GLAST Large Area Telescope
Calorimeter Subsystem

5.1 Dual PIN Photodiode

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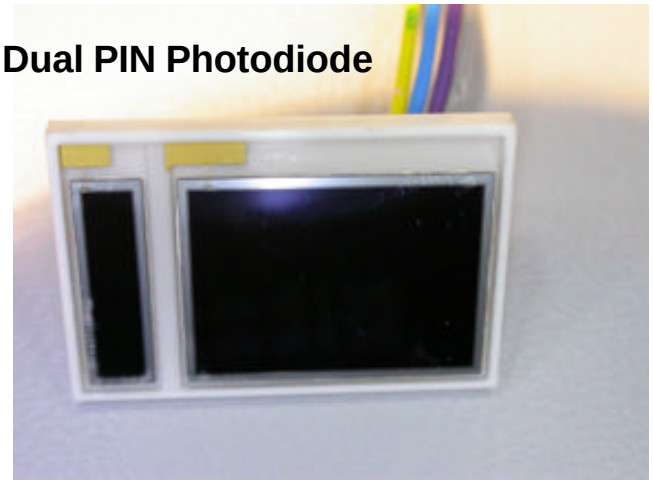
DPD Outline

- Goals and History
- Responsibilities and Status
- Requirements
- Changes from EM to FM
  - Highlight: Optical Window
- Qualification Program
- Procurement
- Schedule

Goals and History

- Requirements on DPD are linked to the performance of the CDE and ultimately CAL
  - Collects the light from energy depositions in the CsI (SIGNAL)
  - DPD electrical characteristics (capacitance and dark current) affect the front end electronics NOISE
  - Desire is to maximize SIGNAL/NOISE

CAL EM Dual PIN Photodiode



7 years of DPD development

NASA ATD Program

Commercial PIN

PIN Diode	Dates	Optical Window Material	Silicon Die thickness (um)	PIN A Area (mm^2)	PIN B Area (mm^2)
S3590	1/1996 – 12/1998	Hard epoxy resin		n/a	100
S3590-08 SPL	2/1999 – 10/2001	Hard epoxy resin	200	24	96
S8576	1/2001 -	Hard epoxy resin	300	25	152
S8576-01	2/2003 -	Silicone resin	300	25	147

EM DPD

Flight DPD

Responsibilities and Status

- FM Requirements and Specs – joint responsibility of NRL and CEA
  - Worked closely with Hamamatsu in USA and Japan
- FM Procurement – joint responsibility of NRL and CEA.
  - CEA contributions
    - qualification and acceptance screening of all DPD
    - procurement of ~$200K (USD) in flight diodes
  - NRL contributions
    - overall management of the effort,
    - coordination and negotiation of the specification, and
    - procurement of the residual flight diodes (~$400K)
- FM Status
  - Specification is complete: LAT-DS-00209-12
  - Successful Procurement Readiness Review: 13 Feb 03
  - Qualification program will begin June 03
    - Evaluation of pre-production FM DPDs in progress now

DPD Requirements

- CAL Flight Dual PIN Photodiode Specification, LAT-DS-00209-12
  - Electrical and Optical Requirements
    - Area, sensitivity, dark current, capacitance, bias voltage
  - Ceramic Carrier Requirements – mechanical
    - Dimensions and tolerance control, electrical leads
  - Manufacturing Requirements
    - Die attach, wire bonds, optical window encapsulant
  - Product Assurance Requirements – Qualification and screening
  - Environmental Requirements
  - Deliverables – Documentation and data package
  - Shipping and handling
  - Acceptance Criteria
- Crystal Detector Element Specification, LAT-SS-01133-02
  - DPD bonding to CsI
  - Electrical lead treatment and positioning

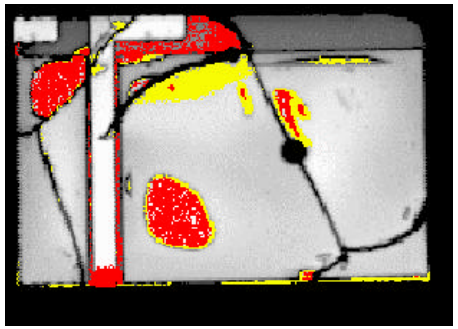
Changes from EM to Flight DPD

- **Several changes have been made based on EM lessons**
  - **Ceramic carrier size: S8576-01 carrier is 1 mm smaller in width and length**
  - **PIN B silicon die active area: S8576-01 die is 0.5 mm smaller in one dimension (~3%)**
  - **Electrical lead positions have been moved**
  - **Electrical leads shall be tinned by Hamamatsu prior to assembly of the silicon die to the carrier**
  - **Optical window encapsulant is changed to Shin Etsu KJR 9022E silicone resin**
  - **Shipping container has been modified to provide ESD protection and to protect the electrical leads from bending**

Let's talk about this one

Optical Window Issues

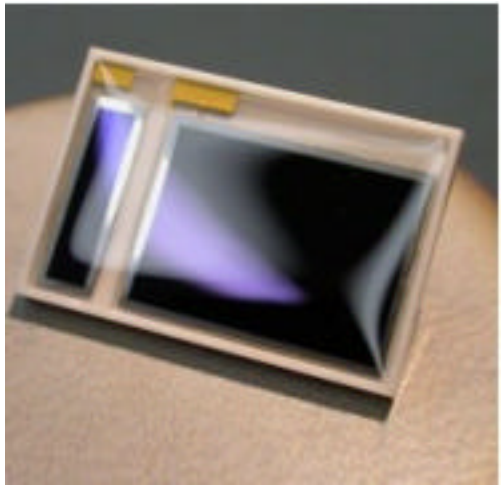
- **The problem with EM**
  - Hard epoxy window of EM S8576 could not withstand thermal cycling (-30C to +50C, 100 cycles)
    - Extensive testing program in France and US
      - ~650 units used in bonding, thermal, optical, etc. studies
    - "Microcracks", severe cracks, delamination
      - Latter two could cause electrical failure
  - But otherwise it worked well
    - Bonds to crystal were excellent and exceeded specs
      - Mechanical strong
      - Thermally stable
      - Optically clear



Acoustic microscopy of failed window

- **The solution for FM**
  - Make the window flexible: ShinEtsu silicone

Optical Window Verification



- Verification program for ShinEtsu window
  - Report LAT-TD-1476-01
  - Tested performance of commercial PDs and sample EM DPDs with ShinEtsu window
    - Thermal stability of window
      - No cracks or delam at up to 180 cycles
    - Out-gassing
      - After bake-out, passes Mass Loss and Condensible Volatiles requirements
    - Bond compatibility
      - Forms fully-cured, strong bonds with optical adhesive for CsI(Tl)
    - Optical properties
      - Light yield: ~90% of hard epoxy
      - Thermal stability of optical bond: No significant loss of light after >100 cycles
    - Mechanical strength of bond
      - Tensile strength: >160 N (spec is >10 N)
      - Shear strength: >0.80 N/mm^2 (spec is >0.12 N/mm^2)
  - Conclusion: DPD with ShinEtsu silicone window still exceeds specs

Qualification Program

- Qualification program for FM DPDs is responsibility of CEA
  - Begins June 03
  - Discussed in agenda item 5.3
  - Principle tests
    - Solderability of leads
    - Moisture uptake
      - ShinEtsu window
    - Thermal cycling
      - stability of ShinEtsu window
    - Operating lifetime
    - Radiation hardness
  - Tests of pre-production samples are in progress now
  - Expect no issues

Procurement Quantities

Level	Operation or Loss Process	Loss %	Loss Count	TOTAL CNT
CDE	**Required CDE for Flight**			**1728**
	Flight Spares	6.4%	110	1838
	CEA Delivery to NRL			**1838**
	Acceptance Test Failures	1.0%	19	1857
DPD	**DPD for CDE Acceptance Test**			**3714**
	Bonding Process Fallout	10.0%	413	4127
	PhotoDiode Assy Fallout	2.0%	84	4211
	Solder/Stake Failures	1.0%	43	4254
	Spare DPD	2.0%	87	4341
	Electrical Screening Fallout	1.0%	44	4385
	Dimensional Fallout	1.0%	44	4429
	Lot Acceptance Test	1.0%	45	4474
	DPD Qualification		60	4534
	DPD Evaluation		48	4582
	Bonding Process Development		100	4682
	TOTAL DPD Requirement			**4682**

Deliveries in quantities of 600 DPD

Schedule

- First flight deliveries needed June 2003. Hamamatsu requires 3.5 months to manufacture.
  - First two months of manufacturing are for fabrication of the ceramic carriers. Assembly and test of the DPD are the remaining time.
- Deliveries are based on 600 diodes at 5 week intervals for the first four deliveries and 3 week intervals for the remaining four deliveries