Spectroscopy

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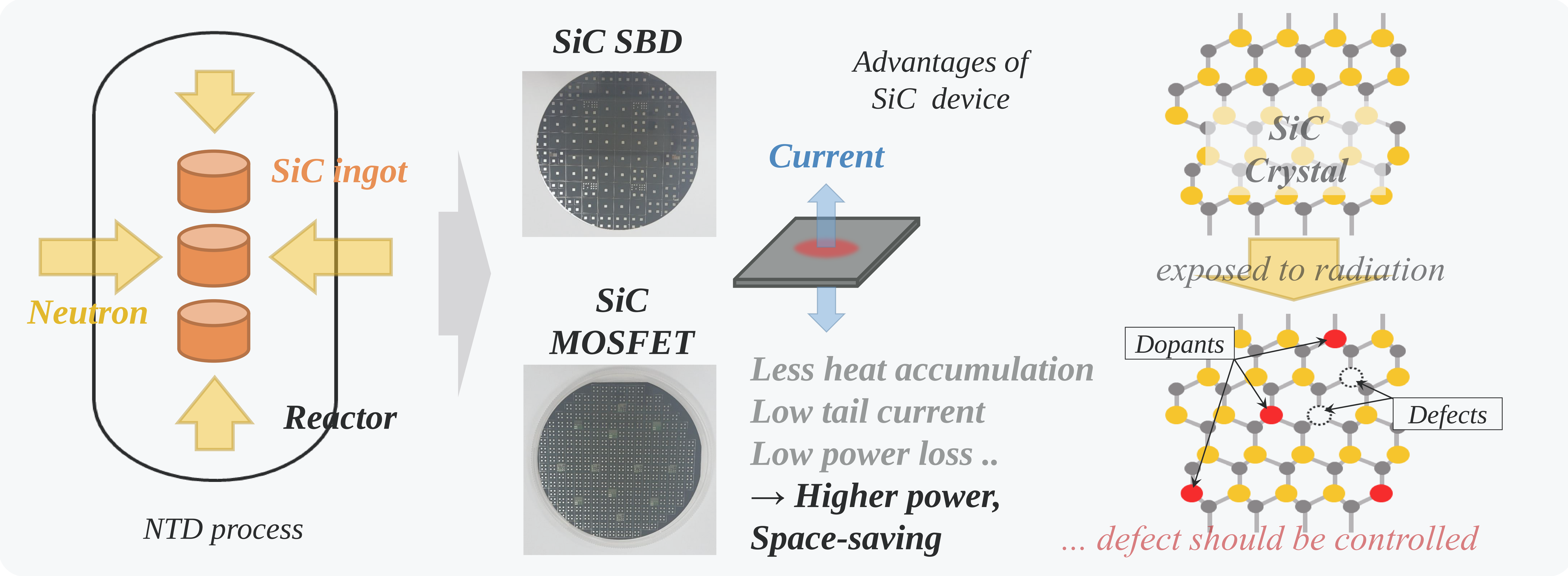
Introduction

● Silicn Carbide (SiC) and Neutron Transmutation Doping

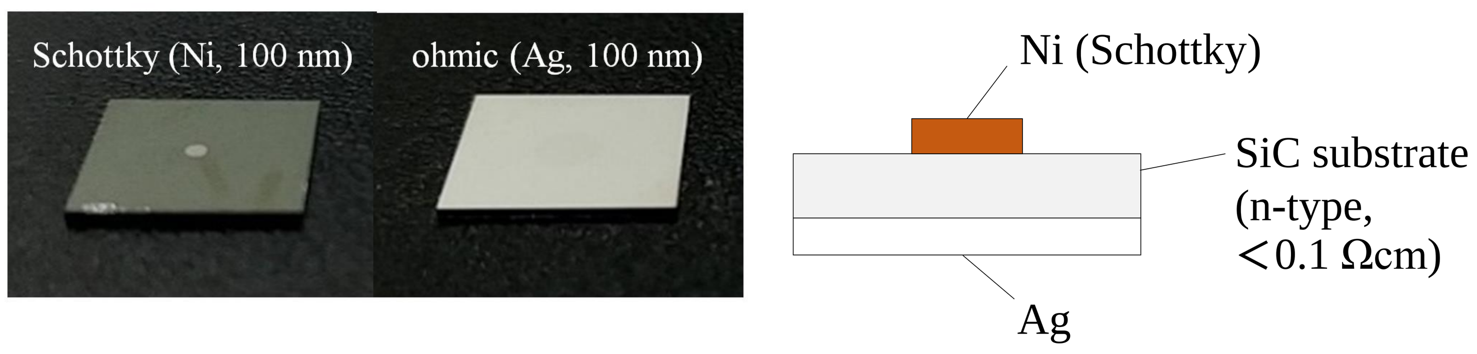
- SiC is a promising semiconductor material which can utilized in next-generation power device.
- It has an advantage of high switching speed and low power loss due to its excellent physical properties (e.g., bandgap 3 times higher than Si) compared to conventional Si-based devices.
- Neutron transmutation doping (NTD) can be an alternative to mass production
- NTD SiC has various defects caused by neutrons and gamma rays, thus it is required to study theses kinds of defects and their behavior.



Methods and Results

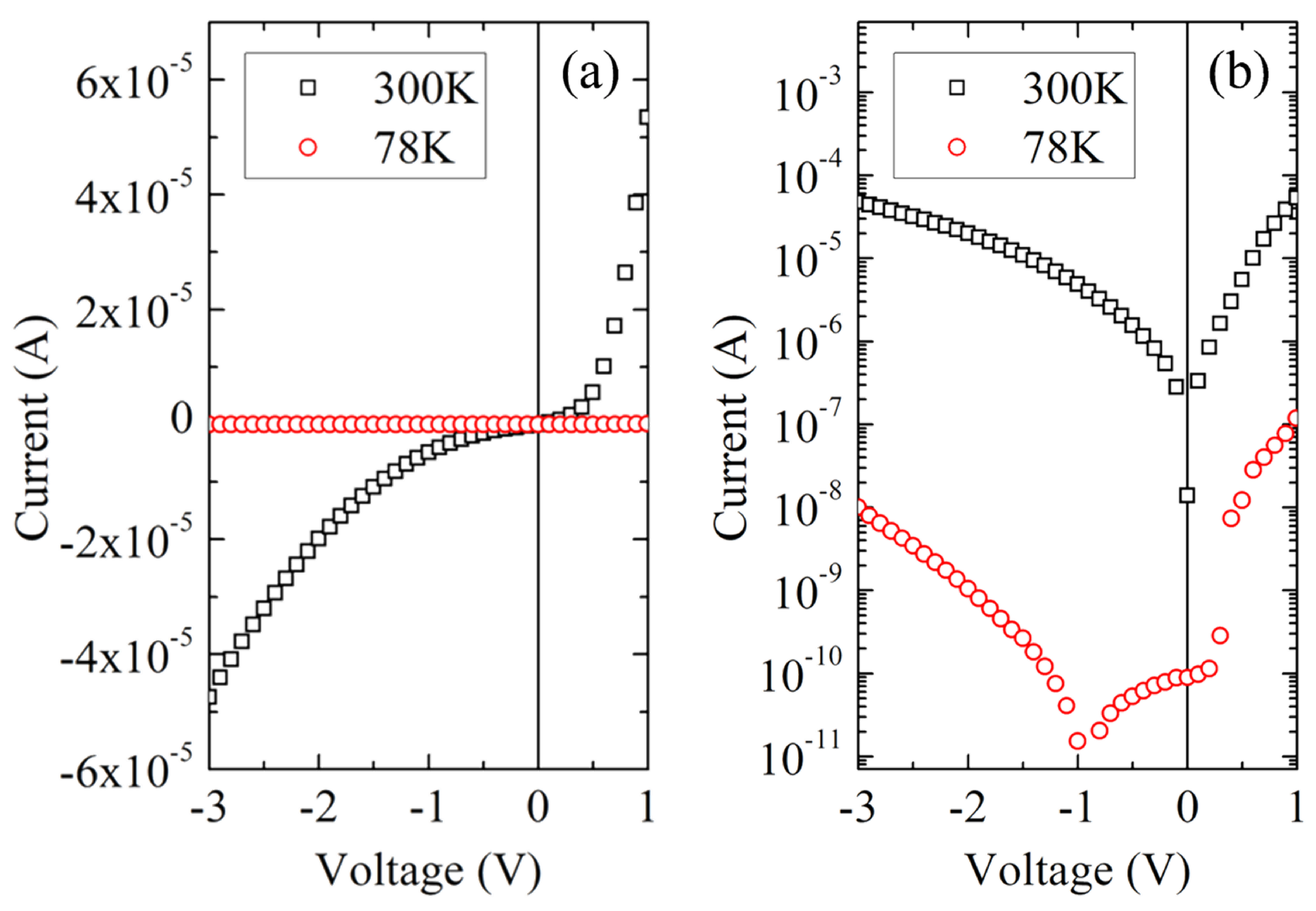
● Sample preparation

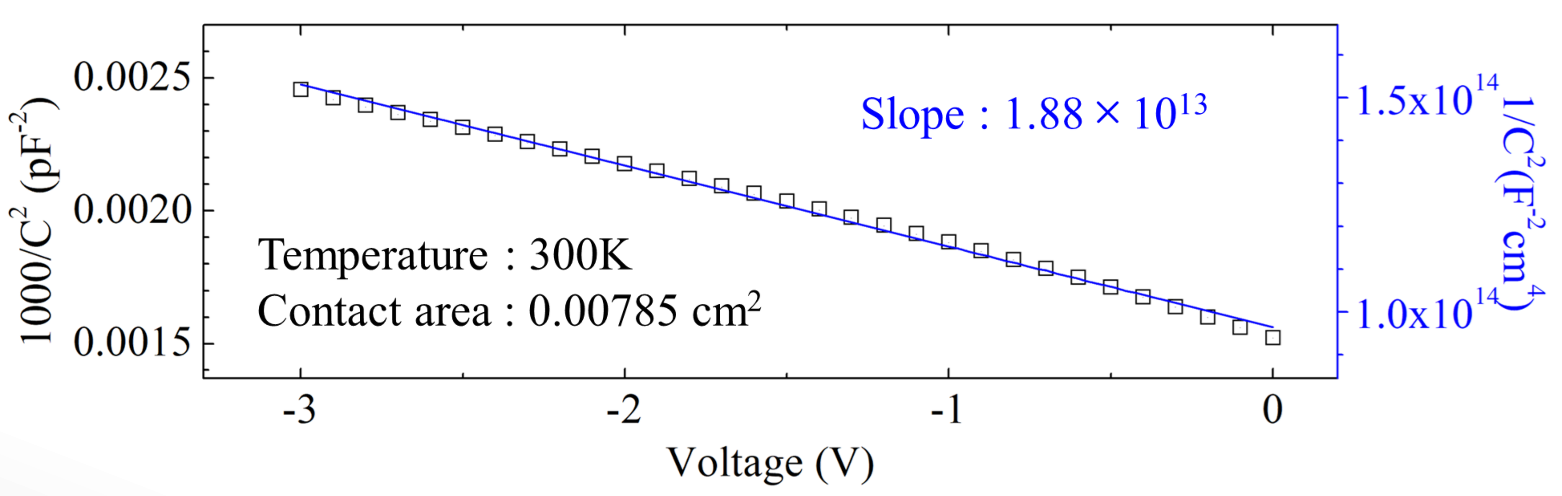
- N-type 4H-SiC (Crystals Inc. [1])
- diced to 1 cm × 1 cm, followed by a wet etching process
- TCE (5min), Acetone (5 min), Ethanol (5 min), 20% HF (40 sec) and N_2 drying
- Schottky contact : 100 nm Ni (1 mmφ), Ohmic contact : 100nm Ag (overall backside)



● I-V and C-V chracteristics

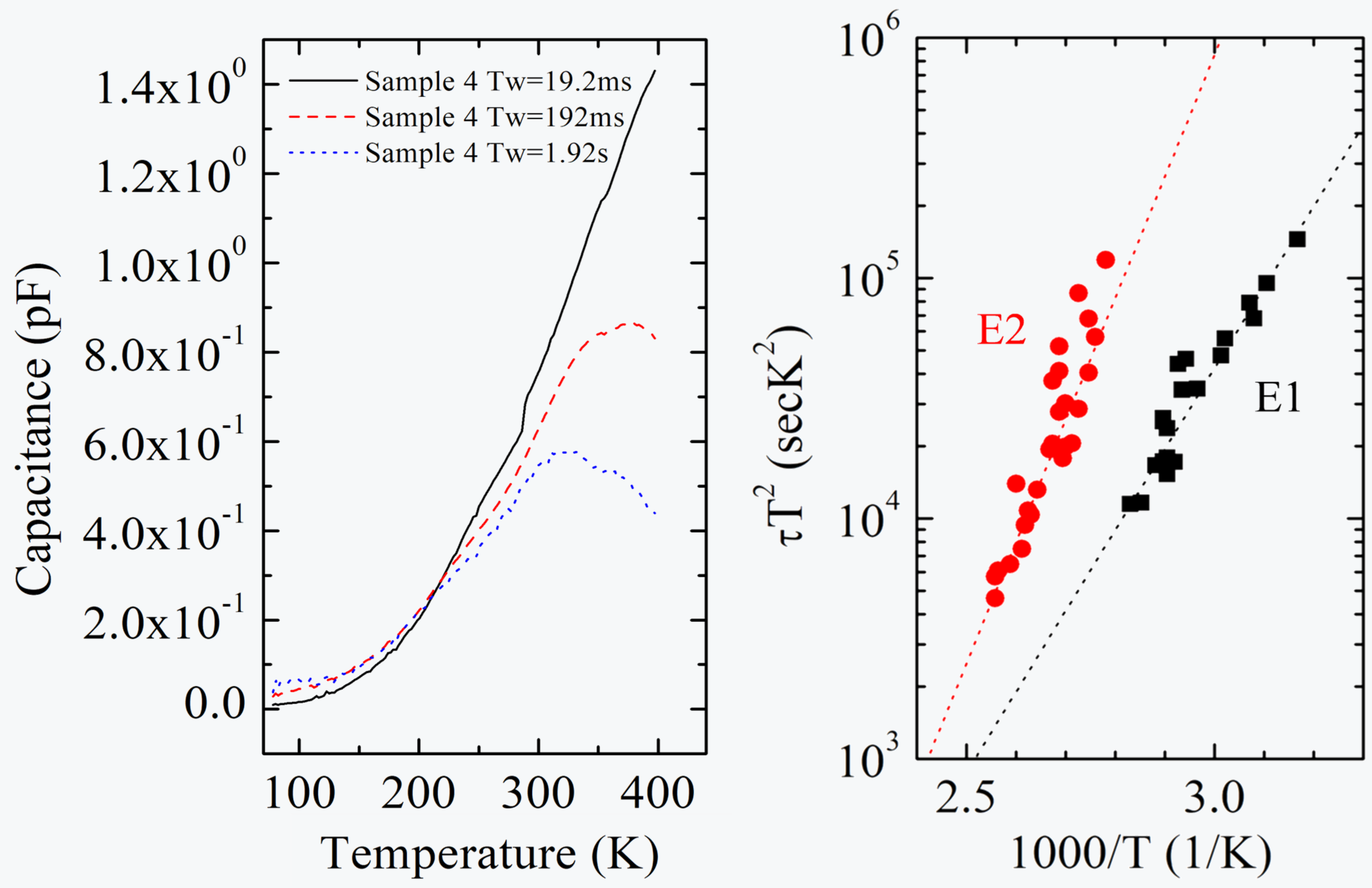
- leakage current was about 20 μA at -2 V. Although the leakage current value was relatively high, it was determined that DLTS measurement was possible.(Nd) was 7.73×10^{17} cm^{-3} which corresponds to about 0.03 Ω·cm of resistivity [2]





● DLTS measurement

- Device : PhysTech FT-1230
- temperature range : 80 to 400K
- A reverse bias of 2 V, Pulse height and width were 2 V and 0.1 msec,



Defect Level	Defect level	Trap density	Capture cross section, σ_{eff}
E1	Ec-0.67 eV	2.7×10^{16} cm^{-3}	3×10^{-17} cm^2
E2	Ec-1.00 eV	3.3×10^{16} cm^{-3}	7×10^{-12} cm^2

- Two broad peaks (E1 and E2) at high temperature (>300K).
- Two trap levels, E1 (Ec-0.67 eV) and E2 (Ec-1.00 eV) centers
- E1 trap → "$Z_{1/2}$", dominant intrinsic defect in 4H-SiC [3], origin : V_C / V_C-V_{Si} [4]
- E2 trap → $RD_{1/2}$ [5], origin : V_C+V_{Si} / C_i (unclear yet)
- Both trap densities are calculated to be about 3×10^{16} cm^{-3} which is relatively higher than typical values of 4H-SiC wafer. It seems due to high leakage current of the diode or many defect in the substrate.

- In future, defect of NTD-SiC will be investigated using DLTS technique, with higher quality substrate and more effective structure of Schottky contact.

● Acknowledgement

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[1] Nitride Crystals Inc., www.nitride-crystals.com
[2] T. Kimoto and J. Cooper, "Fundamentals of Silicon Carbide Technology: Growth, Characterization, Devices and Applications," John Wiley & Sons, Singapore, 2014.
[3] H. Zhang et al., ECS Extended Abstracts, Vol.89-2, p.699, 1989.
[4] L. Patrick and W. J. Choyke, Phys. Rev. B, Vol.5, p.3253, 1972.