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Near infra-red light detection enhancement of plasmonic photodetectors

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Nowadays numerous are the applications interested in exploiting near infrared light detection like LiDAR (at 850 - 950 nm wavelengths), NIR spectroscopy, quantum computation, and the detection of light from NIR emitting scintillators. Silicon based single photon avalanche diodes (SPAD) could be a valid device achieving high detection efficiency and high timing resolution. Moreover, they can provide single photon sensitivity in large areas if arranged in extended arrays named Silicon Photomultipliers (SiPM). Nevertheless, the Photon Detection Efficiency (PDE) of standard SiPMs in the NIR range is strongly limited by the relatively low Si absorption coefficient, leading to an absorption depth much larger than the typical active thickness of Si SPAD, i.e. 18 µm at 850 nm compared to some few µm's. Hence, the performance of Si based detectors in NIR range is still inadequate for almost all the cited applications.

A potential solution to overcome the limited Si absorption coefficient is to couple these photodetectors with a structure supporting highly confined light such as plasmonic oscillations, thus increasing the absorption. In recent years, the development in nanophotonic demonstrated that the interphase between metallic nanostructured and dielectric surface can support Surface Plasmon Polaritons (SPP) i.e. electrons collective oscillation highly confined along the thickness of the device. Some of these interesting nanostructured are: i) 1- and 2-dimensional gratings; ii) bullseye structures; iii) nano-pillars and nano-holes arrays. Among those, 1D and 2D metallic nanograting are the most promising structures considering their feasibility and possible integration with Si based photodetector and SiPM technologies.

In this contribution, we investigated the integration of a bidimensional metallic plasmonic nanograting structure on state of art photodetectors (PDs). For ease of production and characterization, the test devices consisted of conventional Silicon photodiodes instead of a proper SPAD. The PDs have been produced at the facility of Fondazione Bruno Kessler (Trento, Italy) using a custom CMOS-like microfabrication process similar the one used for FBK-SiPM technology.

The previous described metallic nanograting is directly fabricated on a PDs by i) Electron Beam Lithography (EBL), ii) silver deposition, and iii) lift-off. Afterwards, the quantum efficiency (QE) of the produced samples have been measured in (450-1100) nm range. The first results are promising with an enhancement of about 45% at 950 nm with respect to the reference PD without any plasmonic nanostructured on top.

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