MICRON SEMICONDUCTOR

SILICON DETECTORS OF THE 1990's

MICRON - C.D. Wilburn

SILICON DETECTORS FOR 1990's

with 'TECHNOLOGY DEMANDS'

MICRON SEMICONDUCTOR
1983 INCORPORATED

HEP DOMINATES MICRON BUSINESS

CURRENTLY	9 CONTRACTS	CERN
	8 CONTRACTS	FERMI LAB

PRIVATE COMPANY U.K. BASED

PLUS U.S.A. MARKETING COMPANY

NO GOVERNMENT SUPPORT

TECHNOLOGY:

ION IMPLANTATION STRUCTURE

3" TECHNOLOGY (SILICON)

4" TECHNOLOGY (SILICON)

OTHER BUSINESS

HEAVY ION PHYSICS

SPACE PHYSICS

MICRON SEMICONDUCTOR

LATEST DEVELOPMENTS IN SILICON DETECTORS

U.K. BASED COMPANY / OPERATES FULLY TRACEABLE MONITORED QUALITY CONTROL

SUPPLIED APPROXIMATELY 50 DESIGNS TO PHYSICS MARKET

TECHNOLOGY 3" AND 4"

CAPABILITY: DETECTORS Several 100/Month. PHOTODIODES Several 1000/Month

Single Area: 0.1mm^2 - 25cm^2 (3")
0.1mm^2 - 50cm^2 (4")

Ring Counters with central hole to 9.6cm 0

Gamma Transient Detectors
Microstrip Detectors

Pitch 10μ to 1cm
Channels 5 to 2000

Thickness 150μ, 300μ*, 500μ
Response Time < 10nS

* Leakage Current 6nA/cm^2 Capacitance 40pF/cm^2

Single Sided and Double Sided

Integration with VLSI Electronics

Paralleled and Daisy Chained

FAN-OUT ON-CHIP / PCB / CERAMIC

Acceptance Levels: 99% - 100%

PIXEL Detectors
Ring Counter Format 384 Pads
Ceramic Overlay / Particles through back
Charge Injection Devices (Indium Bump)
256 x 256 (30μ PIXELS) and 12 x 66 (75μ PIXELS)
Designed to Interface Hughes RAM MICROCHIP with same pixel format

SILICON PHOTODIODES
0.1cm^2 - 2.5cm^2 Id 1nA/cm^2 to 2nS
High Speed 1 Large Area / Low Series Resistance / Low Cost

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PACKAGING / ASSEMBLY MATERIALS
FOR
SILICON DETECTORS

PCB MATERIAL G 10 or G 30

Minimum Track Width	40µm
Minimum Pitch	100µm
Maximum Size	40cm x 40cm

KAPTON

Minimum Track Width	70µm
Minimum Pitch	150µm
Maximum Size	40cm x 40cm

CERAMIC

Minimum Track Width	10µm
Minimum Pitch	20µm
Maximum Size	15cm x 15cm

KEVLAR

Minimum Track Width	70µm
Minimum Pitch	150µm
Maximum Size	40cm x 40cm

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DETECTORS FOR 1990's

MICROSTRIP DETECTORS

SINGLE SIDED

	2048 Ch	25µ PITCH	300µ
*	520 Ch	10µ PITCH	150µ

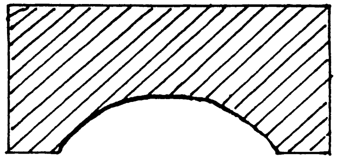
Both Active and Inactive FAN-OUT

PROFILED DETECTORS (ZEUS)

Instead Straight Edge

Edge Termination $\frac{X^2}{a} - \frac{Y^2}{b}$ (ELLYPSE)

SINGLE SIDED (HIGH RATE) CLOSE CUT



800Ch
45°

300µ

Edge < 500µ

ELECTRONICS - SANTA CRUZ
(Dielectric Isolated VLSI)

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DOUBLE SIDED MICROSTRIP DETECTORS

for 1990's

5 DESIGNS TO DATE

1988	1.	RING COUNTER DESIGN S	Heidelberg / CERN
1988	2.	MICROSTRIP 40 x 40 x 1mm	LEAR / CERN
1988	3.	MICROSTRIP 50 x 50 x 3mm	Edinburgh / SERC Daresbury
1989	4.	MICROSTRIP 50 x 50 x (25μ & 50μ)	BCD / FERMI LAB
1989	5.	MICROSTRIP 16 x 32 x 2mm (A/c)	UA2 / CERN

Problems

Yield

Uniformity of Characteristics

Manufacturing Control

Silicon Handling

Interstrip Impedance on Ohmic Side

AC or DC Coupling

Radiation Effects

Testing

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DOUBLE SIDED DETECTORS

Necessary to bias all strips during testing.

Assembling devices prior to Test too costly.

Micron have developed 'Double Sided' computerised probe station for coarse detectors and will enlarge this for fine strip devices.

Probe station gives rapid control and feedback of processing for these difficult devices.

Double Sided Microstrip Detectors are a Triple Implant Device

(1) Junction Strips

(2) Ohmic Strip Isolation

(3) Ohmic Strips

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SILICON PIXEL DETECTORS

During 1988 MICRON built 2 DESIGNS for SLAC for SSC DEVELOPMENT

(1) 10 x 64 120μ PIXELS

(2) 256 X 256 30μ PIXELS

Designed to Interface with HUGHES PIXEL ELECTRONICS built for INFRA-RED SYSTEMS and operate on U.C. Berkeley Test Facility.

STATUS

Both devices assembled via INDIUM BUMPING
Detectors at Berkeley, Space Science Lab.

10 x 64 resolving Minimum Ionising Betas (2MeV) with Oscilloscope S/N > 10:1

256 x 256 ready for first Beta Test.

Radiation Hardness

10 x 64 Claimed to be RAD HARD (1 M.RAD Co60?)

256 x 256 not RAD HARD, but RAD HARD version is now funded by SLAC to HUGHES (August 1989)

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PIXEL DETECTORS

Pixel Electronics Studies EUROPE

CERN Heinje/ Jarron 200μm

RUTHERFORD Sharp / Seller 200μm

Pixel Collaboration U.S.A.

SSC Proposals

D. Nygren / N. Lockyer / G. Trilling / Hughes

Santa Cruz / Berkeley / Cornell

'Architecture for High Speed, High Rate Systems'

Limitations

Small Size $1cm^2$ Indium Bump / Pressure Limits

Larger 'In'Solder Pads

Advantages

High Radiation Damaging Environments
Individual Pixels Damaged / Knocked out but sufficient numbers remain to collect and analyse data usefully. If damage rate high pixel should be small. S/N Min. Ionising needs to be high.

Future Physics

If successful EXPERIMENTS will most likely use some PIXELS along with MICROSTRIPS which will still carrry most of the AREA coverage.

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RADIATION DAMAGE EXPERIENCE

EXPERIMENT CERN UA2
PHYSICIST: CLAUS GOSSLING
HADRONS: PROTONS with 15% NEUTRONS

OUTER DETECTOR	7 PAD ARRAY	6cm x 4cm	300µm
DESIGN I	LEAKAGE CURRENT (FD) 100nA typ.		
1 METRE²	FULL DEPLETION (FD) 30 VOLTS		
INNER DETECTOR DESIGN DD	16 Ch. ARRAY	16.4mm x 32mm	300µm
OPERATIONAL	1 Year with Off-Periods		
Damage	1nA/cm² / 100 Rads		
Total Dose	100K Rads		
	Some Design I received 30K RAD during beam alignment		
Electronics Inner	AMPLEX 16Ch CMOS VLSI IMEC (P. Jarron Design)		
Outer	8 Ch. Hybrid. 0.8 µsec Shaping		

EXPERIMENT E653

PHYSICIST BYRON LUNDBERG (Radiation mask

Reported Similar Damage results UA2

RADIATION DAMAGE IN INNER ARRAY 1988

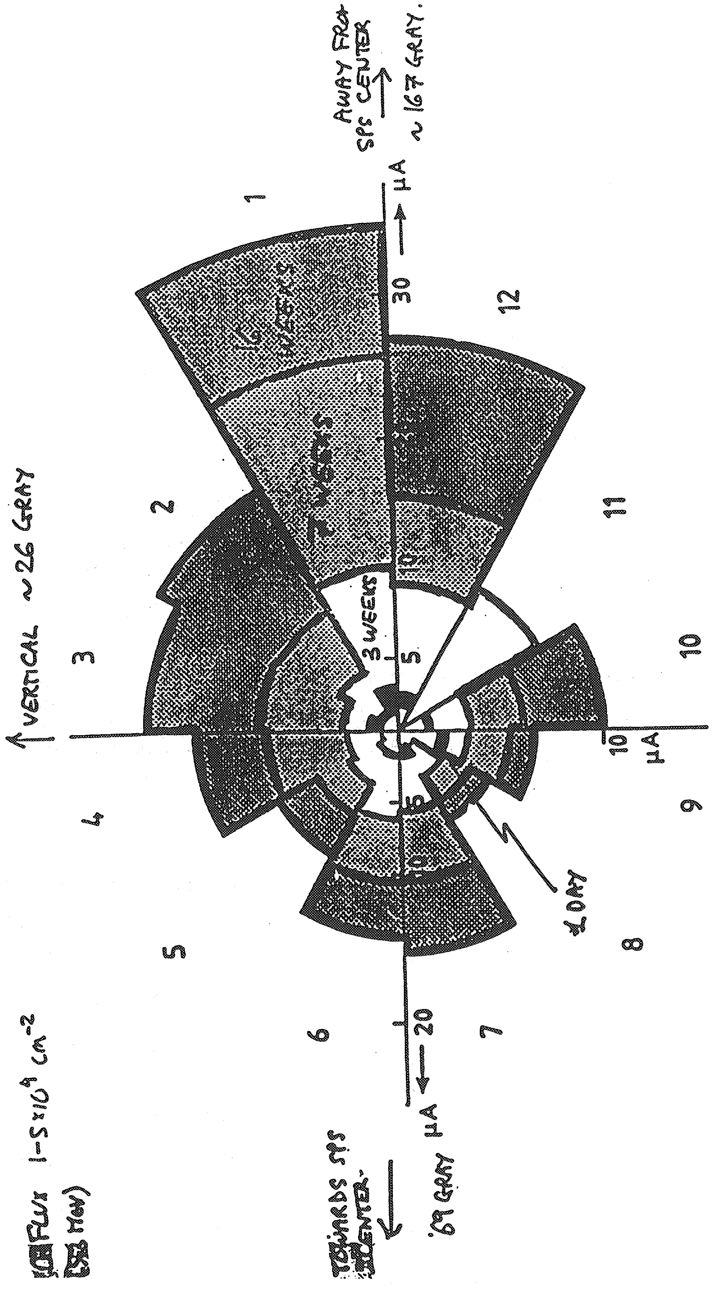

Fig. 11

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CURRENT RADIATIION EXPERIENCE

NEUTRONS $10^{12}/CM^2$

REACTOR (14 MeV)

3 Test Detectors FD ≃ 50V OP.V. 80V

Exposure ≃ 10^{12} neutrons/cm² (≅ 1 Year SSC)

I LEAKAGE (BEFORE)	I (AFTER)	I(AFTER 3 MONTHS)
1.7nA	680nA	125nA
2.0nA	690nA	120nA
2.5nA	700nA	118nA

RISE TIME (B)	FALL TIME(B)	RISE TIME(A)	FALL TIME (A)
2.2nS	3.0nS	2.2nS	3.0nS
2.6	4.6	2.5	4.2
2.5	4.0	2.5	4.4

RESPONSIVITY (0.85µm) (B)	RESPONSIVITY (0.85µm) (A)
1	0.89

Capacitance and Breakdown Voltage

NO CHANGE

ANNEALING
85°C 80V

I LEAKAGE ≃ 50nA

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RADIATION DAMAGE EXPERIENCE

EXPERIMENT: FERMI LAB E789

PHYSICIST: JOHN KAPUSTINSKY 'LANL'

LANL TEST AUGUST 1989

SILICON MICROSTRIP DESIGN B
5cm x 5cm
1000 Channels
50 Micron Pitch
Thickness 300µm
Full Depletion 40 Volts
Total Current 2µA

RADIATION

High Rate bursts of 300nS 800MeV PROTONS
Run Times 2 Hours and 12 Hours
Total Dose 1×10^{14} PROTONS
Event Rate: 5×10^7 PROTONS/cm²/sec and 10^8 PROTONS/Cm²/sec
Ambient AIR

DETECTOR (20°C)

Leakage Current / Strip increased 8nA - 200nA
Optimum Operating Voltage increased 60V to 150V
Additional Current only present when Beam on
Higher on Outer Strip and level proportion to Beam intensity

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SILICON STRIP BEAM TESTS
AT LOS ALAMOS

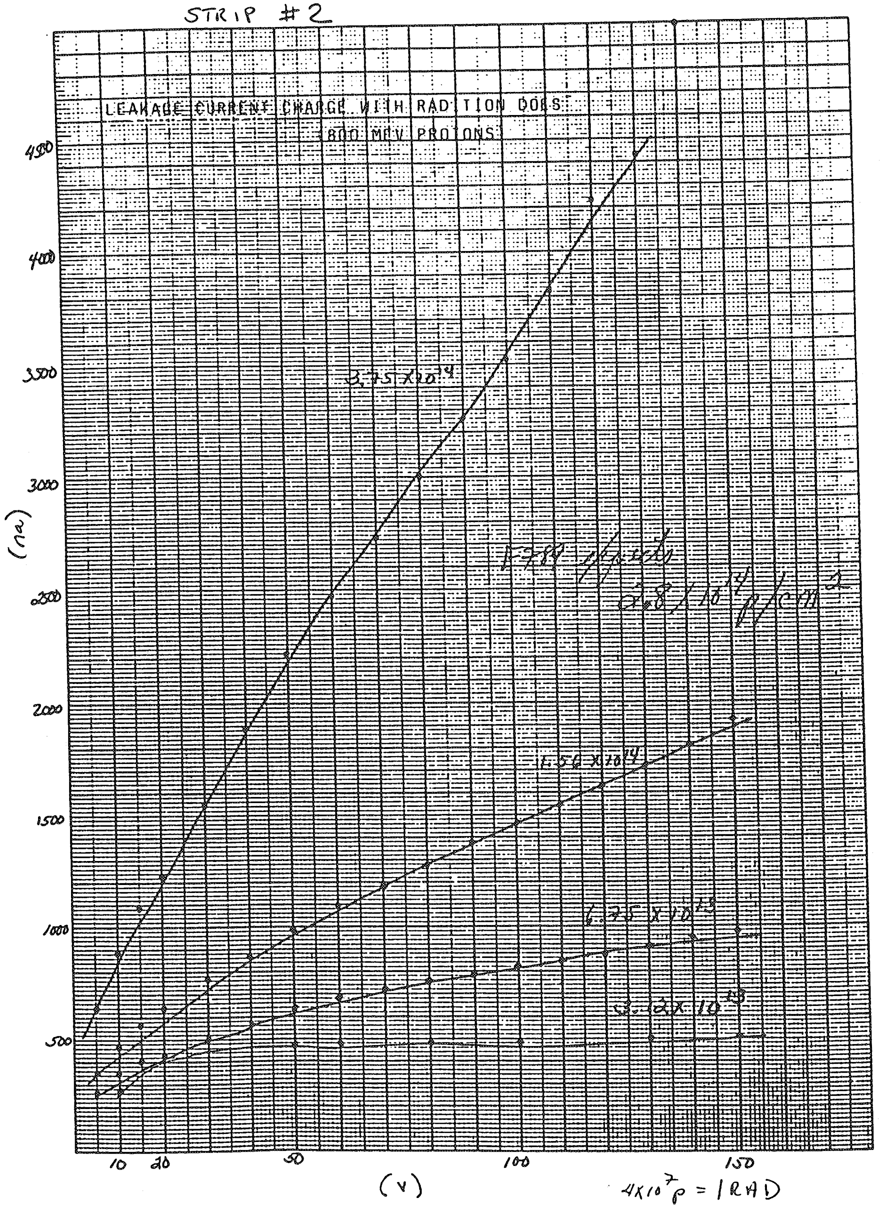
(8/1 - 8/13/89)

MICRON TYPE B W / and Plane

10 HIGH INTENSITY EXPOSURES OF 800 Me V/C PROTONS

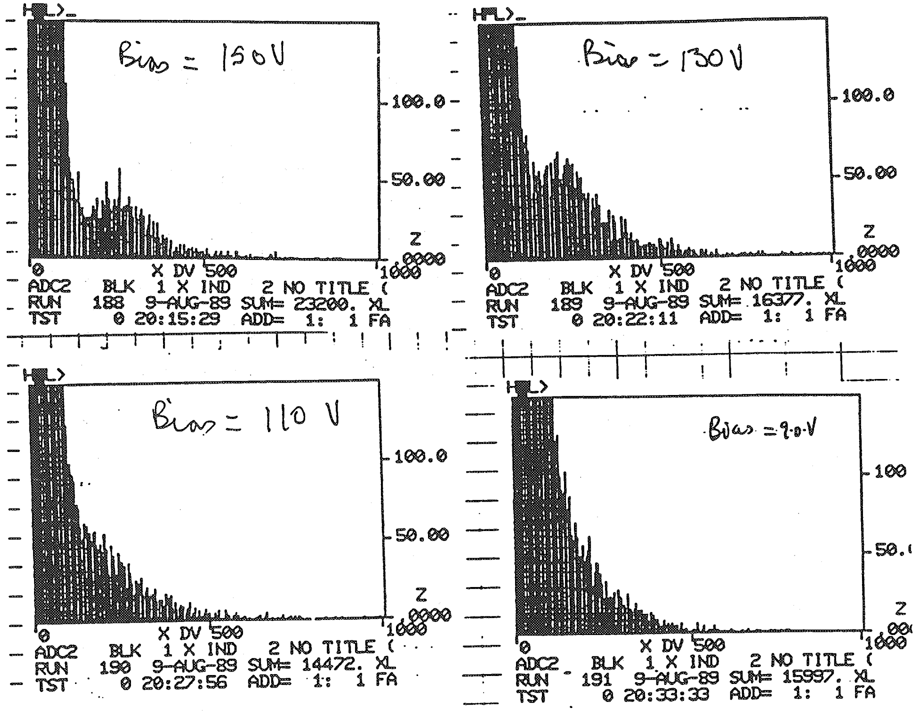
1.	1.82×10^{12}	2 Hrs	2.5×10^{8} Ptm^{2} .5	ON
2.	1.86×10^{12}	2 Hrs	"	ON
3.	1.86×10^{12}	2 Hrs	"	OFF
4.	8.77×10^{12}	14 Hrs	1.7×10^{8}	ON
5.	9.29×10^{12}	14 Hrs	1.8×10^{8}	OFF
6.	9.29×10^{11}	5 Hrs	5.2×10^{8}	ON
7.	9.29×10^{11}	5 Hrs	"	OFF
8.	2.81×10^{13}	10 Hrs	8.0×10^{8}	OFF
9.	7.62×10^{13}	19 Hrs	1.0×10^{9}	OFF
10.	1.75×10^{14}	9 Hrs	5.4×10^{9}	OFF
	4×10^{14} P/cm^{2}			

10 Megarad Total Exposure



after irradiation 2 10^{13} p's/cm^2

Minimum Ionising Pulse to Applied Bias Voltage



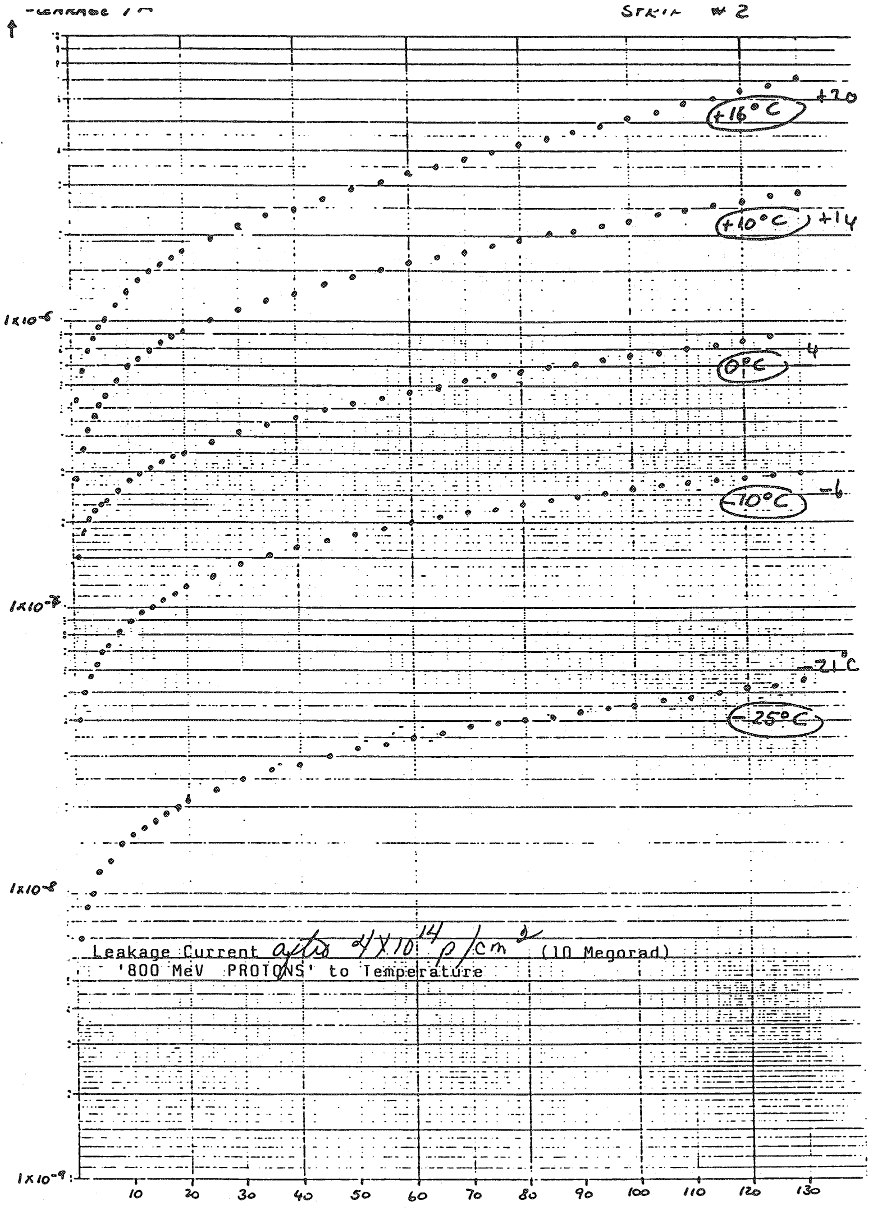
```
ADC2    BLK  1 X IND   2 NO TITLE (
RUN   188  9-AUG-89 SUM= 23200. XL
TST      0 20:15:29  ADD=  1:  1 FA
```

```
ADC2    BLK  1 X IND   2 NO TITLE (
RUN   189  9-AUG-89 SUM= 16377. XL
TST      0 20:22:11  ADD=  1:  1 FA
```

```
ADC2    BLK  1 X IND   2 NO TITLE (
RUN   190  9-AUG-89 SUM= 14472. XL
TST      0 20:27:56  ADD=  1:  1 FA
```

```
ADC2    BLK  1 X IND   2 NO TITLE (
RUN   191  9-AUG-89 SUM= 15997. XL
TST      0 20:33:33  ADD=  1:  1 FA
```

ADC of a single strip



Leakage Current after 4X10^{14} p/cm^2 (10 Megorad)
'800 MeV PROTONS' to Temperature

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SILICON PHOTODIIODES

Micron Semiconductor is manufacturing a wide range of 'LOW COST' SILICON PHOTODIODES.

Standard and Thin Window Implants are shown.

The Standard Window is ≃ 0.5µm

The Thin Window is ≃ 0.1µm

Detector / Photodiode all depleted structure also available.

Typical Q.E. characteristic is shown next.

I dark Current - 1nA / cm²

Capacitance (150µm) ≃70pF

Capacitance (300µm) ≃40pF

Suitable for (Scintillation Interfacing'.

QUANTUM EFFECIENCY VS. WAVELEHCTH FOR VARIOUS TYPES
OF 100MM.SQ OPTICAL DETECTORS
DEVICES:HAMMAMATSU,MICRON(OLD) MICRON(NEW) detectors.