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Development of Diagnostic Method for Deep Levels in Semiconductors using Charge Induced by Heavy Ion Microbeams

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Deep-level defects which act as carrier traps are created in semiconductors during crystal growth, device fabrication and also operation under radiation conditions, and they negatively affect the device characteristics. Therefore, it is important to clarify deep levels in semiconductors. Deep Level Transient Spectroscopy (DLTS) is known as one of the most famous techniques to investigate deep levels [1]. However, DLTS does not well work for samples with high resistivity. For deep level investigation in samples with high resistivity, Photo Induced Current Transient Spectroscopy (PICTS) was proposed [2]. However, PICTS has a disadvantage that we need to fabricate semi-transparent contacts since the injection of laser into samples is required to generate carriers (electrons/holes). To overcome this issue, DLTS using charge generated by ion incidence was proposed [3]. Recently, we developed a deep level evaluation system based on Charge Transient Spectroscopy using alpha particles from 241Am (Alpha Particle Charge Transient Spectroscopy: APQTS) and reported the effect of deep levels in 6H SiC pn diodes generated by electron irradiation on the characteristics as particle detectors [4]. In this study, we will report the development of Charge Transient Spectroscopy using Heavy Ion Microbeams (HIQTS). The HIQTS can detect deep levels with micron meter spatial resolution since microbeams are applied. Thus, we can clarify the relationship between deep levels and device characteristics with micron meter resolution. When a 6H-SiC pn diode was irradiated with12 MeV-oxygen (O) ions at 4x109 and 8x109 /cm2, the charge collection efficiency (CCE) decreased to 71 and 52 %, respectively. HIQTS signals obtained from those damaged regions using 15 MeV-O microbeams increased at measurement temperature ranges above 350 K, and the signals are larger with increasing 12 MeV-O ion fluence. On the other hand, the increase in HIQTS signals at temperature range between 250 and 300 K was obtained from 6H-SiC pn diodes irradiated with 1 MeV-electrons although no significant increase was obtained for 12 MeV-O ion irradiated samples. This indicates that deep levels created by O ions are different from those created by electrons.

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