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New radiation hard 3D-Trench electrode detector using low resistivity N-type silicon bulk material

Space Charge Sign Inversion(SCSI) fluences (φ) of detectors using various low resistivity N-type Silicon bulk material have been calculated. For a given value of (N) in set of 5.00×1013, 1.00×1014, 5.00×1014, 1.00×1015 neq/cm2 (neq:1 MeV neutron equivalent), we used the the oretical calculated full depletion voltage for 3D-Trench electrode detector (V) to determination the corresponding electrode spacing (L). By setting V(≤200V) to get the corresponding electrode spacing. Following, the Silvaco TCAD is used to study various properties of the detector, using various L values. Simulated detector electrical properties include detector electric potential , electric field, electron concentration, full depletion voltage, leakage current, and capacitance.

Summary

As an example, for a 3D-Trench electrode silicon detector with an initial doping concentration of N=1*1014cm2, the calculated SCSI fluence is φ= 1.14*1015neq/cm2. If we chose an electrode spacing of L=50μm for this detector, then the detector will not not reach SCSI up to a fluence of 1.14*1015neq/cm2 and the detector full depletion voltage is 134 V according to our calculation. This detector will be therefore radiation hard up to 1.14*1015neq/cm2 under a working bias voltage of 134 V. Full 3D TCAD simulations have shown that, for the 3D-Trench electrode silicon detector with an initial doping concentration of N=1*1014cm2, and an electrode spacing of L=50μm, the detector is fully depleted under a bias of 134 V, in excellent agreement with our calculations. Similar works have been done for detectors with other initial doping concentrations.

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