Demonstration of low contact resistance in SiC using high repetition rate KrF excimer laser irradiation

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The current-voltage (*I*-*V*) characteristics of 4H-SiC doped with high concentration of nitrogen formed with silicon nitride (SiN_x) film deposited on SiC and excimer laser irradiation were investigated. Until now, evaluation has only been possible at low repetition rates such as 100 Hz.[1] However, we have achieved high-throughput laser doping by enabling high repetition rate irradiation at 4000 Hz using KrF excimer laser manufactured by Gigaphoton Inc., which is necessary for the scale-up of SiC wafers to 8-inch diameters. On the other hand, increasing the repetition rates of the laser raises concerns about the substrate's heat accumulation and melting. In this paper, we will report the repetition rates dependency (100, 1000, 4000 Hz) of *I*-*V* characteristics and roughness on the SiC surface after laser irradiation.

After irradiation in N_2 gas flowing chamber, the SiC substrate was immersed in phosphoric acid at 150 ℃ for 25 minutes to remove the SiN_x film (20 nm in thickness). Then, a plasma ashing process using CF_4 (10 min) and O_2 (5 min) was carried out to remove any residual Si and C from the surface. As shown in Fig. 1, the good linearity was confirmed based on the *I*-*V* characteristics using 2 tungsten probes in 1000 and 4000 Hz conditions at the laser fluence of 2.8 J/cm^2, and the irradiation number of 50 shots. The results potentially suggest that the increase in irradiation repetition enhances nitrogen doping and improves ohmic conductivity.

Furthermore, the surface roughness (arithmetic mean roughness) of SiC was measured to be 11 nm at the condition of 4000 Hz, 2.8 J/cm^2, and 50 shots from a confocal 3D microscope. The results indicate that there was minimal surface degradation observed on the SiC surface when compared to the initial roughness of 9.1 nm under non-irradiated conditions.

During the conference, we will also present the results of surface nitrogen concentration obtained through SIMS (Secondary Ion Mass Spectrometry) analysis, the crystalline state by cross-sectional TEM (Transmission Electron Microscopy) as well as the evaluation of contact resistance between Ti electrodes and doped region.

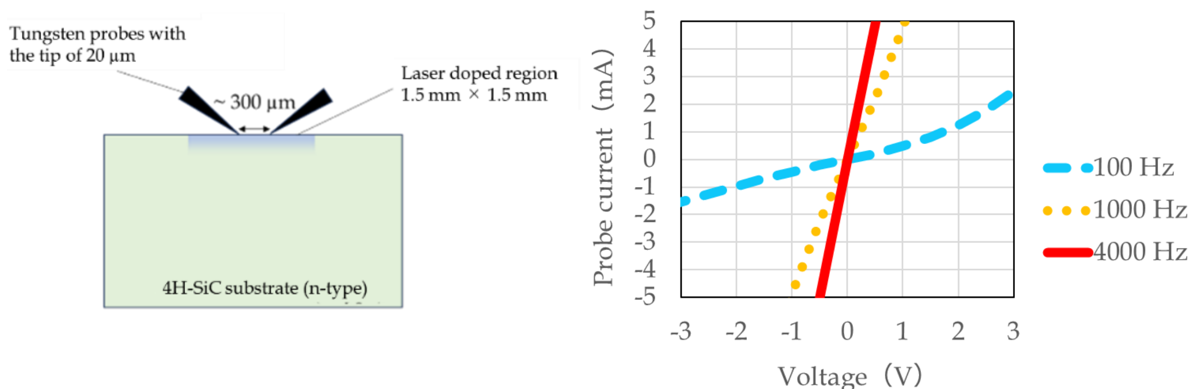

Figure 1: The *I*-*V* characteristics between 2 tungsten probes on the surface of irradiated SiC at 2.8 J/cm^2, and 50 shots.

Reference:

[1] T. Yasunami, D. Nakamura, K. Katayama, Y., Kakimoto, T. Kikuchi, et al. “Laser doping mechanism of 4H-SiC by KrF excimer laser irradiation using SiN_x thin films”, Japanese Journal of Applied Physics. 62. (2023).