CANBERRA

Passivated Implanted Planar Silicon (PIPS) Detectors

Ker Kemmer may 9 Science

N: 226 p 923

Features

- Ion implanted contacts
- SiO_2 passivated
- Low leakage current
- Low noise
- Thin window
- Cleanable
- Bakeable to 100 °C

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Description

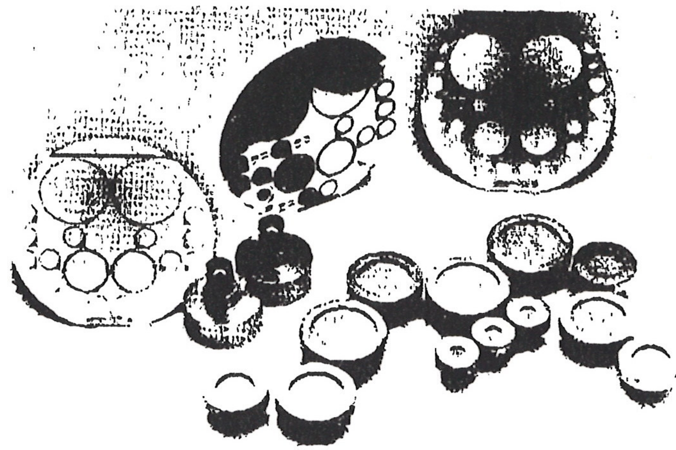
Canberra's new Passivated Implanted Planar Silicon (PIPS) Detector is a product of modern semiconductor technology. In most applications, this detector replaces silicon surface barrier (SSB) detectors and diffused junction (DJ) detectors, both of which are still made the same way they were made in 1960. 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 1/10 to 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 a wide variety of device geometries including multielement rectangular and microstrip detectors. Resistivity of the uniform ion-implanted contact can be controlled accurately to produce position sensitive detectors. Low reverse leakage current translates into low noise contribution, and special versions of the PIPS detector make excellent room-temperature X-ray detectors.

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 dependant 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.

The face contact (entrance window) of the PIPS detector is ion-implanted. Canberra 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	< 500 Å
SSB (Au Window)	≈ 800 Å
SSB (Al Window)	> 2000 Å

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 acetone. This facility makes it possible to exploit applications heretofore reserved to diffused junction detectors which cannot compete with the PIPS in leakage current, resolution or window thickness.

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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 3000 mm² and thicknesses from 100 to 700 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 an Axial BNC connector (model number suffix -AB). Other connectors are available on special order at extra cost (see illustrations). Special packages and configurations are also available as are bare chips for use in customer designed and fabricated systems.

PARTIALLY DEPLETED PIPS DETECTORS SERIES: PD

Thickness	100 microns			300 microns			500 microns			700 microns *		
Active Area mm²	Resolution keV (FWHM) α	β	Model No.	Resolution keV (FWHM) α	β	Model No.	Resolution keV (FWHM) α	β	Model No.	Resolution keV (FWHM) α	β	Model No.
25	12	6	PD25-12-100AM	11	5	PD25-11-300AM	10	4	PD25-10-500AM	10	4	PD25-10-700AM
	14	8	PD25-14-100AM	13	7	PD25-13-300AM	12	6	PD25-12-500AM	12	6	PD25-12-700AM
50	12	6	PD50-12-100AM	11	5	PD50-11-300AM	11	5	PD50-11-500AM	11	6	PD50-11-700AM
	14	8	PD50-14-100AM	13	7	PD50-13-300AM	13	7	PD50-13-500AM	13	7	PD50-13-700AM
100	13	7	PD100-13-100AM	12	6	PD100-12-300AM	12	6	PD100-12-500AM	12	6	PD100-12-700AM
	15	9	PD100-15-100AM	14	8	PD100-14-300AM	14	8	PD100-14-500AM	14	8	PD100-14-700AM
150	14	9	PD150-14-100AM	13	8	PD150-13-300AM	12	7	PD150-12-500AM	12	7	PD150-12-700AM
	16	10	PD160-16-100AM	15	9	PD150-15-300AM	14	9	PD150-14-500AM	14	9	PD150-14-700AM
300	16	11	PD300-16-100AM	15	10	PD300-15-300AM	14	9	PD300-14-500AM	14	9	PD300-14-700AM
	19	14	PD300-19-100AM	18	13	PD300-18-300AM	17	12	PD300-17-500AM	17	12	PD300-17-700AM
450	17	12	PD460-17-100AM	16	11	PD450-16-300AM	15	10	PD450-15-500AM	15	10	PD450-15-700AM
	21	16	PD460-21-100AM	20	15	PD450-20-300AM	19	14	PD450-19-500AM	19	14	PD450-19-700AM
600	22	17	PD600-22-100AM	21	16	PD600-21-300AM	20	15	PD600-20-500AM	19	14	PD600-19-700AM
	24	19	PD600-24-100AM	23	18	PD600-23-300AM	22	17	PD600-22-500AM	22	17	PD600-22-700AM
900	27	22	PD900-27-100AM	25	20	PD900-25-300AM	23	18	PD900-23-500AM	22	17	PD900-22-700AM
	33	28	PD900-33-100AM	30	25	PD900-30-300AM	28	23	PD900-28-500AM	27	22	PD900-27-700AM
1200	35	30	PD1200-35-100AM	30	25	PD2100-30-300AM	28	23	PD1200-28-500AM	27	22	PD1200-27-700AM
	42	37	PD1200-42-100AM	37	32	PD1200-37-300AM	35	30	PD1200-35-500AM	33	28	PD1200-33-700AM
2000	50	45	PD2000-60-100AM	40	35	PD2000-40-300AM	35	30	PD2000-35-500AM	33	28	PD2000-33-700AM
	58	53	PD2000-58-100AM	48	43	PD2000-48-300AM	43	38	PD2000-43-500AM	41	36	PD2000-41-700AM
3000	60	55	PD3000-60-100AM	55	50	PD3000-55-300AM	50	45	PD3000-50-500AM	48	43	PD3000-48-700AM
	70	65	PD3000-70-100AM	65	60	PD3000-65-300AM	60	55	PD3000-60-500AM	58	63	PD3000-58-700AM
5000				75	70	PD5000-75-300AM						
				85	80	PD5000-85-300AM						

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 3000 mm². FD PIPS detectors are cut off-axis to reduce the effects of ion-channeling. 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 1500 Å. The resolution through front contact, with a thickness of 500 Å, is generally better. If timing resolution is of utmost importance, consult the factory for information on special versions.

FULLY DEPLETED PIPS DETECTORS SERIES: FD

THICKNESS	300 microns			500 microns			700 microns *		
Active Area mm²	Resolution keV (FWHM) α	β	Model No.	Resolution keV (FWHM) α	β	Model No.	Resolution keV (FWHM) α	β	Model No.
50	15	8	FD50-15-300RM	15	6	FD50-15-500RM	14	5	FD50-14-700RM
	16	8	FD50-16-300RM	16	8	FD50-16-500RM	16	7	FD 50-16-700 RM
150	16	8	FD150-16-300RM	16	8	FD150-16-500RM	15	7	FD150-15-700RM
	18	10	FD150-18-300RM	18	10	FD150-18-500RM	17	9	FD150-17-700RM
300	18	11	FD300-18-300RM	17	10	FD300-17-500RM	17	10	FD300-17-700RM
	20	14	FD300-20-300RM	19	13	FD300-19-500RM	19	13	FD300-19-700RM
450	22	15	FD450-22-300RM	21	14	FD450-21-500RM	20	13	FD450-20-700RM
	24	17	FD450-24-300RM	23	16	FD450-23-500RM	22	15	FD450-22-700RM
600	24	18	FD600-24-300RM	24	17	FD600-24-500RM	23	16	FD600-23-700RM
	28	21	FD600-28-300RM	27	20	FD600-27-500RM	26	19	FD600-29-700RM
900	29	22	FD900-29-300RM	28	21	FD900-28-500 RM	27	20	FD900-27-700RM
	33	26	FD900-33-300RM	32	25	FD900-32-500RM	31	24	FD900-31-700RM

* Consult factory for availability.

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.

ALPHA PIPS DETECTORS

Active Area (mm^2)	Alpha Resolution keV	Typical Background (counts/day)	Model Number
300	17	4	A300-17AM
	19	4	A300-19AM
450	18	6	A450-18AM
	20	6	A450-20AM
600	23	8	A600-23AM
	25	8	A600-25AM
900	25	12	A900-25AM
	30	12	A900-30AM
1200	30	16	A1200-30AM
	37	16	A1200-37AM

Resolution is given for ^{241}Am, 5486 MeV alphas, using standard Canberra electronics and 0.5 µs shaping time constant.

Beta resolution is 5 keV less than Alpha resolution, and is approximated by pulser line width.

A series detectors are normally supplied with axial microdot connector (model number suffix AM).

CAM PIPS DETECTORS: SERIES CAM

The Canberra 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, which is 0.5 µm thick, is sufficiently light-tight to allow operation of the detector in ambient light. The varnish coating, which is 1.0 µm thick, provides mechanical protection for the aluminum and abrasion and solvent resistance as well. 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.

BETA PIPS DETECTORS: SERIES B

The B series of PIPS detectors is optimized for beta counting and electron spectroscopy. The naturally-thin entrance window of the PIPS detector provides little attenuation for even weak betas but the B-PIPS is especially good in this application because of the extra thickness and low noise of this series. The minimum thickness of B-PIPS detectors is 475 µm. Furthermore, these detectors are cut off-axis to minimize channelling effects. The B-series PIPS detectors are selected for low noise in order to: maximize the realizable efficiency for low energy betas, and to provide good resolution for conversion electrons. Since the minimum discriminator level (below which noise counts are excessive) is about 2.5-3 times the noise measured in (keV) FWHM, the low noise of the B-PIPS is extremely important in helping resolve true beta counts from system noise counts.

BETA PIPS DETECTORS

Active Area	Beta (electron) Resolution keV (FWHM)	Beta Threshold (keV)	Model Number
50	6	18	B50AM
100	7	21	B100AM
300	11	33	B300AM
450	12	36	B450AM
600	16	48	B600AM
900	20	60	B900AM
1200	25	75	B1200AM

Resolution and threshold are measured using standard Canberra electronics with amplifier time constants between 0.5 and 2 µs.

Electron resolution is approximated by pulser width FWHM. Alpha resolution is 5 keV (FWHM) worse than Beta resolution.

B series detectors are normally supplied with axial microdot connectors (model number suffix AM).

CAM PIPS DETECTORS

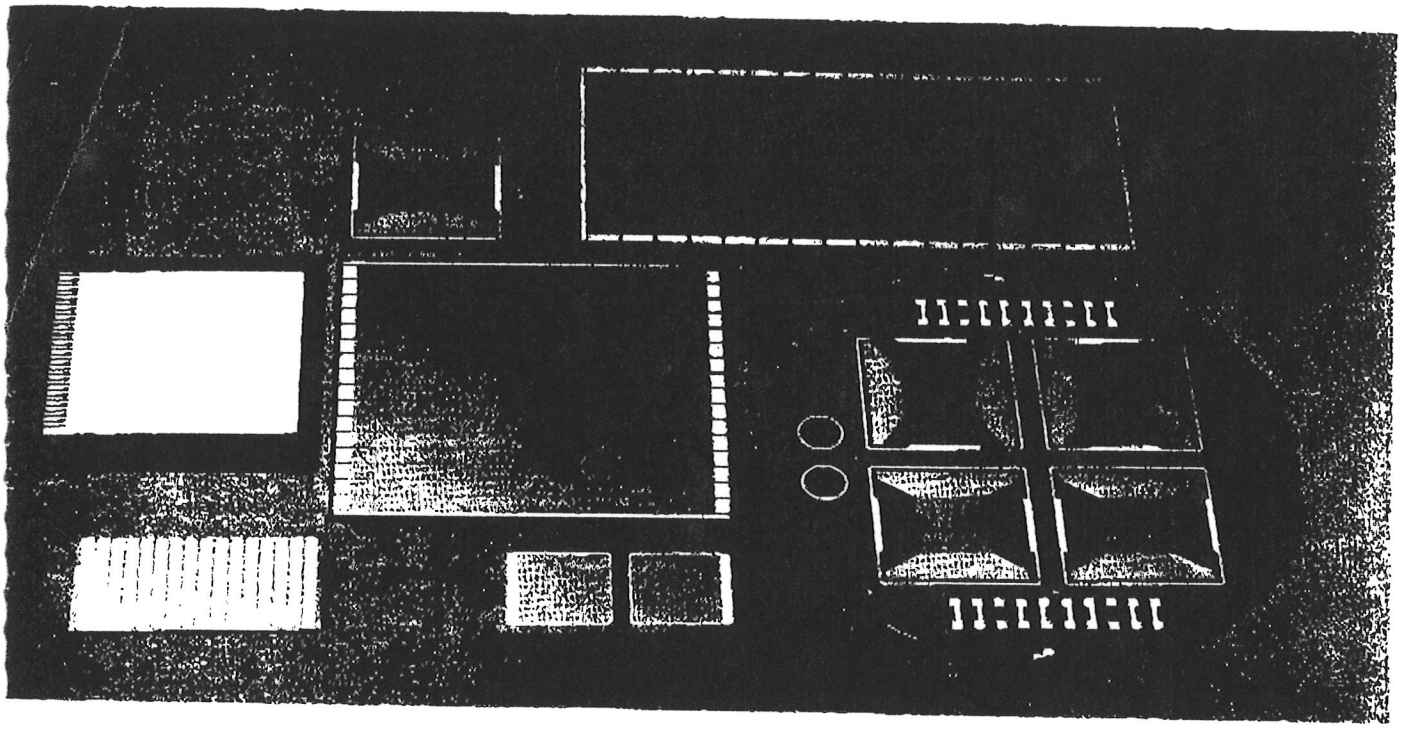
Active Area (mm^2)	Resolution (keV) Alpha	Beta	Det. Bias (Positive)	Beta Threshold (keV)	Model Number
300	36		15-24 V		CAM 300AM
	33	15	70 V	45	
450	38		15-24 V		CAM 450AM
	34	17	70 V	51	
490	39		15-24 V		CAM 490AM
	35	18	70 V	54	
600	42		15-24 V		CAM 600AM
	37	20	70 V	60	
900	45		15-24 V		CAM 900AM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

Resolution is given for ^{241}Am, 5486 MeV alphas, using standard Canberra electronics and 0.5 µs shaping time constant.

STOM DESIGNED PIPS DETECTORS

photolithographic process which is used to define device geome- allows Canberra to fabricate detectors of virtually any shape with ensions approaching 90 mm diameter. The ion-implantation proc- lends itself to the production of strips or resistive contacts which e possible position sensitive detectors. Since our PIPS detectors intrinsically passivated, no epoxy edge encapsulation is needed the basic PIPS chip can be efficiently packaged in space saving figurations by Canberra or by end-users.

Some of the variety in custom designed PIPS detectors is illustrated in the following images. Consult the factory or your local sales representative with your requirements if they cannot be met with the standard product.



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.