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Technology Offer

Modular low light level sensors: a scalable approach

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Summary

A scalable and easy to handle method for the creation of larger (up to square meters) low light level detectors is disclosed. While the fast read-out times of a single detector is kept, the area covered by the detector ensemble (dramatically) increases. The large area is enabled by transversal connection of hybrid “base cells”. These “base cells” consist of vertically stacked tiers of (i) a detector array, (ii) a first level electronic read-out, and (iii) and a second level read-out which can be coupled to the other second level read-outs (e.g., optically). The tiers are electrically interconnected and the hybrid approach facilitates the usage of state-of-the-art detectors and electronic components. The resulting surface can be planar or curved, the individual components remain accessible. Appropriate read-out circuits allow a (virtual) variation of the pixel size resulting in different spatial resolutions/collection modes. Analogous, read out times in the ns regime which become possible for the entire detector, can be sampled down for applications in which longer time scales are of interest.

Background

Silicon photoelectric multipliers (SiPM) have developed over the past decades to highly efficient detectors for low light level optical signals from different emission sources. While attractive
for many different applications as, for example, industrial/medical tomography, life science, nuclear, particle and astro-particle physics, some drawbacks remain, for example: (1) The manufacturing process and especially the resulting size of the detectors is not standardized, this results in (2) a variety of ways user interconnect the detectors to achieve large detection areas. (3) In parallel, the same argumentation holds for the electronic readout schemes and (4) for the time being, the size of single SiPM seems to be constrained to sizes below or around 10 mm.

Technology

This invention proposes a modular, scalable set-up of larger low light level detectors:

1. A hybrid approach in the set-up of the individual silicon photomultipliers (SiPMs) and the read-out electronics: the detector is placed on top of a stack with usually two further tiers below consisting of a first and second level read-out electronic. The electronics of the different tiers are electrically interconnected via the (vertical) junctions. This concept is sketched in Figure 1 and allows to easily exchange, e.g., the detector and to use the best up-to-date front-end electronics.
2. A transversal connection possibility of the hybrid “basis cells” allowing to come up with arrays in the size of square meters (for comparison: the basis cell obeys typical areas of a few square centimeters). The transversal connections are virtually seamless. The connected base cells can build a planar module or it might have a curved surface. Cf. Figure 2 for an array build out of the ground cells according to Figure 1.

3. The electronics can be connected via (e.g.) optical or Ethernet connections available in the second level electronics. Appropriate circuits allow also to operate the entire device at different effective spatial resolutions/collection areas.

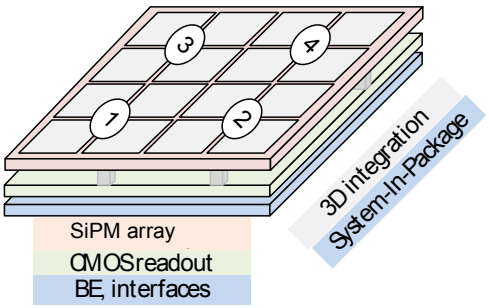

Figure 1. A base cell made up of three tiers: (i) a low light level detector, here a single-photon avalanche photodiode (SPAD) detector, (ii) a first level electronic read-out, here a complementary metal-oxide-semiconductor (CMOS), and (iii) a second level read-out: back end (BE), interfaces.

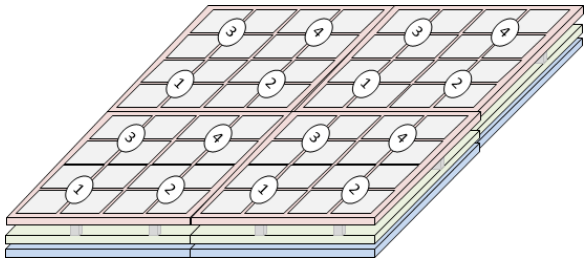

Figure 2. Array built of four base cells.

Advantages

- Scalable areas of resulting detectors, surface can be planar or curved.
- Easy reconfigurability: detectors or electronics can be easily accessed and changed on a short time scale.
- Hybrid set-up allows usage of state-of-the-art detector and electronics solutions.
- Read-out interface units can provide a scalable data interface or a fast synchronization interface.
- Effective area/spatial resolution of the detector can be changed via read-out electronics, e.g. a 16 SiPM array con be used as a 4 x 4 SiPM array (four “virtual” detection cells each consisting of four SiPMs) increasing the sensitivity of the detection cells while decreasing the spatial resolution.
- Low power consumption (< 100 mW / cm^2).
- Defined dimensions.

Applications

All cases of measurements with low light level detectors.

Patent Information

Patent application EP: EP20153057
Patent application PCT: WO21051448