Student paper

4H-SiC Vertical RESURF Schottky Rectifiers and MOSFETs

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The wide band gap, high breakdown field and good thermal conductivity of SiC makes the material attractive for power device applications which should provide lower power dissipation and better high temperature performance than existing components. Superjunction Schottky rectifiers offer lower specific on-resistance (lower on-state losses) than other Schottky rectifiers at the desired voltage range ($\geq$1kV), but require complicated process technology, especially in SiC [1]. With the concern of lowering the on-state losses with reduced process complexity compared to the Superjunction devices, RESURF principle has been explored in both Silicon and SiC technology [2-5]. This work details the advantage of 4H-SiC vertical RESURF rectifiers and MOSFETs

Numerical simulations have been used to verify and optimize the performance of the 4H-SiC Vertical RESURF Schottky rectifier. Fig. 1 shows a Design-of-Experiment (DOE) optimization of the oxide thickness, electrode depth and doping concentration with a 10μm thick drift layer. A blocking voltage of approximately 2.1kV and a specific on-resistance of 0.85Ω-cm^2 are obtained using W_D=10μm, N_D=3x10^{16}cm^{-3}, W_{ox}=W_{SiC}=2μm, T_{ox}=1.8μm and Y_{Metal}=5.0μm. Fig. 2 illustrates the simulated on-resistance versus breakdown voltage of 4H-SiC conventional Schottky rectifiers, SJS rectifiers and selected vertical RESURF Schottky rectifier designs. It is evident that the new structures offer performance tradeoffs between that of conventional Schottky rectifiers and SJS rectifiers for voltages above 1kV.

4H-SiC Vertical RESURF MOSFETs are also evaluated with the similar structure parameters. As shown in Fig. 3, the electric field is uniformly distributed through the drift region, which results in the improvement of blocking capability at relatively high drift doping concentration. One concern comes from the peak electric field in the oxide. Fig. 4 shows the trade-off between the oxide field and breakdown voltage at different oxide thicknesses and depth of gate electrode. As high oxide field is observed, two-zone approach is considered as a solution. By adjusting the doping concentration and the zone region, low field in oxide is expected.

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References:

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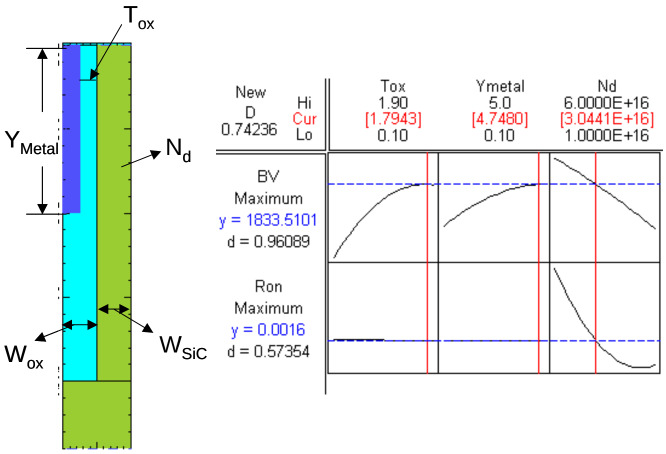

Fig. 1. DOE optimization of 4H-SiC Vertical RESURF Schottky rectifier W_{EPI}=10µm, T_{ox}, Y_{Metal}, N_d varied

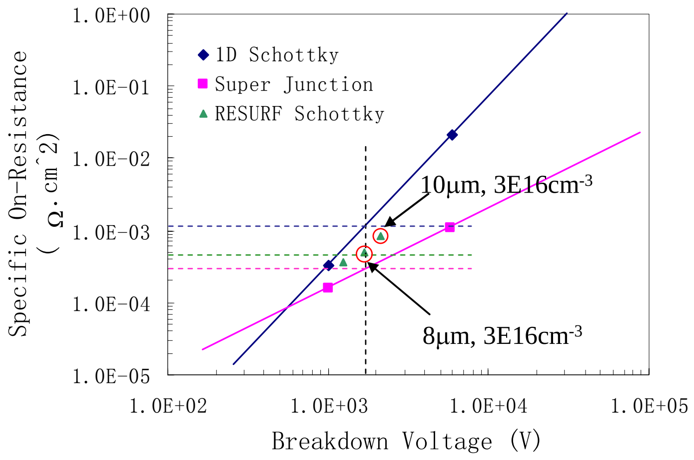

Fig. 2. Simulated performance tradeoffs of 4H-SiC Schottky, Superjunction Schottky and Vertical RESURF Schottky rectifiers (SJS: W_P=W_N=2µm)

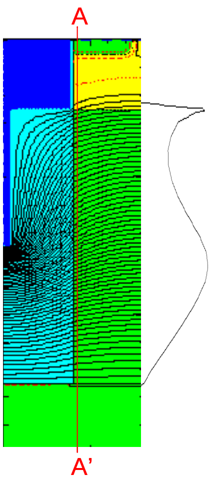

Fig. 3 Electric field distribution in the Vertical RESURF MOSFET

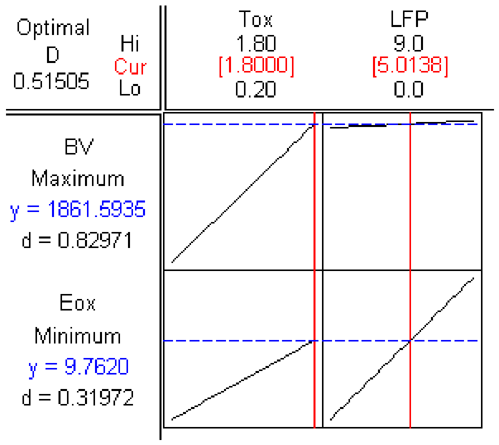

Fig. 4 Trade-off between the blocking capability and electric field in oxide