Contribution ID: **44** Type: **not specified**

Small and Fast : Nanophotonics for Fast Timing

Sunday, June 5, 2022 8:30 AM (15 minutes)

This presentation will present the opportunities offered by nanophotonics to improve the performance of detectors including results obtained from the ATTRACT-Photoquant project [1] that aimed at demonstrating that recent nanophotonics innovations such as metalenses and more generally metamaterials could allow a breakthrough in single-photon time resolution. Silicon photomultipliers are bidimensional arrays of single photo-avalanche diodes (SPADs). Many applications would benefit from a single photon time resolution much lower than what is the current state of the art, ideally 10 ps, or even less. Moreover, a photo-detection efficiency as close as possible to 100% is also required. Simulations and measured results show that, using both a light concentrator and including light trapping features to the device stack, the photo-electron generation can be confined in a region as small as 820×780×500 nm3, which could greatly improve the single-photon time resolution and the sensitivity of the device. A concentrator based on a metatamerial gradient index (MM GRIN) lens was created as a 2D square lattice of holes with different diameters [2]. The focusing effect is generated by the refractive index gradient, with bigger holes in the outer region of the concentrator. Moreover, we have shown thanks to numerical simulations that modified SPAD with a thickness reduction of the Si layer down to 500 nm (usually several µm Silicon thickness) and a grating at the bottom or above of the stack resulted in a photon absorption efficiency of nearly 100% in the Si layer.

1 - https://phase1.attract-eu.com/showroom/project/nano-photonics-applied-to-ultrafast-single-photon-quantum-sensors-photoquant/
2 - Mikheeva, E., et al. (2020). CMOS-compatible all-dielectric metalens for improving pixel photodetector arrays. APL Photonics, 5(11), 116105.

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Session Classification: Technologies for ≤100ps TOFPET resolution: Photodetectors

Track Classification: Technologies: Photodetctors