Feb 96 Beamtest at KEK (T383)

- First Results from the execution on Feb. 7-14, 1996 -

Y. UNNO
Physics, KEK
e-mail: unno@kekvax.kek.jp

for

HKKLMOIS Collaboration [1]

Main contributor of the analysis:

Kazuki FUJITA
Graduate student of Hiroshima Univ.

[1] Hiroshima-KEK-Kyoto Edu-Okayama-LBL-Melbourne-UCIrvine-UCSantaCruz Collaboration

Motivations

- First beam test of the ATLAS spec Hamamatsu n-on-n detector ("nn75AC")
- Also, the first beamtest of an proton-irradiated "nn75AC" detector (1.2×10^{14} p/cm^2)
- Rϕ-style module layout, 12cm detector length (=2×6cm detector)
- Binary-readout Frontend electronics
  - Irradiated FEE chip: Hybrid to be irradiated being mounted on the detector. This was unsuccessful due to an accident... Sorry.

Detector-Module

- 5 detector-modules

	UCSC1	ATT2	ATT4	UCSC2	LBIC2
Detector	**Hamamatsu**	**LBL**	**Hamamatsu**	**Hamamatsu**	**LBL**
Type	**AC**	**DC**	**AC**	**AC**	**DC**
Pitch [μm]	**50**	**75**	**75**	**75**	**75**
Readout	**n**	**p**	**n**	**n**	**p**
Bulk	**n**	**n**	**n**	**n**	**n**
Irradiation	**non**	**non**	**1.2×10^{14} p**	**non**	**non**
Strip length [cm]	**12/6**	**12**	**12**	**12**	**12**
Stereo	**- -**	**- -**	**- -**	**- -**	**40 mrad**
FEE	**LBIC**	**CAFE**	**CAFE**	**LBIC**	**LBIC**

Proton Irradiation

- 12 GeV protons from the KEK 12 GeV PS into EP1-A beamline

- Irradiation on 1995/11/22, 1.2×10^{14} protons/cm^2 (nominal), in a cold box (6°C)

- Accidents:

(1) Air circulation fan failed in the box (when being stored in the beamline), detectors were warmed up at 25 to 35 °C for 8 days. Fortunately, we had the best beneficial annealing in the warm-up time...

- Expected full depletion voltage (Calculation based on H.Ziock)
- Full depletion voltage measurement of the same detector irradiated at the same time.

(2) Killed CAFE chips by accidentally "zapping" by applying the detector bias voltage to the chip during the preparation of the irradiation. The detectors were warmed up again during the hybrid repairing and gluing...

- Full depletion voltage would be very high (~300V?). If fully anti-annealed, ~460V expected.

Detector Arrangement in the beamtest

- Limited readout area
- Relative alignment was fixed by using the beam data
- Data taken for

  - Beam position at +30 mm (through the ceramic hybrid area), +55mm, 0 mm
  - Rotation angles at 0°, ±14°, -18°, -7°
  - UCSC1 rotated 90° for evaluation of the edge insensitive area
  - Bias voltage frequently over 200V, to 250~280V!

- Cooling - Gas N_2 flow from the evaporated LN_2, -5~0°C operation, ~ -20°C possible...

General Features

- Leakage currents
  - Over mA in the irradiated detector (12 cm) as expected
  - Observed thermal runaway at 280V! (~0°C, air cooling only!)
    SECOND OBSERVATION! and FIRST! in a LIVE detector
- Cluster-center correlation
- Cluster-center difference - confirms good mechanical setting after all... (Thanks to our engineer, Takashi KOHRIKI)
- Determined alignment parameters - TRUE angles were slightly different from the setting angle because of the setting of the shield/cold box.

Efficiency - Median Pulse Height

- Analysis so far for the normal incidence, i.e. 0°. All tools (i.e., analysis programs) are available; just a matter of time for other angles... (Somebody says, "Do excuse when you can")

- Threshold scan - Bias voltage dependence

  - DUT's are UCSC2, ATT4, ATT2

- Bias voltage dependence of the median (mean of the error function fitting) pulse height

  - UCSC2 (non-irradiated n-readout on n-bulk) saturate at ~ 120V

  - ATT2 (non-irradiated p-readout on n-bulk) saturate similarly

  - ATT4 (irradiated, n-readout on (inverted) p-bulk) as expected; partially depleted...

- Caution: Calibration (threshold mV to Charge fC) is yet preliminary!

Noise Occupancy
- Beam Triggers -

- Threshold scan for high thresholds, 0.8 ~ 4 fC

  UCSC2, ATT4, ATT2

- Two components of the noise

  - Below 1fC, looks like the electronics thermal noise

  - Above 1fC, other component

  - Occupancy (due to the thermal noise) is a few times 10^{-4} at 1fC threshold

Thermal Noise

- Random triggers
- Threshold scan for low thresholds, 0.2 ~ 1.0 fC
- Error function fit to obtain (1) noise sigma, (2) pedestal
- Bias voltage dependence of the noise sigma
  - All for 12cm strips (UCSC1-6cm is only a 6 cm strip)
  - The figure is for data presentation. The mV-fC conversion is different for different detectors! This figure will have meaning when transformed into fC.

Pedestal Consistency Check

- Pedestal of the electronics can be obtained by "calibration", i.e., injecting known charges into the FEE. Result is the "calibration curve" of mV-fC conversion, and extrapolating to "null" charge point.

- Another way of obtaining the pedestal is the threshold scan with random triggers. Fitting the error function gives the pedestal as the mean. The result of the fitting is, I think, satisfactory...

Edge Insensitive Region

- A detector has
  - an inactive edge region surrounding the detector (1~1.2 mm)
  - More over, AC-coupling detector has a bias resistor to a strip where an AC-coupled electrode does not exist over the strip implant (300μm)

- Measurement of the insensitive area
  - 90° rotated UCSC1, 50μm pitch scan over the boundary
  - Strip coincidence of the UCSC1 and other detectors
  - Consistent with 2.0 mm gap. Unfortunately, the UCSC1 had a dead region around the strip 260 where one edge (with the bias resistor) lied...
  - Suggesting the signal to the implant underneath the bias resistor is sensitive to the electrode

Microdischarge Noise?

- Observed a noise increase over a bias voltage coincidencing the increase in the leakage current, around 180V in the non-irradiated detector

- The noise and the leakage current appeared and diminished as the bias voltage was increased and decreased, thus having a non-destructive nature, consistent with the avalanche breakdown (i.e., we call "microdischarge")

- A hit map shows the noise is local, possibly generated at one strip, spreading noises in neighbors

- The number of strip affected is less than 10 strips

Remaining Analysis

- Non-zero angle data for efficiency-median pulse height - 7°, 14°, 18°
- Pulse height position dependence - 0 mm, 55 mm
- Resolution

Conclusion

- The n-on-n 75μm pitch Hamamatsu detector has been successfully operated
- The 1.2×10^{14} p/cm^2 proton irradiated n-on-n detector works, cooled $\leq 0°C$, bias voltage up to 280V where we have started to observe the thermal runaway (under air cooling condition).
- Successful high voltage operation nearly 300V for both non-irradiated and irradiated detectors.
- No humidity control. Dry N_2 gas, but, occasionally we opened the box and the detector surface certainly fogged. Nothing happened for operations for over 200V operation.
- Efficiency, pulse height, noise as expected. No surprise.
- Underneath the bias resistor seems still sensitive
- Confirmed the microdischarge at 180V is local