iWoRiD 2022
23rd International Workshop on Radiation Imaging Detectors
26 – 30 June 2022
Riva del Garda, Italy

Contribution ID: **88** Type: **Poster**

TCAD optimization of LGAD sensors for extremely high fluence applications

Monday, 27 June 2022 17:16 (1 minute)

The next generation of high-energy physics experiments will require tracking detectors able to efficiently operate in extreme radiation environments, where expected fluences will exceed 1E17 n/cmˆ2. This new operating scenario imposes many efforts for the design of effective and radiation-resistant particle detectors. Low-Gain Avalanche Diode (LGAD) represents a remarkable advance because the radiation damage effects can be mitigated by exploiting its charge multiplication mechanism after heavy irradiation [1]. To obtain the desired gain (˜ 10 –20) on the sensors output signal, a careful implementation of the "multiplication"region is needed (i.e. the high-field junction implant). Moreover, a proper design of the peripheral region (namely, the bias guard-ring structure) is crucial to prevent premature breakdown and large leakage currents at very high fluences, when the bias voltage applied creates an electric field higher than 15 V/µm. In this contribution, the design of LGAD sensors for extreme fluence applications is discussed, addressing the critical technological aspects such as the choice of active substrate thickness, the gain layer design and the optimization of the sensor periphery. The impact of several design strategies is evaluated with the aid of Technology-CAD (TCAD) simulations based on a recently proposed model for the numerical simulation of radiation damage effects on LGAD devices [2].

[1] G. Pellegrini et al., 2014 J. NIMA 12 765
[2] T. Croci et al., 2022 JINST 17 C01022

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Session Classification: Poster