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# The Silicon Photomultiplier Status and Perspectives

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The Silicon Photomultiplier (SiPM) is a solid-state device capable of sensing, timing and quantifying with high accuracy light signals down to the single-photon level. Featuring large internal gain with negligible fluctuations, high intrinsic timing resolution, low-voltage operation, insensitivity to magnetic fields, high degree of radio-purity, mechanical robustness and excellent uniformity of response, the SiPM is a very attractive alternative to Vacuum and Hybrid Photomultiplier Tube devices.

This review talk summarizes the present status of the SiPM development and put it in future perspective by examining the four following subjects:
1) Device Physics and Technology
2) SiPM properties and performance
3) New developments and trends
4) Selected applications examples

After a short introduction aiming at presenting the two main families of SiPM (namely the Analog and the Digital SiPM) the review will illustrate the Physics of the device. In particular the main working principles of the Single Photon Avalanche Diode (SPAD), which is the building block of any SiPM, will be discussed in order to clarify both intrinsic benefits and issues related to the solid-state sensor and to introduce the technology challenges that in the last 15 years have been addressed and gradually solved. Key Technology points will be then shown to be mostly related to the constraints (1) of building the SiPM device as a closely packed array of thousands of SPADs working in parallel and (2) of providing effective feedback mechanisms for controlling the SPADs discharge and recharge. Custom and CMOS silicon technologies will be discussed while illustrating the main technological differences between the Analog and the Digital SiPM families.

In the second part of the review the SiPM properties will be discussed in terms of main parameters characterization. Gain and dynamic range , Noise (both of uncorrelated and correlated type), Phodo-Detection Efficiency (PDE), Timing properties, stability and radiation hardness will be addressed, providing also the occasion for a performance comparison with respect to other types of high-sensitivity light sensors.

Despite the SiPM technology is quite mature there is still large room for improvement. Thus in the third part of the review the most challenging new developments and trends will be instanced by showing how noise (for example single photo-electron equivalent noise or correlated after-pulsing noise) can be mitigated, how the sensitivity spectra are being extended towards very short or long wavelengths (respectively VUV and NIR regions) and how radiation hardness can be improved.

Eventually, selected application examples will illustrate how, in addition to straightforward applications, like for instance high energy calorimetry or medical imaging, the SiPM is becoming the baseline option also for low-light intensity applications, for fast timing applications and, by exploiting their excellent performances at cryogenic temperatures, even for very large area applications. Illustrations of options and clever solutions concerning the related Front-End electronics will be also provided.

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