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Characterization of a large LGAD sensor for proton counting in particle therapy

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Purpose:
Based on LGAD technology, a fast proton counter prototype is being developed for the online monitoring of the fluence rate of therapeutic proton beams. The laboratory characterization of dedicated LGAD sensors segmented in strips covering an area of 2.7x2.7 cmˆ2 is reported.
Methods:
The LGAD sensor is segmented into 146 strips (160 um width, 26260 um length, 180 um pitch, 2 strips without gain, 144 strips with gain, and a nominal inter-strip distance of 66 um). A dedicated production at Fondazione Bruno Keeler (FBK, Trento, Italy) in 2020 consisted of 14 wafers with two different active thicknesses (55 um Si-Si wafers, 45 um for the Epi ones), with shallow gain implants, two p-gain doses, boron- low diffusion, co-implanted with a dose of carbon to improve the radiation resistance. Laboratory characterization of this production was performed at the University of Torino and at FBK, using a probe station, connected with a power devices analyzer for static DC electrical test, and the TCT to study dynamic properties of our sensors.
Results:
A global yield ratio between working strips over the total number of strips measured in the entire production of 89.4% and a mean breakdown voltage for good sensors (sensors without bad strips) measured on the backplane of about 212 V were found. The average full depletion voltage obtained was 22.12-23.47 V and 34.98 V for Si-Si and Epi wafers, respectively. Furthermore, the ratio between the 90/10 percentile for the leakage current at 160 V was lower than 1.6 for all the cases. The inter-strip distance measured was 80.8 um, 22% larger than the nominal no-gain distance, as previously observed by other groups.
Conclusion:
The laboratory characterization showed good results and prepared the groundwork for the selection of the best set of sensors to be tested on clinical proton beams.

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