Low Temperature Studies of SIMOX Charge Trapping

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Previous work has shown that the buried oxide in SIMOX has different charge trapping properties during irradiation than thermal oxide [1-3]. In this presentation, the charge trapping of the buried layer is studied by irradiating SIMOX capacitors at cryogenic temperatures and comparing the results to thermal oxide control samples. The thermal and SIMOX oxide thicknesses are 4000 Å and 3700 Å, respectively. The thermal oxide is a dry oxide grown at 1000°C while the SIMOX is a single implant of $1.8 \times 10^{18} \text{cm}^{-2}$ annealed at 1300°C for 6 hr. Both have aluminum gates. For the SIMOX data in the figures, the top silicon film is etched off in KOH before gate deposition. Thus only the bottom interface of the SIMOX capacitors is measured. Measurements of both interfaces are in progress. The change of the midgap voltage with respect to its pre-rad value, ΔV_{mg} , is determined from low temperature C-V data. In Figure 1, the buildup of positive charge is shown during an x-ray irradiation at 60 K with the gates grounded. Data is shown for doses ranging from 7 to 870 krad(SiO_2). Over this range, both oxides have similar net positive charge buildup.

In Figure 2, the results of isochronal annealing are shown for a thermal oxide capacitor and two SIMOX capacitors from the same wafer. Following the 870 krad(SiO_2) irradiation at 60 K, the temperature is raised to each temperature shown for 20 min. and then lowered to take the C-V measurement. Gates are grounded during annealing. It is evident that the charge trapping in SIMOX is very different than the thermal oxide case. For the thermal oxide there is significant detrapping and hole motion below 200 K, whereas for the buried oxide the changes in ΔV_{mg} are very small below 250 K.

In Fig. 3, the effects of field stressing after irradiation but while still at 60 K. Above 30 V (about 0.8 MV/cm), there is a large increase in the net positive charge that continues to increase to at least 90 V. It is consistent with the previously proposed electron detrapping [1,2]. However, it may also be a low field injection effect. Both models will be discussed.

References

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Figure 1. Change of the midgap voltage as a function of dose determined by low temperature C-V measurements. Aluminum gate capacitors, $V_g = 0 \text{ V}$, are irradiated by 10 keV x-rays at 60 K. The superficial silicon layer is removed from the SIMOX capacitors before depositing the aluminum.

Figure 2. Isochronal annealing of trapped charge following 870 krad(SiO_2) irradiation at 60 K. Each point represents ΔV_{mg} after annealing for 20 min. at 0 V gate bias. The two SIMOX capacitors are from the same wafer.

Figure 3. Increase of the net positive charge in the buried oxide from field stressing following 870 krad(SiO_2). The gate voltage duration is 5 minutes at each voltage. The sample temperature is 60 K.