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Characterization and X-Ray Damage of Silicon Photomultipliers

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Abstract—For Hamamatsu silicon-photomultipliers (SiPM) S10362-11-050P before and after irradiation to 200 Gy, 20 kGy, 2 MGy and 20 MGy, forward current–voltage, reverse current–voltage, capacitance/conductance–voltage, capacitance/conductance–frequency, pulse shape and pulse height measurements below and above the breakdown voltage were performed. The data were analysed using an electrical model of the SiPM which allowed determining characteristic parameters like pixel capacitance, quench resistor and quench capacitance, parasitic resistance, and breakdown voltage in different ways, and studying their dependence on X-ray dose. In addition, the doping profile and the electric field distribution in the SiPM have been determined. It is found that the electrical model provides a consistent description of the data.

The main changes with X-ray dose are a decrease of the parasitic resistance, and an increase in dark current due to current generation at the Si-SiO₂ interface. Whereas for dose values of 20 kGy and below the surface generation current hardly affects the properties of the SiPM above the breakdown voltage, it gets amplified for dose values above 20 kGy resulting in a significant increase in dark-count rate. Apart from this effect, the performance of the Hamamatsu SiPM as high-gain photo detector is hardly affected by X-ray radiation up to a of 20 MGy.

Summary

Hamamatsu Silicon Photo Multipliers (SiPM) of the type S10362-11-050P are characterized and the change of their parameters after irradiation to X-rays of 200 Gy, 20 kGy, 2 MGy and 20 MGy determined. A novel method how characteristic parameters of SiPMs can be obtained in different ways is presented.

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