Investigation of Next-generation Silicon Radiation Detectors Enabled by Tunnel Oxide Passivating Contact

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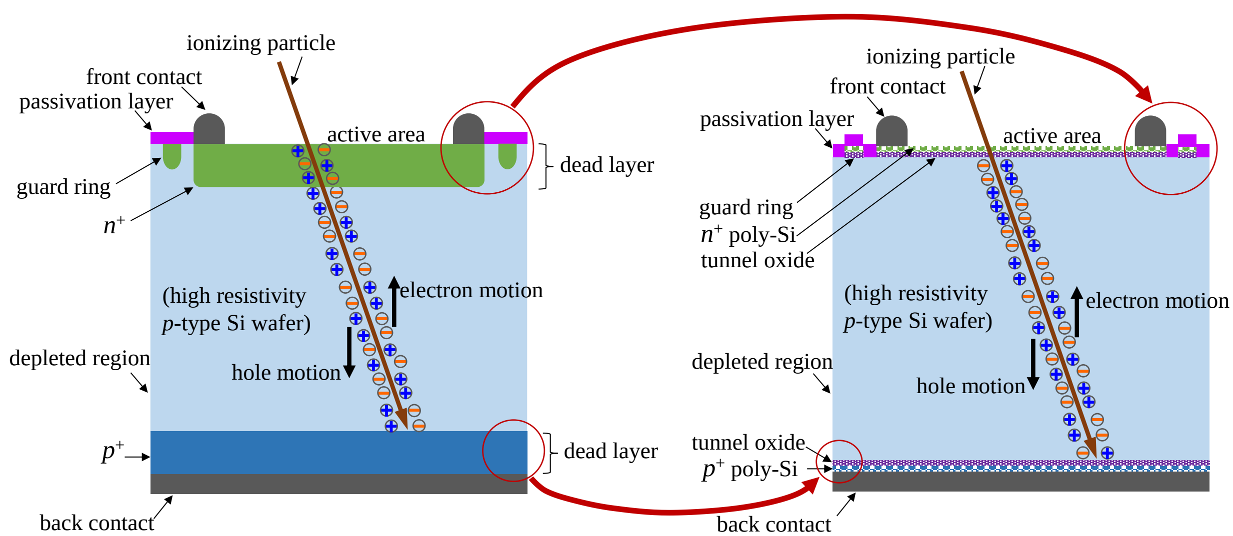
Abstract

Silicon detectors have become the predominant players for many radiation detection applications since 1960s, due to several advantages including great energy resolution, fast timing characteristics, compactness and ruggedness, compared with other competing techniques, i.e., typical gas-filled detectors. However, conventional silicon radiation detectors suffer from severe carrier recombination in the heavily doped p^+ and n^+ layers or regions, as well as beneath the metal contact areas, especially on the detector side, which is also known as "dead layer". In this project we developed the tunnel oxide passivating contact with an outstanding carrier selectivity. Its key element is an ultra-thin (~1.5 nm) interfacial oxide layer that can allow an efficient transportation of majority carriers via tunneling, while effectively block the minority carriers. The extraordinarily low saturation current density of 5 ~ 10 fA/cm^2 even with the metal contact (electrode), which was measured by the quasi-steady-state photoconductance, proves the superiority of tunnel oxide passivating contact. While conventional *p*-*n* junction or high-low junction have the saturation current density in the range of 10 ~ 90 fA/cm^2 for the passivated p^+ and n^+ layers due to Auger recombination, and 800 ~ 6000 fA/cm^2 for the metal contact areas because of significant metal-induced recombination at the interface. This demonstrates the potential and supremacy of applying the tunnel oxide passivating contact for silicon radiation detectors to thoroughly collect the generated charge carriers, leading to much higher energy resolution.



Cross-section sketch comparison of silicon radiation detectors with features of guard ring, passivation layer, and active area: (left) conventional silicon detector with heavily doped p$^+$ and n$^+$ layers; (right) silicon detector enabled by tunnel oxide passivating contact developed in this work.