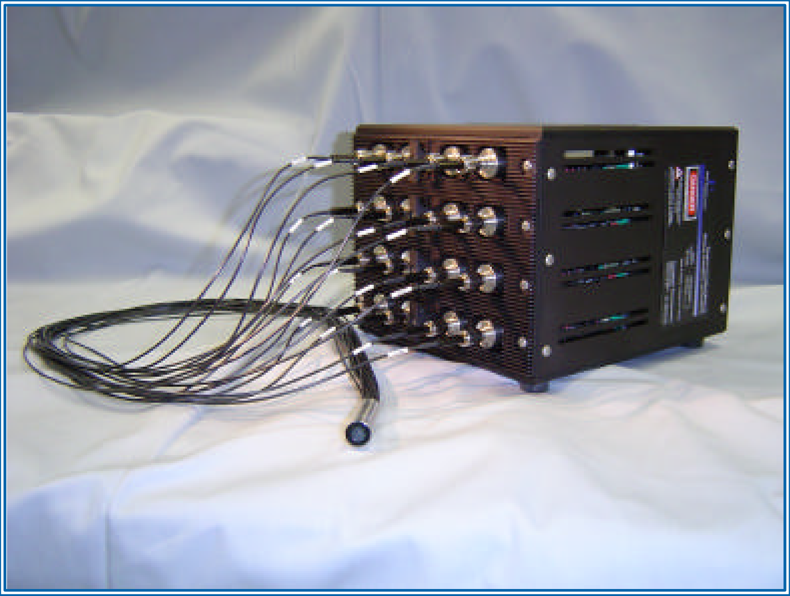
Stackable 4-channel SPCMs unlock the future for photon counting applications



Introduction

Single count SPCM modules have existed on the market for some time, and PerkinElmer Optoelectronics has been at the forefront in the development of the latest photon counting techniques available today. In keeping with the pace and demands of new research technologies, PerkinElmer recently demonstrated a 16-channel SPCM which provides researchers with the means to study several aspects of photons simultaneously over individual channels.

The company has taken its high performance 4-channel SPCM to the next level by enabling the stacking of several modules to create a 16-channel device. This stacking technique will enable scientists and researchers to go beyond the benefits of one channel or even a few channels – it promises the ability to use as many as 24, 32, or even 100 quality channels simultaneously while conserving space.

SPCM's superiority

There are several different technologies used to achieve similar results to that of the SPCM system. The most widely known is the photomultiplier tube (PMT). PMTs generally operate at shorter wavelengths than the SPCM. The PMT is commonly used for ultraviolet (UV) enhanced measurement because it is more sensitive to ultraviolet than the SPCM. However, in the visible ranges – from about 400 nm to 900 nm – the SPCM is much more sensitive than PMTs.

There are two reasons for the success of the SPCM. First is its ability to detect anywhere from a few photons to several million per second. Second, it has extremely high single-photon detection efficiency.

At the heart of the SPCM is PerkinElmer's own SLIK™ avalanche photodiode (APD). APDs are silicon

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semiconductor junctions operated under reversed bias. Under these conditions, they exhibit an electric field profile that will multiply, through impact ionization, primary electrons generated by the incoming light inside the silicon (bulk generation). The SLIK™ APD is unique because of its extremely low bulk leakage current in the dark.

There are two reasons for the high single-photon detection efficiency of PerkinElmer's SPCM. First, the silicon based detector exhibits high quantum efficiency from the UV to the near-infrared. Second, by operating sufficiently high above the breakdown voltage, nearly all generated electrons will induce a junction breakdown that results in a detectable pulse. This method of operating the detector above the breakdown is called the Geiger mode. It uses a "quench and reset" cycle process that takes only about 45ns thus enabling the rapid detection of many photoelectrons.

4- to 16-channel SPCM arrays and beyond

PerkinElmer's 4-channel and 16-channel SPCMs are the logical "next step" for superior photon detection. With the single-channel SPCM, multiple colors, polarizations, and diffusions can be analyzed – but only one measurement at a time. The requirement for simultaneous measurements would call for multiple single-channel SPCMs. With that in mind, PerkinElmer developed its 4-channel SPCM product that enables multiple and simultaneous measurements – a requirement that enhances the performance of most biomedical instrumentation in use today.

With its modular design, the 4-channel SPCM can be stacked to create 16-channel arrays and beyond. For example, if a user wanted to examine four different colors per well and four separate wells at one time – and do so as economically as possible – stacking four 4-channel SPCMs would be a perfect and affordable solution. With the compact size of the 4-channel SPCM, systems with 100 channels or more are achievable, allowing for the collection of multiple parameters. This "plug and play" system is also simple to use – just connect the power supply voltages to it and everything else takes care of itself. No other electronic overhead is involved. The output signal from each channel is a TTL-level digital pulse with one pulse for each detected photon. TTL signals interface easily to whatever signal processing system the user chooses.

Many applications exist

Many applications that require the ability to detect multiple parameters – such as fluorescence intensity, diffusions, lifetimes, and polarizations – already exist today. Single-molecule detection technology enables quick and efficient collection and measurement of these and other parameters – and the 4-channel SPCM, stacked for multiple arrays such as the 16-channel module, will be the detector of choice for this new and exciting technology.

It is also possible to customize any fiber bundle at the front of the module. For instance, if the user has just one card, it's now possible to have a quadrant detector. Using multiple cards, entire arrays can be achieved in a very small area, since the modules are designed for rack-mounting multiple channels. Having all this fiber together can create an unsurpassed imaging system for single-photon detection. With reconfigurable fibers, manufacturers are capable of configuring and reconfiguring different arrays to suit their specific applications.

For imaging applications, the 4-channel SPCM can be coupled with a coherent fiber bundle to reduce system complexity and increase system density. With the proper interface, parallel readout of the data is possible,

Worldwide Headquarters
PerkinElmer Optoelectronics
44370 Christy Street
Fremont, CA 94538
Telephone: +1 510-979-6500
Toll Free (North America): +1 800-775-OPTO (6786)
Fax: +-510-687-1140
Email: opto@perkinelmer.com

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leading to increased speed of data acquisition. Compared to other systems that employ first-in/first-out (FIFO) schemes, the benefits of parallel data acquisition are obvious. In the laboratory, 4X4 element arrays have been demonstrated using a 4X4 coherent fiber bundle. An array with more channels can be envisioned.

The coherent fiber bundle can be fabricated from conventional round fibers. To improve pixel density and to reduce the dead space between pixels, the fibers can be custom extruded into square geometries. Both fiber types (4X4 configuration) have been demonstrated in the laboratory. Preliminary measurement of cross-talk using the round fiber bundle was less than 1% across all channels.

Another application for SPCMs is in particle sizing. This technology requires four, five, or even ten channels for observing angular measurements of light reflecting off the molecules. An array configuration is extremely efficient for gathering angle-of-reflection information for a particular particle. The ability to look at different angles of light scattering can determine information by seeing more or less of the light.

Another example is in DNA sequencing. Looking at multiple samples simultaneously greatly speeds up the overall DNA analysis process. The techniques used in DNA analysis can also be applied to many other important applications requiring the coding of long chains of molecules. SPCM arrays can be used for observing the reaction of specific parts of individual molecules. When this is done at a single-molecule level rather than a large sample, photon counting becomes an important technique and, once again, arrays of multiple 4-channel SPCMs can enable researchers to gather multiple parameters at the same time by looking at different wavelength simultaneously.

Adaptive optics is another popular application for stacking 4-channel SPCMs. The modules are used to control the mirrors of giant telescopes. The larger the mirror, the more susceptible it becomes to distortion and aberration. But by splitting the mirror into smaller sections, each piece can be controlled separately to help null out the distortion effects of the atmosphere and aberration. Each mirror segment contains an SPCM – part of an array of many SPCMs working simultaneously to control the telescope’s mirror.

Another application uses fiber arrays with SPCMs to look at the movement and/or speed of molecules. In other words, the SPCM array is used as a position-sensing device at a molecular level. In this application, the position of a molecule can be observed as it passes through a particular medium. The molecule’s speed can be measured and its position accurately tracked by using multiple SPCMs.

The improvements incorporated into the stackable 4-channel SPCM are a direct result of the successful photon counting technique developed by PerkinElmer for its single-channel SPCM module. Whether it’s a one-channel, 4-channel, or multiple 4-channel array requirement, the performance is the same. Each 4-channel module reduces the system size, power requirements, and cost. It’s a scalable system that enables high-quality results four times faster and four times better – but not necessarily at four times the price.

PerkinElmer Optoelectronics is the pioneer in single-photon counting technology. The new 4-channel SPCM, with the same quality performance as the single-channel module, is taking this exciting technology to an even higher level. With the ability to easily stack multiple modules into 16-channel SPCM arrays and beyond with a simple “plug and play” feature, the cost of measuring multiple parameters is decreased while efficiency is increased. With no limit to applications, the PerkinElmer’s 4-channel SPCM – stackable to 16 or more channels – is leading the charge for new single-molecule detection technologies of the future.

For more information e-mail us at opto@perkinelmer.com or visit our website at **optoelectronics.perkinelmer.com**
All values are nominal; specification subject to change without notice.

Worldwide Headquarters
PerkinElmer Optoelectronics
44370 Christy Street
Fremont, CA 94538
Telephone: +1 510-979-6500
Toll Free (North America): +1 800-775-OPTO (6786)
Fax: +-510-687-1140
Email: opto@perkinelmer.com

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