

Radiation hardness and annealing study of neutron-irradiated 6th International Workshop on New Photon-Detectors (PD24) silicon photomultipliers

Dania Consuegra Rodríguez¹, Rok Dolenec^{2,1}, Peter Križan^{2,1}, Samo Korpar^{3,1}, Andrej Seljak¹, Dejan Žontar¹, Tinka Drozdek¹, and Rok Pestotnik¹

¹Jožef Stefan Institute, Slovenia. ²Faculty of Mathematics and Physics, University of Ljubljana, Slovenia. ³Faculty of Chemistry and Chemical Engineering, University of Maribor, Slovenia.



Abstract: Silicon photomultipliers (SiPMs) are semiconductor photodetectors increasingly used in high-energy physics experiments. In the planned upgrade of the Large Hadron Collider beauty (LHCb) experiment, they are considered to be used to detect Cherenkov photons in the Ring Imaging Cherenkov (RICH) detectors. In this application, the biggest drawback of current SiPMs is their susceptibility to radiation damage, where the dark count rate (DCR), typically on the order of 10⁵ Hz/mm² at room temperature, significantly increases proportionally with the irradiation fluence, which hinders the single photon detection beyond fluence of 10^9 neq/cm². In this contribution, 3 x 3 mm² SiPMs of different cell sizes and producers, Hamamatsu (50 μ m), Ketek (25 μ m and 50 μ m), Broadcom (50 μ m), and SensL (35 μ m) as well as 1 x 1 mm² SiPMs from SensL (35 μ m) and FBK (15 μ m)^[2, 3], were characterized. The SiPMs were irradiated at the Jožef Stefan Institute TRIGA nuclear reactor with fluences from 10⁹ neq/cm² up to 10¹³ neq/cm². The main objective was to determine the temperature at which irradiated SiPMs can still meet minimal performance requirements in future RICH detectors. Influence of high-temperature annealing on SiPM performance post-irradiation was also investigated. For the SiPM characterization in all the cases, current-voltage (I-V curve) measurements, DCR measurements, and waveform analysis, including single photon time resolution (SPTR), were carried out at controlled temperature steps from room temperature down to the liquid nitrogen temperature.

