Electrically Detected Magnet Resonance Studies of 4H SiC MOSFETs

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SiC based MOSFETs have great promise in high power and high temperature applications; however, the performance of these devices have so far been limited by the presence of defects near and at the SiC/SiO_2 interface. We have explored 4H SiC MOSFET defects with several electrically detected magnetic resonance (EDMR)[1,2] techniques and have been able to identify some of the most important trapping centers which limit the performance of these devices. EDMR is an electron paramagnetic resonance technique (EPR)[3] which offers the same unparalleled analytical power of EPR with many orders of magnitude greater sensitivity. Whereas conventional EPR has a sensitivity of about 10^{10} total defects,[3] EDMR provides a much higher sensitivity, about 100 total defects, possibly even fewer. It thus allows for the identification of defects within individual high quality devices. In addition to its high sensitivity, EDMR can provide information with regard to the physical location and to some extent the energy levels of the observed defects.

One of the most important topics for EDMR study is identifying how various processing steps can alter the density of performance limiting defects. In this abstract we discuss representative results on one of the several defects identified via EDMR. Figure 1 illustrates a comparison of EDMR traces taken on two otherwise identical 4H SiC MOSFETs in which one of the devices has been subjected to an NO anneal and the other has not.[2] Note the enormous difference in the EDMR amplitude of the signal with g=2.003. (the g is defined from $h\nu/\beta H$, where h is Planck's constant, ν is the resonance frequency, β is the Bohr magneton, and H is the magnetic field at resonance.) The NO anneal increases the effective channel mobility in these devices by nearly a factor of 30. The large reduction in the presence of the defect spectrum with the increase in mobility strongly indicates that this defect plays an important role in limiting channel mobility. In figure 2 we illustrate a representative so called fast passage measurement[1] on this g=2.003 spectrum with the measurement field parallel to the crystalline c axis. Note the weak side peaks present at about 13 and 28 Gauss separation. These side peaks are caused by hyperfine interactions with ^{13}C nuclei within the defect. The defect center is a silicon vacancy. The silicon vacancy center has been widely investigated in conventional EPR investigations of large (cubic centimeter) sized samples.[4] In figure 3 we illustrate a calculated EDMR trace utilizing the hyperfine parameters obtained in the conventional EPR studies for the magnetic field parallel for the crystalline c axis. Note the close correspondence; this correspondence and other factors discussed elsewhere [1] provide strong evidence for this identification.

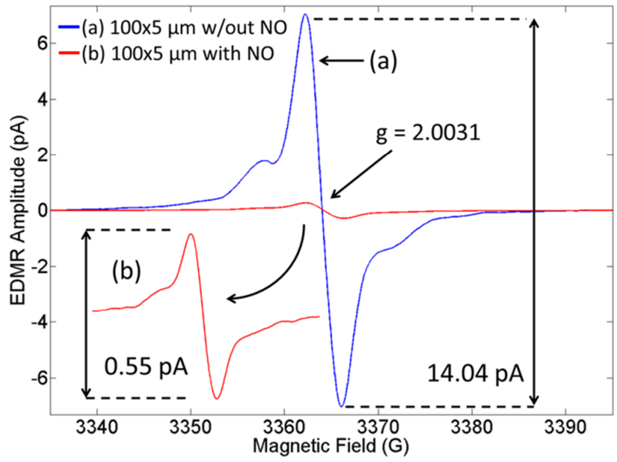

Figure 1. EDMR traces taken (a) device which did not receive a NO anneal and (b) a device which did receive the anneal the lower left insert is a "blow up" of the NO annealed sample.

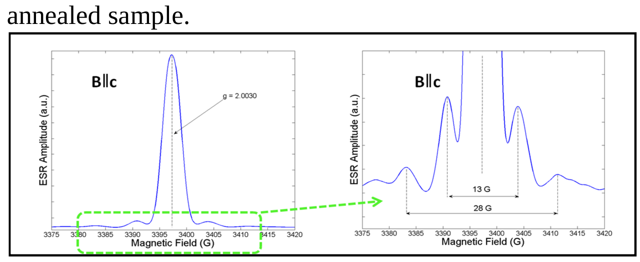

Figure 2. EDMR spectrum of a silicon vacancy in a 4H SiC MOSFET.

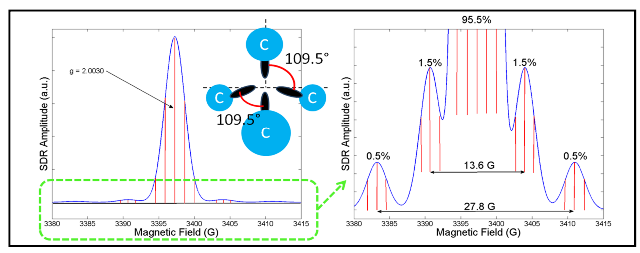

Figure 3. Calculated spectrum of the silicon vacancy based upon literature values obtained have single crystal samples with conventional EPR. Note the correspondence between the results of figure 2 and 3.

In our presentation we will discuss EDMR identification of several 4H SiC MOSFET defect centers.

References

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