A New Approach to Magnetic Resonance at Heterointerfaces: Spin Dependent Charge Pumping in 4H-SiC MOSFETs

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Although 4H SiC MOSFETs have great promise in high power and high temperature applications, their great promise is limited by the presence of a defective silicon carbide-silicon dioxide interface region. We have utilized a new electron paramagnetic resonance (EPR) approach to explore the defect structure at these SiC- oxide interfaces in fully processed transistors: multi-field and RF frequency spin dependent charge pumping.

Conventional electron paramagnetic resonance (EPR) offers unrivalled analytical power for the identification of point defects in semiconductors and insulators. Unfortunately, the sensitivity of conventional EPR measurements is, at best, about ten billion total defects. This sensitivity is inadequate for measurements in most devices of technological significance. A second limitation of conventional EPR in device physics studies is that it is sensitive to all paramagnetic defects within structure under study. EPR detection via electrically detected magnetic resonance (EDMR) can overcome both of these limitations. It provides a sensitivity typically at least ten million times higher than that of conventional EPR and is also exclusively sensitive to defect centers which impact the electronic behavior of the devices.

EDMR studies nearly always utilize spin dependent recombination (SDR). SDR is quite sensitive to deep level defects but, in studies of heterointerfaces such as the SiC/SiO_2 boundary, defects throughout the entire interface bandgap can be important. In this study, we utilize a new EDMR approach to investigate the silicon carbide silicon dioxide interface: multi-magnetic field and RF frequency spin dependent charge pumping (SDCP).

SDCP allows quite sensitive EDMR measurements of interface defects with levels throughout nearly the entire interface bandgap. The SDCP sensitivity is very nearly magnetic field and frequency independent and is typically more sensitive than SDR. The enhanced sensitivity as well as the field and frequency independence allows us to make measurements at resonance frequencies as high as 16 GHz and as low as 85 MHz. The multi-field and frequency measurements yield information about the relative contributions of hyperfine and spin orbit interactions and thereby aid in defect identification. In this presentation I will briefly review the physics involved in SDCP and discuss the defects which we observe via SDCP. In addition, I will briefly outline the close connection between the low frequency SDCP and a near zero field non- resonant response in the charge pumping currents. The near zero field response may one day provide a remarkably simple tool for the study of interface defect structure.