Silicon Photomultiplier for Novel Autonomous Flash LiDAR

D.Mikhaylov[1], V.Saveliev[2]

[1]*Abu Dhabi Maritime Academy, 51133, Abu Dhabi, UAE*

[2]*Integrated Quantum Photonics, 77019, Houston, TX*

The current state of the art in 3D visualization systems, in particular for autonomous vehicles, is to reanalyse the requirements and operation principles of key elements of these systems – Light Detection and Ranging (LiDAR). At the moment, there is probably no solution for visualization systems that satisfy the level of autonomous driving above level 2+. The development trends of LiDAR-based 3D visual systems must correspond to new promising developments of LIDAR sensors, based on 2D Silicon Photomultiplier Structures (SiPM) [1].

First of all, it is necessary to develop the advanced key element of the LiDAR sensor - novel, specially designed and optimized optical sensors for LiDAR operation. Optical sensors must provide true single-photon sensitivity, high detection efficiency, and advanced real-time timing analysis. The optical sensor must provide a high degree of built-in integration, including the ability to analyze information based on artificial intelligence algorithms. Regarding the technology of the optical sensor, the future lies in the use of CMOS technologies, which can provide a high integration of sensors and processing electronics at fairly low cost. Silicon Photomultiplier Optic Sensor is one promising solution [2].

Second, one has to abandon the principle of mechanical scanning of the LiDAR sensor, which is responsible for the main limitations of the most important characteristics of the LIDAR, such as time response, limitations in the generation of information (sequential scanning) and intelligent analysis in real time. One of the promising options is the flash principle – the pulsed illumination of the entire situation, reading information in the video camera format and ranging using the time-of-flight technology.

A pulsed laser source with discrete spatial distribution for high performance can be implemented based on 2D diffraction optics, which improves performance and reduces power consumption.

The principle of information detection in the form of a video camera format (images) radically changes the format of information, allowing for faster and more comprehensive analysis in real time, not requiring preliminary reconstruction of sequential data (classical point cloud). The image analysis can be carried out in real time on a chip. This principle realized on base 2D Silicon Photomultiplier with Time of Flight processing electronics on chip.

Integrated Quantum Photonics (IQP, Houston, TX) is working on this concept to create flash LIDAR sensors based on the optimization of photosensors, laser sources on base diffraction optics and is currently making significant progress in the development of miniature long-range flash LiDARs with improved characteristics [3].

At CES 2025, Flash LiDAR with a SiPM sensor and diffractive optics was awarded an innovation Award in the Vehicle Technologies and Advanced Mobility Solutions Category [4].

References

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