Design and characterization of Single Photon Avalanche Diodes arrays

L.Neri[1,2], S.Tudisco[1], L.Lanzanò[1,2], F.Musumeci[1,2], S.Privitera[1,2], A.Scordino[1,2], G.Condorelli[3], G.Fallica[3], M.Mazzillo[3], D.Sanfilippo[3], G.Valvo[3]

[1]INFN-Laboratori Nazionali del Sud, Via S.Sofia 44, I95123 Catania Italy

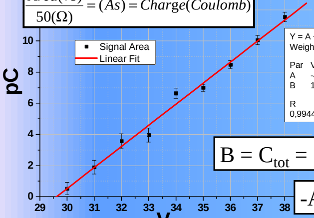
[2]DMFCI e Dipartimento di Fisica ed Astronomia, Universita' di Catania, I95123 Catania Italy

[3]ST-Microelectronics, Stradale Primosole 50, I95100 Catania Italy

Electric SPAD Model Calibration

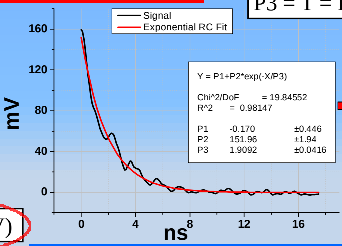
The **area**, the **shape** and the **maximum** amplitude of the **signal** of a **single diode** was studied at various source voltages to extract the real magnitude of the electrical components involved in the sensor.

$$\frac{Area(Vs)}{50(\Omega)} = (As) = Charge(Coulomb)$$

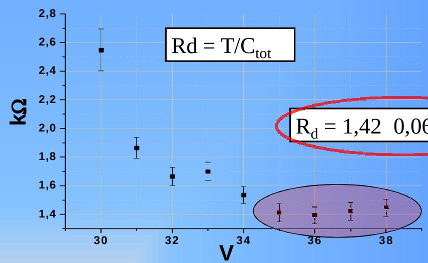


B = C_{tot} = 1,35 0,05 (pF)

-A/B = V_B = 29,6 1,6 (V)

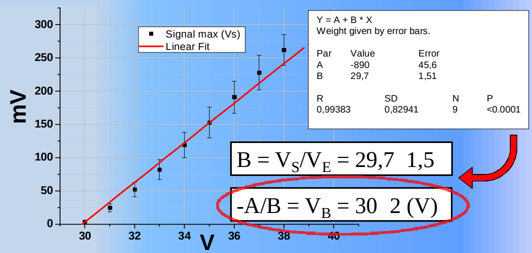


P3 = T = $R_d \cdot C_{tot}$



Rd = T/C_{tot}

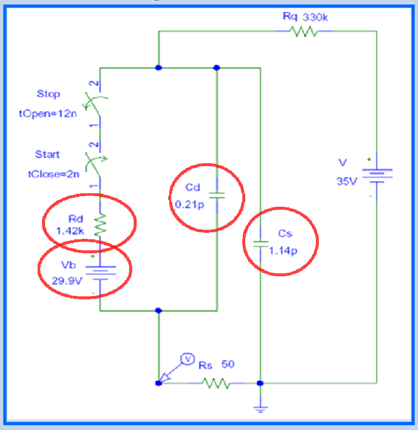
R_d = 1,42 0,06 (kOhm)



B = V_S/V_E = 29,7 1,5

-A/B = V_B = 30 2 (V)

We took into account the single SPAD electric model proposed by Cova [3]. We inserted two switch instead of one proposed by Cova, one for the avalanche starting and the other to open the circuit below the latching current. The time interval between this two operation was manually set by the analyzing of current drop off. This two switch was proposed only for the simplification of the designing of the model. <u>The magnitude of the electrical component extracted from the characterization of the single diode was inserted into the model, and the simulation results fit with extremely precision the real signal.</u>



$$V_s \cong V_E \frac{R_s}{R_d\left(1+\frac{C_d}{C_s}\right)}$$

$$C_{tot} = C_s + C_d$$

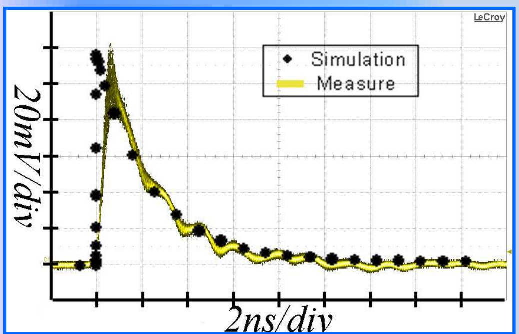
$$V_E = V - V_B$$

[ref.3]

$$C_s = \frac{V_s}{V_E}\frac{R_d}{R_s}C_{tot}$$

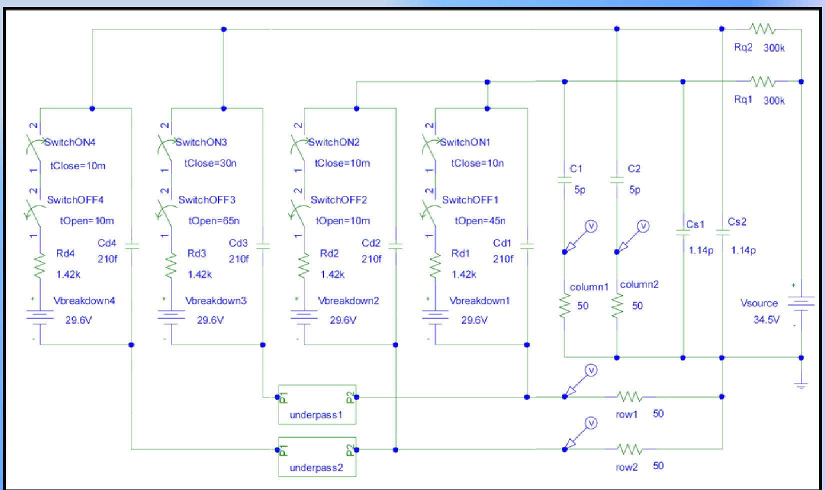
C_d = 0,21 0,09 (pF)

C_s = 1,14 0,09 (pF)

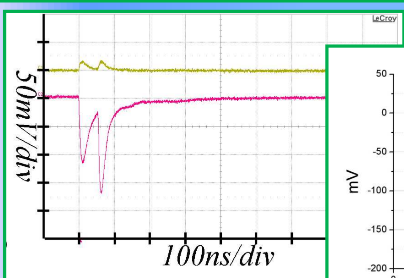


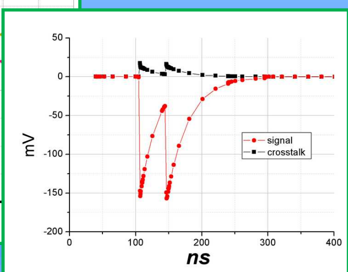
Electric SPAD Matrix Sensor Model

The calibration was used to design the complex electric model of our imaging sensor. We inserted in the electric scheme many diodes in a two dimensional array configuration. Each diode shares the anode contact with all the diodes of the same row, and the cathode contact with all the diodes of the same column[2]. The figure shows only two rows and two columns of the matrix.



This configuration needs the study of the creation and propagation of two photon signals generated from two diodes that share the same reading channel. The simulation and the measurements too, show that the two close signals should be different by more than the half duration of the single signal, and the two diodes should be quenched by two different ballast resistors. In the future sensors the quenching resistor will be integrated in the diode cell.





Our prototype matrix uses underpass technology to prevent the crossing of row and column contacts [2]. The perturbation introduced in the signal creation was studied and inserted in the simulation. We have already planned another solution without underpass.

[1] S. Privitera et al. (2008) Sensors 8, 4636-4655 ; [2] L. Neri et al. (2008) Proceedings of SPIE 7021 702129 -1/11, S. Tudisco et al. in press on NIMA ; [3] S. Cova et al. Appl. Optics 35(1996)1956

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