Defect level passivation in 4H-SiC using hydrogen plasma treatment

Myung Yoon Um, Bum Seok Kim, Hoon Joon Na,
Ho Keun Song, In Sang Jeon, Da Il Eom
and Hyeong Joon Kim

School of Materials Science and Engineering,
Seoul National University, Seoul 151-742, Korea

Hydrogen is known to be able to passivate the defect levels in many semiconductor materials by forming the defect complexs and the plasma treatment is effective for introducing hydrogen in many materials. There are a few reports regarding passivation using hydrogen of the interface state between hexagonal SiC and SiO_2 [1]. Many reports relating to hydrogen passivation of donors and/or acceptors in SiC have also been published [2,3]. There was a report on the passivation of deep levels in 3C-SiC on Si by hydrogen plasma treatment [4]. However, there is no report on the defect level passivation in 4H-SiC using hydrogen plasma treatment. Therefore, in this study, we investigated on the influence of H_2 plasma treatment on the defect levels in 4H-SiC and subsequent annealing effects for reliability.

The material, used in this experiment, 4H-SiC single crystal acquired from Cree Corp., doped with N (~10^{17} cm^{-3}) has been cut in four pieces. Three of these samples were exposed to a H_2 plasma in a ICP-RF plasma system (0.5 torr, 50 W) for 1 h at a substrate temperature 300 ^oC. Then, samples were annealed under N_2 atmosphere for 1h at several temperatures (400^{o}C, 500^{o}C). To characterize the electrical properties, schottky contacts were formed by evaporation of Au/Ti through shadow mask and ohmic contact was formed at the backside by In paste.

Fig. 1 showed the reverse I-V characteristic curve. As-grown sample had a high leakage current level and so DLTS measurement could not be performed. However, the sample treated by H_2 plasma had lower leakage currents level than that of the former. From this fact, it could be speculated that H_2 plasma treatment could passivate the defect center effectively.

Fig. 2 showed the DLTS spectrum of the sample treated by the H_2 plasma. The spectrum has strong peak around 314K and broad peak around 386 K. Parameters for peaks were extracted from the Arrhenius plot, and the activation energies were 0.335 eV, 0.444 eV, respectively, as shown in Fig.3. It was assumed that these levels were originated from hydrogen plasma damage. In order to investigate thermal stability of hydrogen passivation and to reduce the plasma-induced damage, the samples were annealed and its effects were investigated.

In summary, hydrogen passivation of defects in 4H-SiC single crystal was achieved using plasma treatment. Leakage current level was lowered by the effective hydrogen passivation of defects. Plasma-induced defect levels were formed after hydrogen plasma treatment, but these damages could be reduced through the subsequent annealing process. From the above results, hydrogen plasma treatment at low temperature could be applied to the passivation of defect level in 4H-SiC device.

Acknowledgements

This work was supported by SiC Device Development Program under Ministry of Commerce, Industry, and Energy republic of Korea through Inter-University Semiconductor Center.

References

[1] K.Fukuda, S.Suzuki, T.Tanaka and K.Arai, Appl. Phys. Lett. 76, 1585, 2000.
[2] F.Gendron, L.M.Porter, C.Porte and E.Bringuier, Appl. Phys. Lett. 67, 1253, 1995.
[3] D.J.Larkin, S.G.Sridhara, R.P.Devaty and W.J.Choyke, J.Electron.Mater.24,289,1995.
[4] M.Kato, F.Sobue, M.Ichimura, E.Arai, N.Yamada, Y.Tokuda and T.Okumura, Jpn.J.Appl.Phys.40,2983,2001.

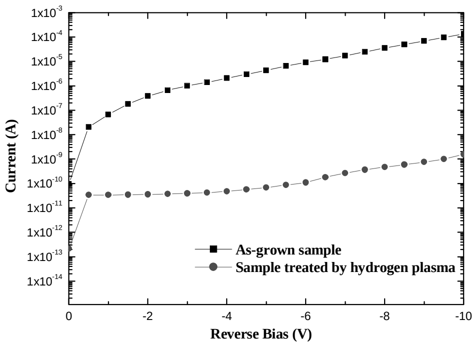

Fig. 1. Reverse current-voltage characteristics of Au/Ti/4H-SiC rectifier at room temperature.

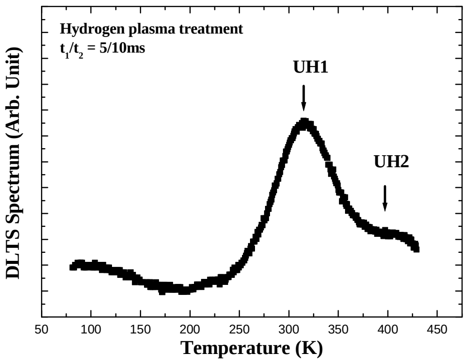

Fig. 2. DLTS spectrum (time window t_1=5ms/t_2=10ms) taken on the hydrogen-plasma treated n-type 4H-SiC single crystal.

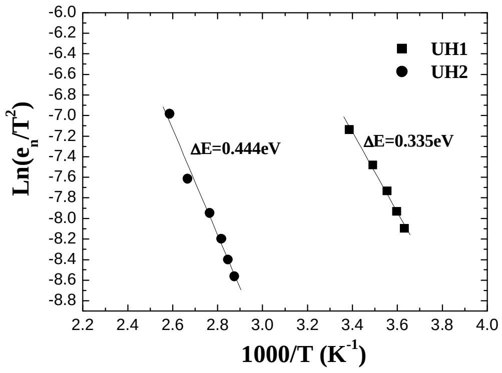

Fig. 3. Arrhenius plot of DLTS signal for the hydrogen-plasma treated n-type 4H-SiC single crystal.