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STMicroelectronics Photodetectors Technology – From SPAD to Analog SiPMs

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Abstract. Single Photon Avalanche Diodes (SPAD) and Silicon Photo Multipliers (SiPM) are high sensibility sensors with a great potential in heterogeneous insertion of optical technologies. They find main application in Healthcare, in particular inside Medical Image Systems for Nuclear Medicine like Single Photon Emission Computer Tomography (SPECT) and Positron Emission Tomography (PET). Among a lot of others application fields, biological diagnostic micro-Total-Analysis-Systems is a very interesting one. The activity of STMicroelectronics about SPAD and SiPM has been planned and executed in three phases. First of all, target specifications for a general purpose SPAD device and a manufacturing process flow (not derived from CMOS process) were fixed. The technology was then consolidated, featured with an innovating optical trench that actually has no competitor equivalent. Special cleaning procedures were developed in order to obtain an internal dark noise below 10 Hz in small diodes. In a second phase the device was tailored to the requirements of the PET equipment. Large area SiPM prototypes were fabricated. To increase the Photon Detection Efficiency, the edge of the diode has been compacted efficiently (fill factor up to 62% with cell pitch of 60 microns), while some further process, device structure and layout optimizations have been simulated and implemented. Both technology versions: "p on n substrate"and "n on p substrate"were fabricated and characterized. In the blue/violet wavelength range a PDE of about 40% and a Single Photon Time Resolution (SPTR) below 150 ps were obtained. Reliability tests at wafer level and on packaged devices showed that the SiPM has a ruggedness equivalent to the state-of-the-art silicon devices. Moreover: a lot of optical/low-stress package solutions have been exploited: open metal-can or ceramic; Chip-Scale-Package; Surface Mounting Device (SMD) with transparent resin. Finally, a lot of exploitation activity has been started. Some of them are running in the framework of European or Italian funded projects. Inside "CSI"project (European Nano-electronic Initiative Advisory Council ENIAC 2009-2012: Central Nervous-System Imaging) a Small-Animal-PET equipment will be assembled using ST-SiPM. The "High Profile"project (ARTEMIS) has a task for the conceptual design of a Near Infrared Imaging system based on SiPMs photon sensors. The "Muon Portal"project will exploit a muon tracking system for the inspection of cargo containers (to prevent nuclear fissile material contraband).

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Session Classification: Photodetectors: - Developments in SiPMs - overview SiPM different designs and properties