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A comparative study of LGAD radiation damage mechanisms

Aiming to a sub 30 psec time resolution at fluences in excess of $6{\times}10^{15}$ 1 MeV n_{eq}/cm^2, several dopants are explored to improve radiation tolerance of intrinsic gain sensors. Using a common mask, CNM produced LGADs with boron, boron + carbon and gallium implanted gain layers are subjected to neutron and proton irradiation ranging from 10^{14} to $6{\times}10^{15}$ 1 MeV n_{eq}/cm^2 on both particle species. A systematic study of acceptor removal, gain reduction and timing performance is presented at different temperatures (-10^oC, -20^oC, -30^oC). Charge collection, relative efficiency, signal shape and noise analysis are also addressed, using charged particles in a laboratory setup. Three different approaches are used to individually evaluate different mechanisms of radiation damage and their effect on sensor performance, with a distinction between bulk and gain layer effects. Finally, stability is evaluated via dark count rate, which combined with efficiency, determines the sensor's operatable region and it's evolution with radiation.

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