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Downscaling of detectors on high resistivity semiconductors

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Electrical contact properties play a major in the overall performance of metal-semiconductor-metal (M-S-M) type detectors. For near-room-temperature applications the M-S-M detectors have to be constructed with high resistivity, wide bandgap semiconductors, in order to limit the electrical noise related to leakage currents. In wide bandgap semiconductors the high resistivity is often achieved (willingly or unwillingly) through deep-trap compensation process. Introduction of such deep-traps affects not only the resistivity, but also carriers' lifetimes, and thus charge collection efficiency. However, even high resistivity semiconductor with long carrier lifetimes does not guarantee low leakage current, or good detection performance if the contacts are not optimized. The contacts are known to affect the polarization, and leakage currents. Understanding and modeling the effects of contact (detector) downscaling, particularly on high resistivity semiconductors are complex tasks. In this study finite element computation was employed to solve combined Poisson and continuity equations for three-dimensional M-S-M detectors. The effects of contact dimensions, charge carriers' velocity saturation, and contact generation-recombination velocity were investigated.

Summary

It is shown that the contact current scale with perimeter length for small ohmic contacts and with the contact area for larger contacts. It is shown that the velocity saturation effect gains extra weight with contact downscaling and may introduce considerable asymmetry and non-linearity, in the current-voltage curves of ideal ohmic contacts, particularly in compensated semiconductors. Furthermore, these dc characteristics depend on the capture cross-sections of the compensating traps.

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