



PIPS[®] Detectors

Passivated Implanted Planar Silicon Detectors



KEY FEATURES

- Ion-implanted contacts
- SiO₂ passivated
- Low leakage current
- Low noise
- Thin window
- Cleanable
- Bakeable to 100 °C

DESCRIPTION

The Passivated Implanted Planar Silicon (PIPS) Detector is a product of modern semiconductor technology. In most applications, this detector replaces silicon surface barrier (SSB) detectors and diffused junction (DJ) detectors, both of which are still made the same way they were made in 1960. The PIPS detector has a number of advantages over SDB and DJ types:

1. All junction edges are buried – no epoxy edge sealant is needed or used.
2. Contacts are ion-implanted to form precise, thin, abrupt junctions for good alpha resolution.
3. Entrance window is stable and rugged – it can be cleaned readily and reliably.
4. Leakage current is typically $\frac{1}{8}$ to $\frac{1}{100}$ of that of SSB and DJ detectors.
5. Dead layer (window) thickness is less than that of comparable SDB or DJ detectors.
6. Standard detectors are bakeable to 100 °C – higher for special models.

The PIPS Detector is fabricated by the planar process using photolithographic techniques for defining device geometries. Proprietary techniques are used to provide precise control of the oxide passivation, and ion implantation is used to form the accurately controlled junctions necessary for low reverse leakage currents and thin entrance windows. The photolithographic technique lends itself to virtually any geometry which fits onto a diameter of 140 mm.

Resistivity of the uniform ion-implanted contacts can be controlled accurately to produce position-sensitive detectors with extremely thin entrance windows (<50 nm).

Low reverse current translates into low noise contribution. Shown by the newly introduced X-PIPS™ detector, an excellent room-temperature X-Ray detector.

Unlike SSB detectors which have raw junction edges that are epoxy sealed to achieve some measure of stability, the PIPS detector junctions are all buried within the silicon wafer. There are three major advantages to this innovation: 1) The device stability is not dependent upon an epoxy sealant; 2) There is little risk of microplasma breakdown which can afflict SSB detectors and 3) Leakage current is a small fraction of that of SSB or DJ detectors.

Passivated Implanted Planar Silicon (PIPS) Detectors

The face contact (entrance window) of the PIPS detector is ion-implanted. Mirion has developed proprietary techniques for minimizing window thickness while retaining the ruggedness, reliability and stability inherent in this type of contact. The PIPS detector has a window that is substantially thinner than conventional SSBs and far thinner than any detector approaching it in ruggedness. A comparison is shown below:

Detector	Window Thickness (eq. Si)
PIPS	< 50 nm
SSB (Au Window)	≈ 80 nm
SSB (Al Window)	> 200 nm

This thin window not only improves typical resolution as normally measured but it exhibits an even greater improvement at close detector-source spacing which is necessary to achieve the high efficiency required for low-level alpha spectroscopy. The reason for this is very simple – at close detector-source spacing, peak broadening occurs because many alphas enter the detector at an acute angle – with a resultant variation in energy loss (or straggling) in the entrance window. With thinner windows, less straggling occurs.

Since the PIPS detector does not rely on delicate evaporated metallic contacts as do SSB detectors, but rather a passivated, implanted surface, it can be touched by hand and cleaned readily with a cotton ball dampened with isopropyl alcohol. This facility makes it possible to exploit applications heretofore reserved for diffused junction detectors which cannot compete with the PIPS in leakage current, resolution or window thickness.

Available in the Following Series	
Partially Depleted – Series PD	Annular – Series AN
Fully Depleted – Series FD	Custom Design – Series CD
Alpha – Series A	X-PIPS Detector
CAM – Series CAM	Single and Multi-element – Series SMEPS

FULLY DEPLETED PLANAR PIPS DETECTORS: SERIES FD

The FD series of PIPS detectors are used in *particle identification*, detector telescopes and in other de/dx measurements. They are particularly good in thickness uniformity, 1 to 2 μm for small active areas and 2 to 4 μm for areas up to 900 mm^2 . The FD series are normally supplied in a transmission mount with a radial microdot connector (model number suffix-RM). Resolution is conservatively specified with alpha particles entering through the rear contact which has an entrance window thickness of 1600 Å. The resolution through front contact, with a thickness of 500 Å is better. Typical operating voltages are 60 V for 300 μm thick detectors and 100 V for 500 μm thick detectors.

FULLY DEPLETED PIPS DETECTORS SERIES						
Thickness	300 microns			500 microns		
Active Area mm^2	Resolution keV (FWHM)		Model No.	Resolution keV (FWHM)		Model No.
	α	β		α	β	
50	14	6	FD50-14-300RM*	14	6	FD50-15-500RM*
150	15	8	FD150-15-300RM*	15	8	FD150-16-500RM*
300	18	11	FD300-18-300RM*	17	10	FD300-17-500RM*
450	18	12	FD450-18-300RM*	19	14	FD450-19-500RM*
600	22	16	FD600-22-300RM	22	15	FD600-22-500RM
900	24	17	FD900-24-300RM	24	17	FD900-24-500RM

Resolution is given for ^{241}Am , 5.486 MeV alphas, using standard Mirion electronics and 0.5 μs shaping time constant.

ALPHA PIPS DETECTORS: SERIES A

The A series of PIPS detectors is optimized for high-resolution, high sensitivity, and low-background *alpha spectroscopy*. The thin window of the PIPS detector provides enhanced resolution with the close detector-source spacing needed for high efficiency. The low leakage current helps minimize peak shift with temperature variation. Detectors in the A-PIPS series are fabricated with specially designed and selected packaging materials which reduce alpha background and are processed and tested in low-background conditions to avoid contamination from alpha-emitting radionuclides. Because of these measures, the background count rate for A-series PIPS detectors is typically less than 0.05 counts/hr/ cm^2 in the energy range of 3 to 8 MeV. Alpha PIPS detectors have a minimum active thickness of greater than 140 μm which is sufficient for full absorption of alpha particles of up to 15 MeV. Typical operating voltages are 40 V or 60 V.

ALPHA PIPS DETECTORS			
Active Area mm^2	Alpha Resolution keV	Typical Background (counts/day)	Model Number
300	17	4	A300-17AM
450	18	6	A450-18AM
600	22	8	A600-22AM
900	25	12	A900-25AM
1200	32	16	A1200-32AM

Resolution is given for ^{241}Am , 5.486 MeV alphas, using standard Mirion electronics and 0.5 μs shaping time constant.

THICK PD PIPS DETECTORS				
Area (mm^2)	Resolution keV (FWHM)		Thickness (μm)	Model No.
	α	β		
150	14	9	1000	PD150-14-1000AM
300	16	11	1000	PD300-16-1000AM

PARTIALLY DEPLETED PIPS DETECTORS:

SERIES PD

The PD series of PIPS detectors finds widespread application in *charged particle spectroscopy*. With sizes ranging from 25 mm² to 5000 mm² and thicknesses from 100 to 1000 μm, the PD series is adaptable to a wide variety of physics research and applied physics experiments. Partially-depleted PIPS detectors are normally supplied with our Axial microdot connector (model number suffix-AM) but can be ordered with other connectors at extra cost (see illustrations). Special packages and configurations are also available as are bare chips for use in customer-designed and fabricated systems. Typical operating voltages are 40 V for 100 μm, 60 V for 300 μm, 100 V for 500 μm and 350 V for 1000 μm thick detectors.

SERIES PD OPTIONS (CONSULT FACTORY)

Cryogenic (Prefix CY)

For operation at temperatures as low as -200 °C (77 °K).

Timing (Prefix TM)

Provides improved timing performance by the addition of 200 Å aluminum layer. For example a 450 mm² detector improves from 5 ns to 200 ps (FWHM). This is at the cost of ≈ 4 keV (FWHM) in energy resolution. Available models marked with (*).

Bakeable (Prefix BK)

Packaged to endure bake temperatures up to 200 °C (non-operating).

PARTIALLY DEPLETED PIPS DETECTORS SERIES: PD						
Thickness	100 microns		300 microns		500 microns	
Active Area mm ²	Resolution keV (FWHM)		Resolution keV (FWHM)		Resolution keV (FWHM)	
	α	β	α	β	α	β
25	12	6	11	5	10	4
50	12	6	11	5	11	5
150	14	9	13	8	12	7
300	16	11	15	10	14	9
450	17	12	16	11	15	10
600	22	17	20	15	20	15
900	27	22	22	19	22	17
1200	35	30	25	20	26	21
2000			40	35	35	30
3000			55	50	50	45
5000			80	75	75	70

CAM PIPS DETECTORS: SERIES CAM

The Mirion CAM PIPS detector is a special version of the standard PIPS detector which has features that are very important in applications involving the measurement of alpha (and beta) particles from filters associated with continuous air monitors. The same device is ideal for measuring filter samples off-line. The CAM PIPS detector has aluminum and varnish coatings on the front surface. The aluminum coating allows the detector to be operated in ambient light and the varnish coating provides mechanical protection for the aluminum layer. The total entrance window thickness is less than 2 μm equivalent silicon. For convenience and cost savings the CAM PIPS detector is designed to operate with +15 to +24 V bias. This means that, for most systems, no H.V. bias supply is required. The detector operates from the dc voltage that is normally available to power the electronics in the system. For alphas, the detectors can operate with bias voltage as low as 15 V. With 70 V bias, the beta threshold (noise) is reduced to the levels indicated in the table and full depletion is achieved which ensures uniform response.

CAM PIPS DETECTORS					
Active Area (mm ²)	Resolution (keV)		Det. Bias (Positive)	Beta Threshold (keV)	Model Number
	Alpha	Beta			
300	36		15-24 V	45	CAM 300AM
	33	15	70 V		
450	38		15-24 V	51	CAM 450AM
	34	17	70 V		
490	39		15-24 V	54	CAM 490AM
	35	18	70 V		
600	42		15-24 V	60	CAM 600AM
	37	20	70 V		
900	45		15-24 V	66	CAM 900AM
	39	22	70 V		
1200	55		15-24 V	75	CAM 1200AM
	45	25	70 V		
1700	70		15-24 V	90	CAM 1700AM
	55	30	70 V		
2000	80		15-24 V	110	CAM 2000AM
	65	37	70 V		

Resolution is given for ²⁴¹Am, 5.486 MeV alphas, using standard Mirion electronics and 0.5 μs shaping time constant.

ANNULAR PIPS DETECTORS

These detectors have a 4 mm diameter through hole, and are available in RM mounts only. They are available in Partially Depleted (PD) and Fully Depleted (FD) versions which are 300 microns thick.

Active Diameter (mm)		Resolution keV (FWHM)		Mount Size mm ²	Model Number
Inside	Outside	Alpha	Beta		
5.5	19.5	20	15	300	ANFD300-20-300RM
5.5	19.5	18	14	300	ANPD300-18-300RM

**Consult factory for availability.

MOUNTS AND DIMENSIONS

See chart and drawings. Detector face is recessed 1.0 mm in AM, AB, RM and ABM mounts.

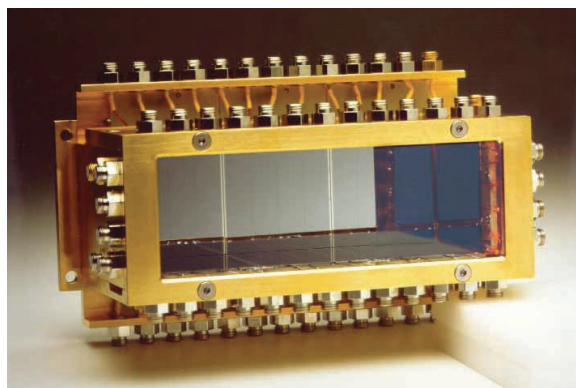
Detector Size (mm ²)	Active Diameter (mm)	Axial X (mm)	Radial X (mm)
25	5.7	16.7	19.4
50	8.0	16.7	19.4
100	11.3	23.6	26.1
150	13.8	23.6	26.1
200	16.0	28.6	31.6
300	19.5	28.6	31.6
450	23.9	32.0	34.8
490	25.0	33.4	N.A.
600	27.6	36.1	38.4
900	33.9	45.2	50.0
1200	39.1	48.8	53.0
1700	46.5	59.0	N.A.
2000	50.0	65.5	70.0
3000	61.8	76.2	80.0
5000	79.8	94.0	N.A.

SINGLE AND MULTI-ELEMENT PIPS DETECTORS: SERIES SMEPS

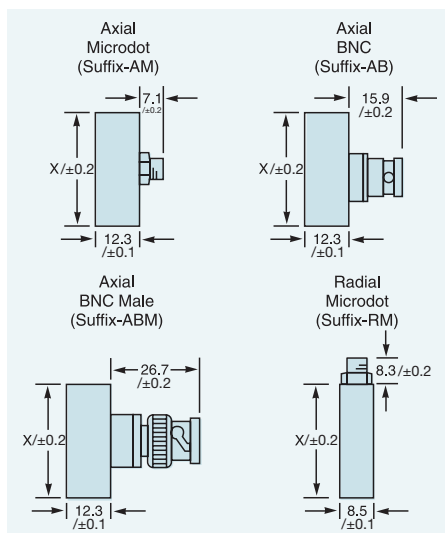
As a result of Mirion's extensive work in Custom Design PIPS Detectors a number of these detectors, called SMEPS Detectors, are available at modest cost without a tooling charge. The Single Element PIPS Detectors are subdivided as one dimensional position sensitive detectors (resistive charge sharing over the implanted junction) and standard rectangular elements.

The Multi-element PIPS Detectors are subdivided into standard pad detectors, thin window pad detectors (<50 nm) and two dimensional position sensitive detectors. These detectors are generally mounted and wire bonded to an epoxy board for the ease of use.

Detailed information on these detectors can be found on the Mirion website under heading PIPS Detectors, Single and Multi-element PIPS Detectors.



This detector assembly manufactured by Mirion and others like it have been used in the discovery of super-heavy man-made elements at the Joint Institute for Nuclear Research in Dubna, Russia, at GSI Darmstadt in Germany, and at the Lawrence Berkeley National Laboratory in California.



Connectors Available

- AM:** Axial Microdot female
- AB:** Axial BNC female
- RM:** Radial Microdot female
- ABM:** Axial BNC male
- AM default for PD, CAM and A-SERIES
- AB, ABM, RM available as option
- RM default for FD series



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