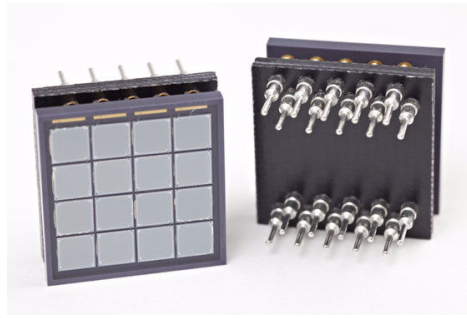sensL [1]

Position sensitive silicon photomultiplier matrix in a four side scalable, non-magnetic package

SensL Array4 is a 4x4 matrix of silicon photomultipliers optimized for the readout of L(Y)SO, NaI:Tl and CsI:Tl scintillators. Array4 is designed to serve as a low light photo detector in PET, X-ray and radiation detection applications.

Integrated on a compact, non-magnetic package designed to have a minimal MRI footprint, Array4 can be tiled to build arbitrarily large, position sensitive detector systems. Low voltage operation, high pixel uniformity, robustness and compactness make Array4 a cost effective and highly versatile alternative for PIN, APD and small area multi-anode photo multiplier tubes.

Applications

Array4 principally addresses the readout of LSO and LYSO scintillator matrices in Positron Emission Tomography (PET) systems. It provides excellent spatial, energy and timing resolution and offers industry leading pixel-to-pixel uniformity. Low bias operation and high signal gain simplify both power supply and front-end readout requirements. Due to its compactness and insensitivity to magnetic fields, Array4 is the enabling photo-detector for MRI compatible PET solutions.

Array4 offers standard pitch pin-out and can be tiled with minimal dead space allowing for simple assembly of application specific detector geometries.

The broad spectral response of Array4 makes it an attractive alternative for 1/2'' PMT in radiation detectors, security and imaging systems based on CsI:Tl and NaI:Tl scintillators.
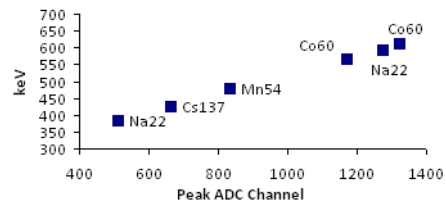
Performance

LSO and LYSO readout: Coupling a $3 \times 3 \times 20mm^3$ LYSO crystal to a single pixel on Array4, energy resolution better than 17% (FWHM) is achieved for 511keV incident radiation.
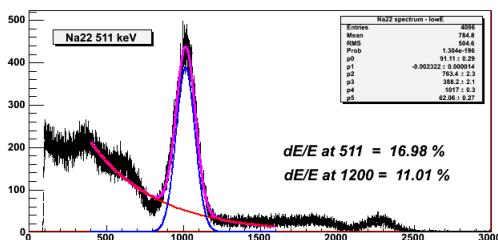
CsI:Tl readout: The following graph shows the energy resolution as a function of incident gamma energy for a $6 \times 6mm^2$ face size cubic crystal coupled to a 2 x 2 pixel quadrant on Array4:
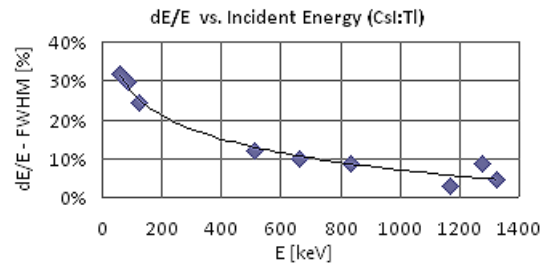
Linearity: The high micro-cell density on each SPM pixel assures excellent response linearity over a wide energy range. The following graph shows this for a CsI:Tl scintillator coupled to a 2x2 pixel quadrant on Array4:


BGO readout: Coupling a $3 \times 3 \times 15 \ mm^3$ BGO crystal to a single pixel on Array4 and integrating the signal over 1μsec, energy resolution better than 20% (FWHM) is achieved for 511keV incident radiation.

Product Characteristics

A Silicon Photomultiplier or SPM is a CMOS device integrating a dense matrix of miniaturized avalanche photo-diodes (APD) which are electrically connected in parallel. Designed to operate above their breakdown voltage, these Geiger mode APDs or *micro-cells* behave like photon switched capacitors, each releasing >10^6 electrons within a 10ns time window when triggered by a single photon. Due to the high density of micro-cells on a SPM, the device offers luminance proportional response in analogy to that of a vacuum photomultiplier tube.

SPM are insensitive to magnetic fields, can be operated under ambient lighting conditions, do not require a high voltage supply, are mechanically robust, compact and do not age.

Array4 incorporates a 4 x 4 matrix of 8.12 mm^2 sensitive area SPM optimized for the 420nm~700nm spectral range. Each SPM is mounted with a pixel pitch of 3.37mm. This matrix is supported by a four side scalable, non-magnetic ceramic package with a 15.81 x 15.31 mm^2 footprint. The device offers individual pin-out for each SPM allowing for spacial reconstruction of the incident photon flux.
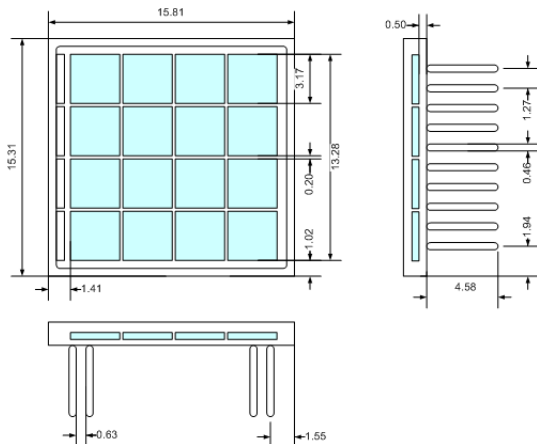
The 16 SPM incorporated in Array4 are selected for bias uniformity allowing the device to be operate with a single voltage supply while offering high response uniformity over all 16 pixels.

A planar, optical grade epoxy coating protects the SPM matrix and allows for safe handling and easy coupling to scintillators, light guides or fiber bundles.

Key Product Data

Array4 key characteristics are:

Parameter	Unit	Typical Value
Number of SPM		16
Pitch between SPM (in X and Y)	mm	3.36
Fill factor: Effective area / package foot print	%	54
Optical response uniformity over all pixels[1]	%	< ±10%
Non-magnetic - tested up to	T	7
Invisible to MRI fields - tested up to	T	< 3

[1]Equivalent to a channel uniformity of 1 : 1.2 in a multi-anode PMT

Each SPM on Array4 has the following characteristics:

Parameter	Unit	Min	Max
Number of micro-cells		3640	
Spectral range	nm	400	1000
Peak sensitivity wavelength	nm	490	
Nominal operating voltage (V_{op})	V	30 +/- 1.5	
Peak responsivity at V_{op}	kA / W	> 80	
Dark current at V_{op}	µA	< 15	
Temperature dependence of signal gain	% / ^oC	< 2.5	
Signal rise time	ns	< 3ns	

Accessories & Related Products

- **Array4-A0**: 16 channel amplifier and bias supply board providing a turnkey readout system for proto-typing and small volume systems.

- **Array4-A1**: Readout board providing access to pixel and summed signals from the Array4-A0 board.

- **Array4p9**: Large area SPM matrix.

- **ScintPack**: Evaluation pacfk including a range of SPM, Amplifier, bias supply and scintillators. Ideal for technology familiarization and educational purposes.

- **Matrix9**: A turnkey readout solution for nuclear medical imaging.

Related Documentation
- Data sheet:**Array4-A0 & A1 electronics**