Sn doping into β-Ga_2O_3 by a KrF excimer laser

Misa Beppu[1], Yohei Tanaka[2], Keita Katayama[1,2], and Hisato Yabuta[1,2,*]

[1] Graduate School of Information Science and Electrical Engineering, Kyushu University,
[2] Department of Gigaphoton Next GLP, Kyushu University,
744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan
*Corresponding author email: yabuta.hisato.475@m.kyushu-u.ac.jp

Introduction: The laser doping method with an excimer laser has recently attracted attention because it potentially bypasses the annealing process of doped wafers for activation of dopant ions owing to the local (surface) heating effect of deep UV light irradiation. In contrast, common doping techniques such as ion implantation require high-temperature treatment of the doped wafer. Therefore, a laser doping process without high-temperature annealing results in a simpler process flow design. In this presentation, we report on some attempts of Sn doping into β-Ga_2O_3 wide bandgap (~4.9 eV) semiconductor material for next-generation power-semiconductor devices by the laser doping method with a KrF excimer laser.

Experimental: We used β-Ga_2O_3 (001) epitaxial wafers (Novel Crystal Technology, Inc.). Thin SnO_2 layers (10 nm) were formed on the wafers by rf-sputtering at room temperature. To irradiate the SnO_2 surface with a deep UV beam to allow the Sn atoms to penetrate Ga_2O_3, a KrF excimer laser (GT600KZ, Gigaphoton Inc.) was used under various conditions (fluence between 0.1 and 1.5 J/cm^2, repetition frequency of 10 and 1000 Hz, and number of laser shots between 1 and 1000). Subsequently, irradiated surface observations and Sn diffusion analyses were performed.

Results and discussion: SEM observations revealed that the surface of the irradiated area became rough due to ablation at a fluence of 0.4 J/cm^2 or higher. Therefore, we accepted the test areas irradiated with the fluence range from 0.1 to 0.4 J/cm^2 for the Sn diffusion analysis by secondary ion mass spectroscopy (SIMS). From the results shown in Fig. 1, we confirmed that irradiation facilitated Sn penetration into β-Ga_2O_3. Figures 1(a) and 1(b) show that a larger amount of Sn penetrates and reaches deeper upon irradiation with a higher fluence and larger number of shots, respectively. In contrast, Fig. 1(c) shows that a large concentration of Sn remains in a shallow region close to the substrate surface after irradiation with a repetition frequency of 10 Hz. This suggests that the depth profile of Sn penetration can be controlled by the fluence, shot number, and repetition frequency. Now, electrical measurements are being conducted to confirm Sn doping in β-Ga_2O_3.

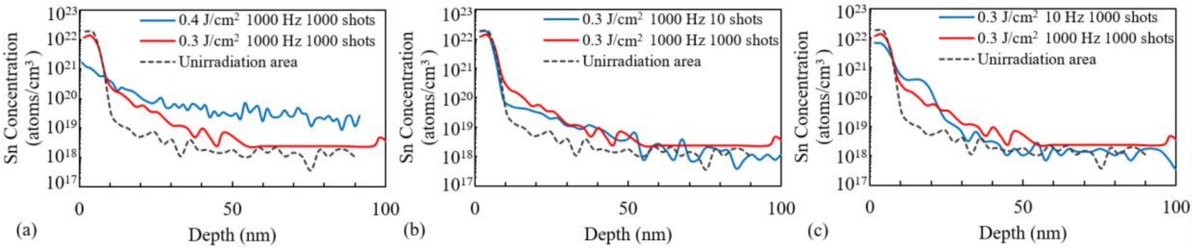

Fig. 1. SIMS depth-profiles of Sn in β-Ga_2O_3 by irradiation