

# High-Density Silicon Photomultipliers with Epitaxial Quenching Resistors at NDL

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Silicon photomultipliers (SiPMs), also known as multi-pixel photon counters (MPPCs), represent an alternative solution that to a large extent combines the advantages of PMTs and APDs. They have high gain, low bias voltage, excellent timing properties and are insensitive to magnetic fields. SiPMs are replacing the traditional PMTs gradually in various applications like high energy physics, astrophysics and nuclear medical imaging. Novel Laboratory Device (NDL) SiPM uses the bulk resistors in the epitaxial layer as quenching resistor (EQR SiPM); it avoids the use of polysilicon employed by other SiPM as an absorber of light and can potentially lead to a higher photon detective efficiency (PDE) and large dynamic range. NDL EQR SiPM features small micro cells with high fill factor, fast response to even a single photon, simple fabrication technology and excellent packing fraction. This report detail the latest progress of EQR SiPM at NDL. The device has active area of  $3 \times 3$  mm<sup>2</sup>, comprising 90000 individual cells, a dark count rate of 700 kHz/mm<sup>2</sup>, the peak PDE was typically 34% for 420 nm photons. The PDE was characterized using both photon counting method and Poisson method. The photon counting method is modified by use of making analysis of the noise component through deducting the correlated-noise component. By analyzing the scatter plot to fitting the recovery curve, the recovery time constant for the microcell of EQR SiPM was obtained approximately 4.0 ns. An intrinsic single photon timing resolution was optimized as 81 ps (FWHM) under 9 V overvoltage at room temperature.

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