Characterization of Recently Developed SiPMs for PET

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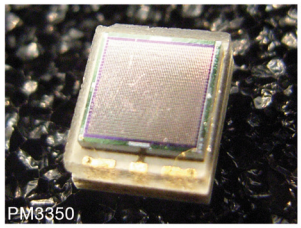
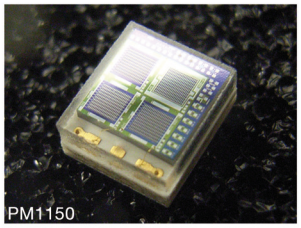
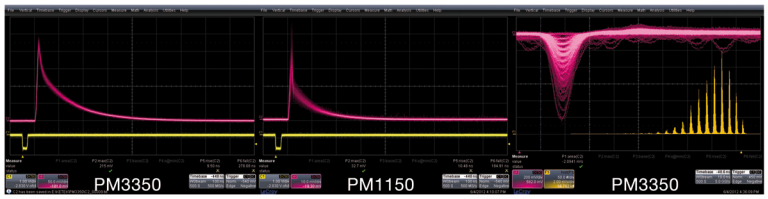
Detectors: PM3350 and PM1150





·: SiPM prototypes developed by KETEK, Munich
- PM3350B-2: 3x3 mm², 50 µm cells, 62% fill factor, w/ optical trenches
- PM1150D-1: 1x1 mm², 50 µm cells, 60% fill factor, w/ optical trenches
- peak sensitivity @ 420 nm
- active surface protected with 300 µm epoxy
- operating voltage range 24 - 32 V
- PM3350 package size 3.9 x 4.4 x 2.0 mm³
- PM1150 tested in prototype package, only one pixel is connected

Detector Signals



·: Measurements performed with pulsed 400 nm LED
·: Pulse shapes with strong light pulse
- PM3350: rise 10 ns, fall 280 ns (10-90%), capacity 580 fF
- PM1150: rise 10 ns, fall 185 ns (10-90%), capacity 480 fF
- Gain: 10^6 @ 2 V overvoltage (according to KETEK datasheet)
- PM3350 has 80% of PM1150's gain

·: Single photon spectrum and pulse of PM3350 @ 26 V with preamp + shaping

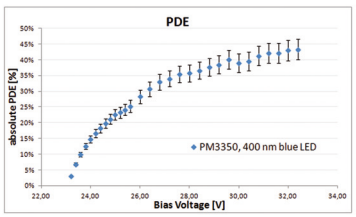
Photodetection Efficiency

·: Relative PDE: single photon spectra
- Poisson statistics

$$P(k,\lambda) = \frac{\lambda^k e^{-\lambda}}{k!}$$

$$k = 0 \quad P(0,\lambda) = e^{-\lambda} = \frac{\text{counts pedestal}}{\text{counts total}}$$

$$PDE_{\text{rel, G-APD}} = \lambda = -\ln \frac{\text{counts pedestal}}{\text{counts total}}$$

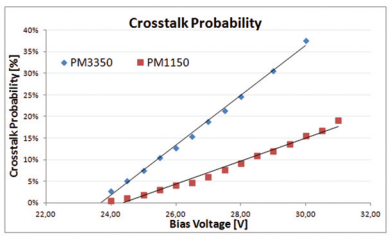


·: Absolute PDE with the help of a known reference MPPC S10362-11-050C
- illuminated with same light intensity and geometrical conditions

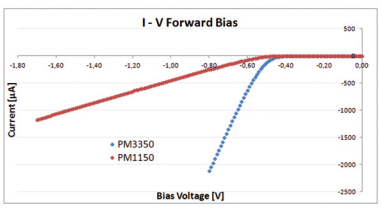
$$PDE_{\text{abs, G-APD}} = PDE_{\text{abs, MPPC}} \cdot \frac{PDE_{\text{rel, G-APD}}}{PDE_{\text{rel, MPPC}}}$$

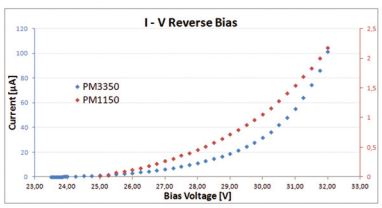
Crosstalk

·: Triggered by DC > 0.5 pe
- XTalk propability is the ratio of total counts and counts > 1 pe
- XTalk takes reflected photons e.g. at boundary epoxy-air into account



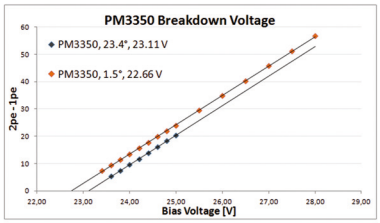
I-V Curve

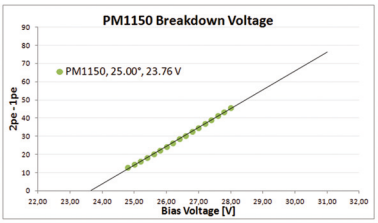




·: Single cell resistivities · PM3350: 481 kΩ · PM1150: 385 kΩ

Breakdown Voltage and Temperature Coefficient

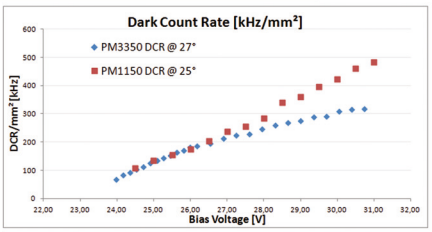




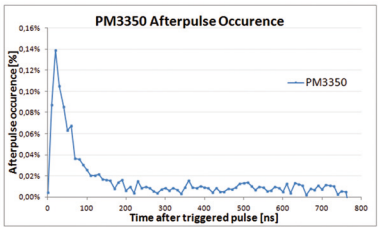
·: Breakdown voltages extracted from single photon spectra with blue LED @ 400 nm
- Breakdown voltage change: PM3350: 23.7 mV/K
- Temperature coefficient is below 1 %/K for operation with relative overvoltages > 12%

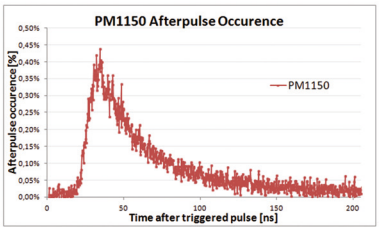
Dark Count Rate

·: Single photon spectra in dark
- randomly triggered gate
- extracted the dark count probability with Poisson
- DCR calculated with known gate length



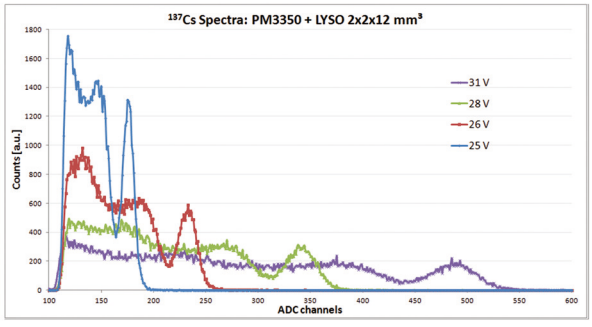
Afterpulsing





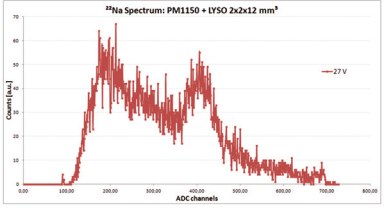
·: Afterpulse occurence after triggering event > 0.5 pe
- triggered by DC, gate directly opened after the triggered pulse maximum
- PM3350: 800 ns gate length PM1150: 250 ns gate length
- histogramming the time of occuring pulses within this gate
- corrected for darkcount background

LYSO Spectra



·: Energy spectra of ^{137}Cs with LYSO as first test for PET usability
- LYSO without any reflector, coupled with optical grease
- PM3350: energy resolution ~12% FWHM (not corrected for nonlinearity) and ~16% FWHM (corrected for non-linearity) @ 26.0 V for 662keV

·: PM1150: less collected light than for PM3350 due to smaller active area and light losses due to the dimensions of the prototype package



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