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GLAST LAT SYSTEM SPECIFICATION	Document # **LAT-DS-00209-03**	Date Effective 28 July 2002
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	Subsystem/Office Calorimeter Subsystem	
Document Title **Specification for the CAL Dual PIN Photodiode Assembly (Flight Units)**		

Gamma-ray Large Area Space Telescope (GLAST)
Large Area Telescope (LAT)
Specification for the Calorimeter Dual PIN Photodiode Assembly (Flight Units)

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
03	28 July 2002	Incorporate changes and agreements from 18 July 2002 meeting in Paris	

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1 PURPOSE

This document specifies the mechanical, optical and electrical characteristics of the PIN photodiode assembly for the Calorimeter (CAL) subsystem of the GLAST Large Area Telescope (LAT). This assembly consists of a ceramic substrate containing two Silicon PIN photodiodes and is named Dual PIN Photodiode (DPD). The optical window of the DPD is encapsulant with optical epoxy resin with an Anhydride catalyst.

2 SCOPE

This specification establishes the requirement for flight DPDs to be used in the Calorimeter subsystem of GLAST LAT. A total of 4500 DPDs are required for the flight instrument and spares.

These DPD shall be tested (screening and qualification) and inspected as per the requirement established herein. Hamamatsu will define process controls and manufacturing methods for the flight DPDs as per Appendix A, prior to finalization of contract. The details of the manufacturing and quality controls for the flight procurement are defined herein.

3 DEFINITIONS

3.1 Acronyms

CAL	The Calorimeter subsystem of the LAT
CEA	Commissariat à l’Energie Atomique
CsI (Tl)	Cesium Iodure (Thallium doped) crystal
DPD	Dual PIN Photodiode
EM	Engineering Model
FM	Flight Model
GLAST	Gamma-ray Large Area Space Telescope
GSFC	Goddard Space Flight Center, NASA
LAT	Large Area Telescope
NASA	National Aeronautics and Space Administration
NCR	Non Conformance Report
LAT	Lot Acceptance Tests
KIP	Key Inspection Point
MIP	Mandatory Inspection Points
FIT	Failure In Time
PAM	Product Assurance Manager

SEM	Scanning Electron Microscope
S/N	Serial Number
RFW	Request For Waiver
DPA	Destructive Physical Analysis
TBR	To Be Resolved
TBC	To Be Confirmed

3.2 Definitions

γ	Gamma Ray
µsec, µs	microsecond, 10^{-6} second
nm	Nanometer
µm	Micrometer
mm	Millimeter
cm	Centimeter
hPa	HectoPascal
°C	Degree Celsius
eV	Electron Volt
MeV	Million Electron Volts, 10^{6} eV
Ph	Photons
GOhm	10^{9} Ohm

4 APPLICABLE DOCUMENTS

The following standards form a part of this document to the extent specified herein. Unless otherwise specified, the issue of these documents is those listed in the current issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereof.

Specifications

MIL-PRF- 19500	Semiconductor Devices, General Specification for
MIL-PRF-38534	Hybrid Microcircuits, General Specification for
KQC-B14514	Delivery Specification for the Silicon PIN photodiode, S8576, dated 7 June 2002, Hamamatsu Photonics K.K.

Standards

MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microcircuits
311-INST-001	GSFC Instructions for EEE Parts Selection, Screening, and Qualification
EIA-625	Requirements for Handling Electronic Discharge Sensitive Devices (ESDs)
LAT-MD-00099-03	GLAST LAT Electrical, Electronic, and Electromechanical Parts Program Control Plan
ISO 9001:2000	International Organization for Standardization Quality Management Systems Requirements

5 INTRODUCTION

The GLAST mission is a NASA gamma-ray mission to be launched in 2006. The expected mission lifetime is greater than 5 years up to 10 years. The Large Area Telescope (LAT) instrument is the primary experiment on GLAST and consists of an anticoincidence device, a silicon-strip detector tracker, a CsI calorimeter (CAL), and a Trigger and Dataflow system. The principal purpose of the LAT is to measure the incidence direction, energy and time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers.

The LAT calorimeter is a hodoscopic array of CsI(Tl) scintillation crystals. Scintillation light is collected by PIN photodiodes and processed by charge sensitive preamps. The CAL subsystem consists of a 4×4 array of identical modules. Each module is a hodoscopic array of 96 CsI scintillation crystals and associated readout electronics. Each crystal is approximately $27 \times 20 \times 326$ mm in size with a DPD attached on each end.

Two PIN photodiodes, one large and one small, are required at each end of the crystal to support the electronic measurements over the required dynamic range of the energy depositions. The DPD shall be coupled to the CsI crystal using an optical silicone adhesive. This specification identifies the mechanical, optical and electrical characteristics of DPD consisting of a ceramic substrate, diode pair, and epoxy optical window.

DPDs procured to this specification are manufactured / assembled by using two dies (photodiodes), one large and one small, attached to a ceramic substrate by silver filled epoxy, gold wirebonded, and optical window covered by optical epoxy resin. Each DPD has 4 gold plated leads/pins for external electrical connections (Anodes and Cathodes of each diodes).

6 REQUIREMENTS ON THE COMPONENTS AND DPD MANUFACTURING

6.1 Requirements on PIN Photodiodes

6.1.1 Heritage of the PIN Photodiode

We refer to the previous GLAST PIN photodiode development at Hamamatsu Photonics, part number S3590 SPL 2CH that was developed for the Naval Research Laboratory in 1998 and the last development for NRL and CEA in 2001, part number S8576. The Hamamatsu specification number for the S3590 SPL 2CH part is K03-B70065, dated 6 August 1998, and for the S8576 is K03-B72019 Rev A, dated 23 November 2001, and KQC-B14514 dated 7 June 2002. This last specification represents a modification to the S8576 design. The characteristics specified in Tables 1 and 2 are based on the Hamamatsu S 8576 characteristics.

6.1.2 PIN Photodiodes electrical, optical and temperature specification

6.1.2.1 Diode A

The smaller of the two PIN photodiodes in the carrier shall be designated Diode A and shall have an active area of 10.5 × 2.4 mm. Table 1 specifies the electrical and optical characteristics of Diode A at +25 °C.

Table 1. Electrical and Optical Properties of PIN Diode A (small diode) at 25 °C ± 1°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Active Area	–	–	- 1%	25.2	+ 1%	mm^2
Active Area Size	–	–		10.5x2.4		mm
Spectral Response Range	λ	–	–	320 ~ 1100		nm
Peak Wavelength	λp	–	–	960	–	nm
Photo Sensitivity	S	λ = 540 nm	0.35	0.38	0.41	A/W
Dark Current	I_D	V_R = 70V	0.2	1.0	3.0	nA
Terminal Capacitance	C_t	V_R = 70V f = 1 MHz	13	15	17	pF
Cut-off Frequency	f_C	V_R = 70V, λ=830nm, R_L=50Ω, -3DB	–	45	–	MHz
Reverse Voltage	V_R			70	100	V

6.1.2.2 Diode B

The larger of the two PIN photodiodes in the carrier shall be designated Diode B and shall have an active area of 10.5 × 14.0 mm. Table 2 specifies the electrical and optical characteristics of Diode B at 25 °C.

Table 2. Electrical and Optical Properties of PIN Diode B (large PIN) at 25 °C ± 1°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Active Area	–	–	- 1%	147.0	+ 1%	mm^2
Active Area Size	–	–	- 1%	10.5 × 14.0		mm
Spectral Response Range	λ	–	–	320 ~ 1100	–	nm
Peak Wavelength	λp	–	–	960	–	nm
Photo Sensitivity	S	λ = 540 nm	0.35	0.38	0.41	A/W
Dark Current	I_D	V_R = 70V	0.5	2.5	7.5	nA
Terminal Capacitance	C_t	V_R = 70V f = 1 MHz	60	65	70	pF
Cut-off Frequency	f_C	V_R = 70V, λ=830nm, R_L=50Ω, -3DB	–	35	–	MHz
Reverse Voltage	V_R			70	100	V

6.1.3 PIN Photodiode Connection Pads

Diodes A & B are connected by 25 to 30 micrometers diameter gold wires. There are a total of 4 wirebond connections, two on each die, of which each one will be redundant. The design of the pads on the PIN photodiodes and wirebond strength verification will be done in accordance with MIL-STD-883, methods 2010 and 2011.

6.2 Requirements on the Ceramic Substrate

6.2.1 Mechanical specification

The ceramic substrate, Al_2O_3, 92% shall be 21.3 (+0.1, 0.2) mm × 14.0 (+0.1, 0.2) mm × 1.78 (±0.18) mm. (see **Figure 1**). The ceramic barrier wall isolating the two wells shall be recessed by 0.51 (± 0.05) mm below the top of the ceramic outer wall. The ceramic substrate base under the dies shall be recessed by 1.0 (± 0.05) mm below the top of the ceramic substrate outer wall.

6.2.2 Electrical connections

The ceramic substrate shall provide isolated connections to the individual diode cathodes and anodes through four (4) brazed iron-nickel alloy (Fe; 58%, Ni; 42%) (kovar) pins 0.46 (± 0.01mm), as defined in figure 1. The connections must be located as close as possible to their theoretical location (absolute maximum: a circle of 0.1 mm radius centered on theoretical location).

The connections shall be oriented as indicated in Figure 1. The pins shall extend 1.85 (± 0.15) mm (TBD) from the back of the ceramic substrate (see **Figure 1**). The pedestals (nominally 0.8 mm diameter) for the pins shall not extend more than 0.3 mm from back of ceramic carrier. The insulation between connections will be > 1000 GigaOhm under 100 V (0.1nA).

NOTE: During preliminary discussions the length of the electrical connection pins shall be considered as an option:

Nominal pin length:	1.85 ± 0.15 mm
Optional pin length:	4.00 ± 0.20 mm

NOTE: While examining some of the DPDs (see figure A) the pedestals 0.8 mm diameter is submerged in the solder connection to the ceramic substrate. Hamamatsu should supply information for the type of solder used for this connection. Integrity of this joint will be affected while soldering the wires on the pin. Please review the figure A and figure B and supply details.

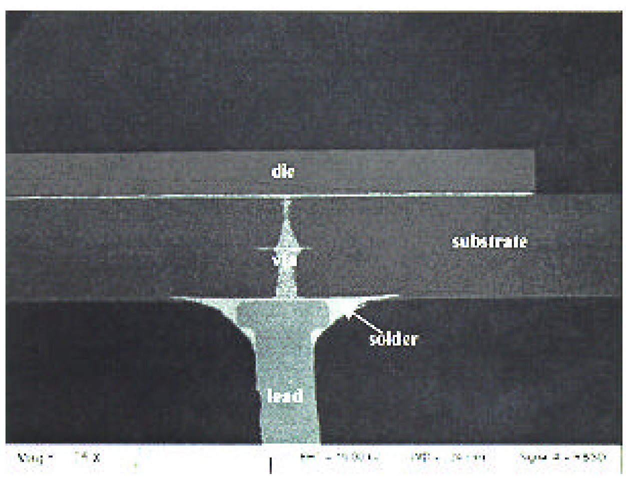

Figure A.

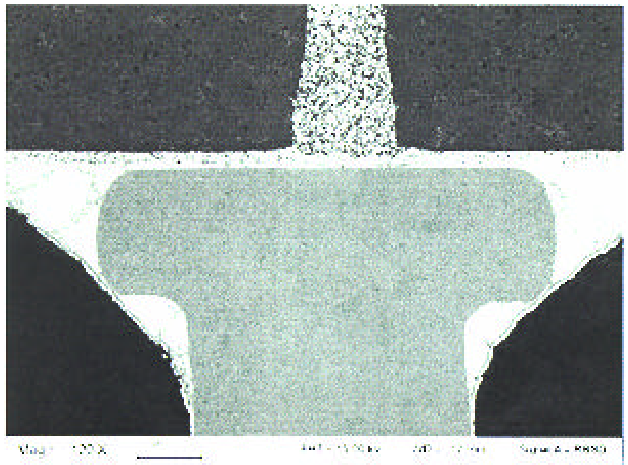

Figure B.

6.3 Requirements for the DPD manufacturing

6.3.1 Die Attach

Die attach, the process by which the die is anchored to the ceramic substrate, is usually the first process performed in the assembly of packages. The crosslinking agents, hardener and resin, react producing several byproducts in addition to the long epoxide chains.

The die attach process control can be broken down into three steps:

1. Dispensing of the adhesive
2. Alignment and placement of the die
3. Curing of the adhesive

In the first step, the adhesive is dispensed in an amount, which ensures the proper bondline (thickness of the cured adhesive under the die).

The second step of the process includes die alignment and placement. The die is acquired from its carrier and properly oriented. The die is place onto the adhesive and set in place producing a visible attachment of material around the edge of the die (refer to table 3). During the filleting process, alignment should be performed for three axes of rotation and three translations simultaneously, resulting in six degrees of freedom. Many die bond problems such as low bondline, edge voids, undercutting, material on die, over filleting (refer to table 4 for a complete list), are traceable to lack control in the die alignment and dispensing of the adhesive.

Table 3. Parameters Defining Die Attach Process and Process Control

DIE ATTACH PROCESS AND CONTROL PARAMETERS
STEP 1: Dispense Adhesive
Dispense quantity and repeatability Pattern uniformity and repeatability

Rheology Pot Life Bondline thickness – before and after cure Bleedout
STEP 2: Alignment and Placement of Die
Six degrees of freedom placement accuracy Repeatability
STEP 3: Cure of Adhesive
Time-temperature sensitivity Humidity Shrinkage Post bonding thermal and mechanical testing (sage, die pull and shear, SLAM) Fillet inspection

Table 4. Parameters Associated with Die Bonding Quality Control

DIE BONDING PROCESS PROBLEMS					
	Dispense	**Place**	**Ceramic Package Handling**	**Cure**	**Rework**
Low Bondline	X	X			
Edge Voids	X	X			
Undercutting	X	X			
Material on Die	X	X		X	
Overfilling	X	X			
Flaking	X				
Bridging	X				
Cracking			X	X	
Disbanding			X	X	
Bleedout				X	X
Misorientation Misalignment		X			
Die Chips/Scratch		X	X		

Curing of adhesives is usually the easiest to perform and control. It is necessary to control time, temperature, and environmental parameters such as humidity or sir flow rate. Table 3 depicts the die bonding process and the list of parameters needing process control.

There will be a minimum clearance of 100 µm between the dies and the ceramic walls and dies are attached to ceramic substrate with silver filled epoxy. This will be verified during visual inspection prior to wirebonding at Hamamatsu.

6.3.1.1 Die Attachment Control and Issues

The relatively high coefficient of thermal expansion (CTE) of the optical epoxy and the use of large dies on the ceramic substrate requires good control on the processes to reduce the effects of thermally induced stresses.

Delamination /voids in the die attach region is known to increase thermal resistance of that interface, leading to increased die temperature, stresses and reduced reliability. The effects of the die attach region delamination/void, especially on corners; can have a significant effect on the cracking of encapsulated epoxy especially in the restricted area of ceramic packages.

6.3.2 Silicon Photodiode Mounting and Insulation

The two photodiodes shall be mounted in such a manner to preserve electrical insulation. The electrical and optical characteristics of the two photodiodes are addressed in Tables 1 and 2. The photodiodes shall be coated with a clear optical epoxy resin to protect their sensitive surfaces. Only the epoxy used in the Hamamatsu DPD S8576 delivered to France, CEA is accepted. Please note that this epoxy has been qualified for space flight in ESA's INTEGRAL program for the PICsIT experiment. Any deviation from this epoxy shall be approved by NRL/CEA prior to its use.

6.3.3 Optical Surface Flatness

The clear epoxy resin shall fill the ceramic substrate wells for the photodiodes, cover the recessed ceramic isolation wall between the cells, and shall be polished to a flat optical mounting surface. The optical mounting surface shall be flat to within ±10.0 μm. Deviation from this flatness is acceptable up to 50 μm inside a strip along the ceramic (bondside) of 1 mm thickness maximum (see figure 1) and not on the side of active area of the DPD.

6.3.4 Alignment of Optical Surface to Ceramic Surface

The optical epoxy surface shall be aligned with the back of the ceramic surface to within ± 50 μm.

6.3.5 Manufacturing flow charts

Detailed manufacturing flow charts shall be prepared for the ceramic substrate and for DPD assembly by Hamamatsu. Hamamatsu will also ensure the availability of the ceramic substrate manufacturing flow chart for review at Hamamatsu.

These flow charts shall evidence the various steps (including inspection points) of the manufacturing and testing, with reference to the relevant procedures. Contractual mandatory inspection points will be selected by mutual agreement of Hamamatsu and NRL/CEA during the kick-off meeting prior to flight production at Hamamatsu.

6.3.6 General Cleanliness

The manufacturing, testing and packaging of the DPD prior to shipment, shall be Hamamatsu's responsibility. The DPD will be packed and shipped as per Appendix B. DPDs will be packed in a clean environment free of dust and free of molecular contamination, according to Hamamatsu internal contamination plan. Contamination control plan and cleaning procedures should be made available for review.

6.3.6.1 Suggested Cleaning Methods to Improve Bondability of wirebond, optical epoxy and Reliability

Various cleaning methods shall be used to remove contaminants at different stages of wafer processing, ceramic substrate, die attachment, wirebonding, and prior to epoxy encapsulation. Bond pad metallizations often contain various additives and are reactive to ion processing of the wafer, which can leave fluorocarbon films on the surface. All of these can inhibit bondability of the epoxy and can affect reliability. Because of the extensive handling, as well as the use of silver die attach, the molecular cleaning methods should be adopted prior to bonding and encapsulation.

Some contaminants primarily affect bondability while others reduce reliability. Considering the large number of possible die attachment degrading contaminants, a variety of methods can be used to clean surfaces containing several contaminants. Some of these contaminants (e.g., halogens) can become chemically bound to surfaces. Organic contamination may be easily removed with UV-ozone/O_2 or argon plasma after die attach, immediately before bonding and encapsulation.

6.3.6.2 Molecular Cleaning Methods

Atmosphere impurities resulting from the long storage of chips combined with a great deal of handling and processing (e.g., from die attach outgassing) leads to contamination, which requires cleaning. If heavy organic and/or ionic contaminants are suspected, then the combination of Freon TMS, oxygen plasma, and cold deionized water cleaning is recommended.

Both UV-ozone and plasma have been shown to be effective in removing organic contamination, although the degree of effectiveness of each method may vary somewhat, depending on the specific contaminant. Therefore, some evaluation must be made to determine the best choice for a specific application.

Oxygen plasma cleaning will blacken (oxidize) silver metallization and may reduce bondability. Changing the oxygen to argon near the end of the cleaning process restored the silver to its original color and regained any bondability loss.

6.3.6.3 Storage

Once a device has been cleaned, it will become recontaminated during storage. For practical purposes, a period of up to two hours' storage, after cleaning, is acceptable for bonding and epoxy encapsulation. If stored for longer periods, the DPD should be recleaned.

6.3.7 Optical Epoxy

The cured optical epoxy shall be capable of enduring temperatures of -30°C to +80°C, humidity, mechanical shock, thermal cycle, thermal vacuum, and must be able to adhere to the substrate, bondwire and die without affecting the performance as specified herein. Optical epoxy shall also meet the optical and electrical requirements as specified herein. The epoxy shall be cured and handled as per the epoxy manufacturer's specification. The optical epoxy shall have excellent optical clarity, wicking and wetting characteristics. Procedures used for epoxy encapsulation and curing shall be controlled from receipt of material to shipment.

6.3.8 Hamamatsu's Controls

Hamamatsu shall define nature and frequency of their own Key Inspection Points (KIP) and must present at the NRL/CEA one month before the flight production kick-off meeting for approval. The Product Assurance Manager of Hamamatsu shall monitor the manufacturing processes.

Mandatory Inspection Points (MIP) will be identified at the kick off meeting by NRL/CEA reserve the right to inspect the DPD at those selected MIPs. Hamamatsu shall maintain the traceability and list of GSE used during assembly and testing of DPDs.

6.4 Product Assurance Requirements

Delivered DPDs shall be those that have been subjected to and passed the requirements, tests, and inspections detailed herein.

6.4.1 Hamamatsu's Capability

Prior to placing an order for flight PIN photodiodes intended for use in Calorimeter hardware, Hamamatsu's capability to comply with the requirements of this document and the associated procurement specification must be verified. Exceptions taken by Hamamatsu to the design rules and process control requirements shall be reviewed and considered for acceptability. Additional requirements for verifying manufacturer capability are given herein in Appendix A.

6.4.2 Capability Assessment

A capability assessment shall be performed to verify that the manufacturer's quality management program achieves a level of quality level of ISO9001:2000 and that Hamamatsu has and uses production facilities, test facilities and a verification program which is capable of meeting the requirements of this specification.

6.4.3 Design and Construction

These design and construction rules should be consistent with Hamamatsu's internal specifications and shall be available for review. The manufacturer shall document all exceptions taken to the requirements and shall justify how the exceptions are implemented without compromising the overall reliability and performance of the device. This documentation shall be available during the visit. Designs shall be capable of passing all tests specified herein.

6.4.4 Materials

The following provisions apply to construction:

a. Optical epoxy seal on the DPD shall be evaluated for reliability and performance.

b. The cure temperature of optical epoxy materials shall be controlled and shall not cause undue stress on the optimal performance of DPD under temperature excursions. Polymeric materials shall meet the requirements of NASA outgassing requirements. The manufacturer shall develop a plan and shall be approved prior to flight production. Heritage data from previous space missions is acceptable as long as it meets the requirements of this mission.

c. Materials shall be selected such that thermal expansion rate mismatches between different materials (i.e., die, ceramic, wirebond) do not compromise integrity and performance during applicable temperature excursions.

d. External metal leads/pins surfaces shall meet the applicable corrosion resistance requirements as specified herein.

e. Coatings including markings shall be non-nutrient to fungus and shall not blister, crack, flow, or exhibit defects that adversely affect storage, operation, or environmental capabilities of the device under the specified test and operating conditions.

f. A list of material to be used for the manufacturing of the DPD shall be maintained at Hamamatsu and shall be available for review except for proprietary material. Materials not approved by NASA/ESA shall not be used without approval from NRL/CEA.

6.4.5 Internal and External Conductors and Pins

Internal thin film conductors on dies (metallization stripes, contact areas, bonding interfaces, etc.), internal wires, and external pins shall be designed such that no properly fabricated conductor will experience current in excess of the maximum value calculated by Hamamatsu, except by design.

6.4.6 Metal Finishes

Tin is prohibited as a final finish and as an undercoat. Finishes on interior dies shall be such that they meet bonding requirements and any applicable design and construction requirements. Finishes of all external pins shall meet the applicable corrosion resistance requirements. External pin finish thickness measurements shall be taken halfway between the seating plane and the tip of the pin. The finish system on all external pins shall conform to the hot solder dip as defined in (a). However, other finishes are allowed prior to final delivery of the DPD for testing, etc.

a. Hot solder dip. The hot solder dip shall be homogeneous with a minimum thickness of 60 microinches (1.52 μm) for round pins and a minimum thickness at the crest of the major flats of 200 microinches (5.08 μm) solder (Sn6O or Sn63). Hot solder dip plating is the final plating required on the DPD pins prior to shipping. Gold plating shall be removed by dipping twice in a solder pot or equivalent method. The goal is to have the hot solder dip plating for assembly. It is advisable that the hot solder dip plating be performed on a blank ceramic substrate prior to assembly of dies.

b. Nickel plate or undercoating. Electroplated nickel or electroless nickel phosphorous nickel undercoating or finishes shall be 50 to 350 microinches (1.27 μm to 8.89 μm) thick measured on major flats or diameters. Electroless nickel shall not be used as the undercoating on flexible or semiflexible leads and shall be permitted only on rigid leads.

c. Gold plate. Gold plating shall be a minimum of 99.78 percent gold, and only cobalt shall be used as the hardener. Gold plating shall be a minimum of 50 microinches (1.27 μm) and a maximum of 225 microinches (5.72 μm) thick. Gold plating shall be permitted only over nickel plate or undercoating in accordance with paragraph b above (Nickel plate or undercoating).

6.4.7 Thermal Design

Thermal design analysis shall be performed and shall establish as a minimum that the functional DPD dies are operating within their design temperature ratings when the DPD is operated at the specified maximum operating case temperature.

6.4.8 General Rework and Repair Provisions

General rework and repair provisions are as follows:

a. All temperature excursions during any rework or repair shall not exceed the baselined rework or repair limitations of design and performance. Time and temperature limits shall be controlled.

b. Any DPD, which is reworked or repaired after non-destructive bond pull, shall be subjected to full screening or rescreening as applicable. If a DPD has not been subjected to a given required screen prior to rework or repair, then that DPD must be subjected to that screen after repair or rework. Full screening is required after any rework or repair operation.

6.4.8.1 Wire Rebonding

Wire rebonding of dies other than substrates shall be permitted with the following-limitations:

a. No scratched, voided, or discontinuous paths or conductor patterns on a die shall be repaired by bridging with or addition of bonding wire or ribbon.

b. All rebonds shall be placed on at least 50 percent undisturbed metal (excluding probe marks that do not expose underlying oxide). No more than one rebond attempt at any design bond location shall be permitted. No rebonds shall touch an area of exposed oxide caused by lifted or blistered metal.

6.4.8.2 Ceramic Substrate Wire Rebonding or Repairs

Wire rebonding on ceramic substrates shall be permitted with the following limitations.

a. Scratched, open, or discontinuous substrate metallization paths or conductor patterns on a substrate, not caused by poor adhesion, may be repaired by bridging with or by addition of bonded conductors having current carrying capacity at least 3.5 times the current capacity of the wire bond connection terminating on the damaged conductor path. The quantity of repairs shall be limited to one for each one-half square inch or fraction thereof of substrate area.

b. No rebonds shall be made over intended bonding areas in which the top layer metallization has been lifted, peeled, or has been damaged such that underlying metallization is exposed at the immediate bond site.

6.4.9 Process Controls

Hamamatsu shall implement a methodology to detect defective processes prior to completion of DPD assembly. Hammatsu shall document all exceptions taken to the requirements and shall justify how the exceptions are implemented without compromising the overall reliability and performance of the manufactured product. Following are the example of process controls to be used for each process.

1) Wire Bonding - The following process controls shall be imposed on wire bonding.

2) Wire Bonding Process Evaluation - A process machine/operator evaluation shall be performed:

   a. When a machine is put into operation.

   b. Periodically while in operation, not to exceed 4 hours.

   c. When the operator is changed. Change of certified auto wire bond operators is allowed without machine reevaluation if all other machine conditions for evaluation are maintained.

   d. When any machine part has been changed.

   e. When any machine adjustment of the process parameters has been made.

   f. When the spool of wire is changed.

   g. When a new device type is started

3) Process Machine/Operator Evaluation - Sample wires from three devices or a test sample shall be destructively pull tested in accordance with MTIL-STD-883, method 2011 and as follows:

   a. A minimum of 10 wires total, consisting of wire bonds to die metallization-bonding systems typical of device assembly operation shall be tested.

   b. If any of the sample wires fail, the machine/operator shall be deactivated and corrective action taken. When a new sample has been prepared, tested, and has passed this procedure, the machine/operator has been certified or recertified, it can be returned to service.

4) Standard Evaluation Circuit (Test Coupon or Test Vehicle) - Standard evaluation circuits (test coupons or test vehicles) that simulate the production DPD device's metal bonding system may be destructively evaluated in lieu of the flight DPD.

5) A list of qualified processes to be used for the manufacturing of the DPD shall be submitted for review to NRL/CEA. Hamamatsu shall be responsible for qualification of all processes used during manufacturing of DPD, assembly and testing of DPDs.

6.4.10 Non-Compliance

Process machines not meeting the evaluation requirements shall not be used. A process machine may be returned to operation only after appropriate corrective action has been implemented and the machine has been evaluated and passed testing.

6.4.11 Traceability

Traceability for each DPD and its constituent materials shall be as follows.

a. All DPDs manufactured shall be traceable within Hamamatsu systems from purchase order review to shipment. Every manufacturing lot shall have a unique number that is traceable from the raw material stage through every step in the manufacturing process. The wafer fabrication and substrate lot is the manufacturing lot. It is preferable to manufacturer all dies from a single wafer lot and substrates from a single material lot and processes. The same lot number with a suffix shall be used to identify all sub-lots of the original manufacturing lot. Once a manufacturing lot has been defined, only sub-lots of the same manufacturing lot can be combined into a single lot. Every lot is documented by electronic and/or paper travelers that record the processing date, measured values, the machine identification and the revision of the control software/test program along with the batch of raw materials that was used at each manufacturing step. Product identity shall be inherently obvious through all manufacturing steps. Every wafer and substrate shall be marked with a wafer number, the fabrication lot number. Individual die may not have any product identity marking. Maintenance of product identity and traceability in the assembly process and for plated die shall be assured by assembly procedures. After assembly, DPD identification shall be again inherent because every assembled DPD is marked with a date-trace code that is uniquely associated with the Hamamatsu manufacturing lot and DPD product family numbers.

b. Traceability will be such that for each DPD, all adhesives and coatings will be traceable to a material production lot, inspection lot, or other specified grouping. All elements and materials used will be traceable to their incoming inspection lots. Records will be maintained to provide traceability from the device serial number to the specific wafer lot from which each die originated.

c. Each DPD, or each group of DPDs which have been fabricated as a common batch, will be identifiable through means of production travelers or similar documentation such that the complete manufacturing history, including rework, will be recorded. The records should include, as a minimum, the performance date of all identified production process steps, the specification, number of production process steps, and the identification of the operator performing the process steps.

d. Lot Traceability shall be maintained to the wafer lot for all dies used in the DPDs. Hamamatsu will maintain production lot traceability.

e. Records should identify when each production or inspection lot was processed through each area. These records should identify, for each production or performance verification lot (as applicable) of finished product, test/inspections performed and results, device serial numbers, date of completion, lot identification, device acquisition specification, lot disposition, and the number of devices at seal, shipped and stocked.

f. The manufacturer should define all processes and methods used to assure the capability and consistency of the processes. As a minimum all critical process parameters should be defined. Hamamatsu should define process monitors as appropriate.

g. Records should cover the implementation of tools such as control charts or other means of indication of the degree of control achieved at the points in the material, utility, and assembly process flow documented in the manufacturing instructions. Records should also indicate the action taken when each out-of-control condition is observed, and the disposition of product processed during the period of out-of-control operation.

h. Design and Manufacturing Documentation - In addition to documentation required as part of the purchased product, design, topography, schematic circuit information, manufacturing flowcharts, and process control documents for all DPDs shall be maintained by Hamamatsu for a period of 5 years and shall be available for review.

i. Laser markings on the back side of the ceramic substrate shall include Photodiode type, lot code, date of manufacturing, and serial number at a location as defined in figure 1.

6.4.12 Evaluation Requirements

6.4.12.1 DPD Evaluation

DPD evaluation shall meet the criteria's of Tables 5 through 9 and as described below. Subgroup testing within a table may be performed in any order, however the tests within any subgroup must be performed in the order shown. Processes used for flight DPD production shall be used for these sample tests shown in Tables 5 through 9. DPD test procedures shall be established by Hamamatsu and shall be available for review.

6.4.12.1.1 Die Evaluation

Die evaluation as per table 5 may not be necessary if Hamamatsu has qualified the dies and data is available for review. Dies tested and qualified using the same processes, materials, and controls and with the similar features may be acceptable for review of the data, in lieu of testing as specified in table 5.

Table 5. Die Evaluation Requirements

Subgroup	Test	MIL-STD-883		Quantity (Accept Number)
		Method	Condition	
1	Die Electrical *	As per Table 8A & 8B		100%
2	Die Visual	2072**		Sample TBD
4	Burn-in Post burn-in functional electrical Steady-state life Final electrical	1015 1005	240 hours minimum at +80°C Static tests at -30°C, 25°C and 80°C These tests will be performed on completed DPDs.	TBD
5	SEM	2018	To be performed at CEA	Two samples dies will be supplied by

				Hamamatsu for evaluation

* This test may not be required if dies are sorted out at the wafer level for functionality of die.

** MIL-STD-750 method.

6.4.12.1.2 Ceramic Substrate Evaluation

Hamamatsu shall obtain qualification and screening data for the ceramic substrate from their subcontractor. This data shall be available for review at Hamamatsu. Ceramic substrates shall be evaluated in accordance with Table 6 as noted below. Previous lot test data using the same processes, materials, and controls are acceptable and these tests may not be required. A ceramic substrate inspection lot will consist of homogeneous substrates having the same number of layers, manufactured using the same facilities, processes and materials, and vacuum deposited, plated or printed as one lot. Independent testing as specified in table 6, shall be performed at CEA, France on two blank substrates to be supplied by Hamamatsu. This test data will be compared with Hamamatsu subcontractor test data.

6.4.12.1.2.1 Visual Inspection

Each substrate will be visually inspected to assure conformance with the applicable requirements of MIL-STD-883, method 2032, and the applicable detail/acquisition specification of Hamamatsu.

6.4.12.1.2.2 General Requirements

From each inspection lot of substrates, a randomly selected sample will be evaluated. Destructive tests may be performed on test coupons which provide the required test data. The test coupons must be made with the same materials that were used in the manufacturing of the inspection lot and processed at the same time as the inspection lot.

6.4.12.1.2.3 Physical Dimensions

Inspect in accordance with MIL-STD-883, method 2016, and the applicable detail/acquisition specification.

6.4.12.1.2.4 Electrical

Substrates will be electrically tested at +25°C for the following characteristics (minimum). Requirements shall be as specified in the applicable detail/acquisition specification of Hamamatsu.

a. Resistors: DC resistance.
b. Capacitors: Capacitance. As specified in the applicable detail/acquisition specification, test for dielectric withstanding voltage, insulation resistance, and dissipation factor.
c. Continuity and isolation testing shall be performed to verify the interconnection of conductors as specified in the applicable detail/acquisition specification of Hamamatsu.

Table 6. <u>Substrate/Package Evaluation Requirements</u> - All tests shall be performed on blank ceramic packages

Subgroup	Test	MIL-STD-883		Quantity (accept number)
		Method	Condition	
1	Radiography	2012.7		5(0)
2	Electrical Testing	As per para. 6.4.12.1.2.4 at 25^{0}C		100%
3	Visual inspection	2032	As per para. 6.4.12.1.2.1	2(0)
4	Physical dimension	2016	As per para. 6.4.12.1.2.3	5(0)
5	Lead Integrity	2004	Lead fatigue, only on blank packages	3(0)
6	Solderability	2003	Soldering temp. = 245°C ±5°C only on blank packages	3(0)
7	Radiography	2012.7		3(0)
8	DPA	5009.1		1(0)

6.4.12.1.3 DPD Process and Material Evaluation

DPD Process and material Evaluation shall be in accordance with Table 7 and shall be performed on fully screened samples as per table 9. After review of qualification data (except for 1000 hours steady-state life test) a decision will be made for flight production. Corrective action if required will be implemented prior to flight production. Total time for this evaluation shall not exceed 5 weeks. A total of 65 DPDs will be supplied by Hamamatsu for this evaluation.

Table 7. DPD Process and Material Evaluation

Subgroup	Test			Quantity (accept number)
		Method	Condition	
1	Acoustic Microscopy			100%
2	Electrical Verification	As specified herein	As per table 8A & 8B	100%
3	Physical dimensions Solderability Resistance to solvents & fluxes	As specified herein 2003 2015	As per para. 6.4.15 +245^{0}C ± 5^{0}C	2 (0) 1 (0) 3 (0)
4	Moisture Intake - Condition 1 - Condition 2	JESD-22-A113	168 hrs, +50°C, 85%RH 168 hrs, +30°C, 60%RH	6 (0) 6 (0)
5	Electrical Verification	As specified herein	As per tables 8A & 8 B	12 (0)

6	Steady-state life and End-point electricals, as per tables 8A & 8B	1005	1000 hours at 60^0C	22 (0)
7	ESD	3015		3 (0)
8	Thermal cycle - Condition 1 - Condition 2	1010	 60 cycles at -30^0C to $+80^0$C at ramp rate of 5°C/minute with ½ hour dwell at each temp. 60 cycles at -20^0C to $+60^0$C	10 (0) 10 (0)
9	Electricals as per table 8A & 8B			20 (0)
10	Radiation Testing	Per para. 7.1	Total Ionizing Dose testing	3 (0)
11	DPA - Radiography - SEM Analysis - Ceramic Substrate Evaluation - Assembly Verification - Die Attachment - Wirebond Evaluation - Optical Epoxy Evaluation			1 (0)

6.4.12.1.4 DPD Electrical Test

The following two tables 8A & 8B, illustrate the electrical and optical characteristics of the DPDs.

Table 8A – PIN A (Small diode)

Parameter	Symbol	Condition	Min.	Type	Max.	Unit	Sampling
Photo Sensitivity	S	λ = 540 nm	0.35	0.38	0.41	A/W	100%
Dark Current	I_D	V_R = 70 V	0.2	1.0	3.0	nA	100%
Terminal Capacitance	C_t	V_R = 70 V, f = 1 MHz	13	15	17	pF	100%

Table 8B – PIN B (Large diode)

Parameter	Symbol	Condition	Min.	Type	Max.	Unit	Sampling
Photo Sensitivity	S	λ = 540 nm	0.35	0.38	0.41	A/W	100%
Dark Current	I_D	V_R = 70 V	0.5	2.5	7.5	nA	100%
Terminal Capacitance	C_t	V_R = 70 V, f = 1 MHz	60	65	70	pF	100%

6.4.12.1.5 DPD Screening

Screening, including burn-in, shall be performed on 100% of flight DPDs in accordance with Table 9. All DPDs electrical measurements taken during screening shall be read and recorded.

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Table 9. Screening

Test Inspection	MIL-STD-883		Requirements
	Method	Condition	
Visual Inspection and Mechanical Measurement after optical epoxy	As specified herein	As per para. 6.4.14 & 6.4.15	100% or samples TBD
Temperature cycling unpowered		-20°C to +45°C for 10 cycles. Ramp rate not to exceed 5°C/minute with ½ hour dwell at each temp.	100%
Electrical	In accordance with tables 8A & 8B	Only dark current measurements required	100%
Burn-in with DPD baised at 70V	1015	168 hrs at +80°C (TBD)	100%
Final electrical test	In accordance tables 8A & 8B		100%
Final Visual Inspection	As specified herein	Paragraph 6.4.14	100%

6.4.13 Workmanship

DPDs shall be manufactured, processed, and verified to meet the performance requirements of this document and with the production practices, workmanship instructions, inspection and test procedures, and training aids prepared by Hamamatsu in fulfillment of his baseline process flow or previously approved quality management program which may be reviewed and approved.

6.4.14 Final Visual Inspection 100%

- Surfaces qualities (hard scratches, chips are not acceptable)
- Foreign material that can be wiped off should be acceptable and if so removed before shipping.
- Foreign material and bubble (in active area) in the epoxy window of DPD should be examined under a magnification of 10-20X. Any bubbles greater than or equal to 200µm in diameter should lead to DPD rejection.
- Leads/Pins, scratches on gold due to tools, abnormal bending, should be rejected.

6.4.15 Mechanical Inspection

a) Width
b) Length
c) Thickness
d) 4 connection pins positions
e) Flatness of the optical window
f) Parallelism versus back side (50 µm)

6.4.16 Definition of a lot/batch (TBD with Hamamatsu)

The definition of a lot/batch will be linked to the delivery rate: a lot will be 600 DPD every 5 weeks.

6.4.17 Failure Reporting and Request for Waiver

A failure is defined as the inability of the DPD to perform within the limits of the test requirement specified herein. All such failures shall be reported to NRL/CEA within 24 hours and a nonconformance report documenting the failure and investigation shall be provided electronically within 2 days of the failure's occurrence.

7 ENVIRONMENTAL

7.1 Radiation

Radiation on DPDs will be performed at CEA and shall not show any degradation in performance of tables 8A & 8B after exposure to a total dose of 10K Rad which is 5 times the expected dose of a 5 year mission. Previous test data of the DPD samples suggests that used silicon processes may be acceptable. The radiation data shall be available for review.

7.2 Vibrations (For Information)

Frequency (Hz)	Qualification Level
20	0.01 g^2/Hz
20 – 50	+4.6 dB/octave
50 - 800	0.04 g^2/Hz
800 – 2000	-4.6 dB/octave
2000	0.01 g^2/Hz
Overall	7.4 g_{rms}

7.3 Temperature Conditions during Spaceflight (For Information)

The following table describes the minimum and maximum temperature conditions for DPD during vacuum and atmospheric conditions of spaceflight.

Parameter	Symbol	Value	Unit	Remark
Reverse Voltage	VR_{Max}	<100	V	
Nominal Instrument Operating Temperature	T_{opr}	– 10 up to +30	°C	Non-condensing
Qualification Operating Temperature	T_{qopr}	– 30 up to +50	°C	Non-condensing
Non operating (survival) qualification	T_{stgv}	– 30 up to +50	°C	FM Parts, Non-condensing
Non operating storage or survival in orbit requirement	T_{stgv}	-20 to +40	°C	FM Parts, Non-condensing

8 DEFINITION OF THE DELIVERABLE

8.1 Dual PIN Photodiode (DPD)

4500 DPD (TBD), fully compliant with the present specification will be delivered to the project.

8.2 Deliverable documentation

All documentation shall be written in English.

As far as possible, all the documentation shall be available in electronic format via e-mail (before delivery). The electronic format shall comply with the following software: Microsoft Word, Excel, PowerPoint, Project, and Adobe Acrobat Reader (.pdf file).

8.3 Delivery description

The following documents will be sent by e-mail (files attached) before delivery and in electronic media along with the shipment.

- Delivery documents shall describe the delivery content:
  - Total quantity of delivered DPD
  - Quantity of containers and reference of their identification
  - Quantity of individual boxes inside each container
- Documents listed hereafter in section 8.4

8.4 Data Requirements

Recorded test data shall be as per this specification and shall be forwarded by Hamamatsu with each shipment of DPDs.

8.4.1 Certificate of Conformance

Each shipment of DPDs shall include certification by Hamamatsu that the DPDs are in accordance with all of the requirements of this specification.

8.4.2 Electronic Test Data

A summary of attributes results for all tests and measurements as per tables 8A, 8B, 7, & 8 shall be part of the submitted test report.

8.4.3 DPD mechanical and electrical data formatting

The name and number of parameters of the data sheet (field of the excel table) will be provided to Hamamatsu by NRL/CEA at the kick-off meeting.

8.5 Monthly production report

A monthly report shall be issued by Hamamatsu and sent to the NRL/CEA. All nonconformances reported earlier and copies of them and their resolutions shall also be included in the monthly reports.

9 SHIPPING CONDITIONS

9.1 DPD packaging

DPD shall be packed in dedicated boxes preventing any stress (mainly on pins) during the transportation and storage. The list (S/N) of the packed DPD shall be written on the cover of the box. In order to prevent mixing of covers, the cover after opening stays attached to the box. Each box shall be individually packed inside a "dry pack" with some additional desiccant inside. The list (S/N) of the DPD shall be written, as well, on the "dry pack".

The number (10 to 50) of DPD by box will be defined by the project TBD. Packaging will be as defined in Appendix B.

The designer of the container will prevent any damages of the DPD due to

- shock
- humidity

One humidity detector shall be included in the container (25g sensitivity). One temperature detector covering, at least, the range -30°C to + 60°C, shall be included in the container. This detector shall indicate the highest and the lowest temperature reached during the transportation. Specific labels will be provided by the project to be glued on the container, such as "High Reliability Material" and "TO be opened in a clean room, by authorized personnel only". That means that the container will not be opened between the Hamamatsu factory and the clean rooms of CEA.

9.2 Delivery address

The delivery address is the following:

Mr Charles LYRAUD

L'Orme des merisiers /Dapnia/Sap bat 709 Pce 161

CEA Saclay

91191 GIF SUR YVETTE cedex FRANCE

9.3 Transportation means and conditions

The door-to-door transportation system is chosen by Hamamatsu under its full responsibility.

10 HANDLING & STORAGE

A procedure describing how to handle the DPD during unpacking and further operations will be written and delivered to the project by Hamamatsu.

10.1 Optical Window

Avoid touching the optical window, because dirt or scratches on the light input window might cause a loss of sensitivity.

If the window needs to be cleaned, use ethyl alcohol and wipe off the window gently. Avoid using any other organic solvents other than ethyl alcohol as they may cause deterioration of the device's epoxy resin coating and may affect the performance.

11 ACCEPTANCE CONDITIONS AT NRL/CEA

11.1 Checklist

Each shipment will be checked by the NRL/CEA as per this specification requirement.

a. Visual inspection of the container including shock detection
b. Visual inspection of the internal packaging
c. Checking of the delivery versus the contractual arrangements
d. Checking of the delivery versus the content list
e. Checking of the exportation documentation conformity
f. Checking of the presence of electronic media (CD-ROM) and its content
g. Checking of the DPD recorded parameters versus the acceptance limits
h. Systematic control will be done on:
    - Visual inspection, cleanest, scratch, concavity on samples only
    - Mechanical: thickness on samples only
i. Sampling on about 10% of the DPD lot (PIN A and B):
    - Electrical: Capacitance (at 1MHz, 70Volt), Dark Current (70Volt)
    - Optical: Sensitivity at 525nm (green LED) and 660nm (red LED) in pulse mode with all the PIN diode illuminated.
    - Mechanical: the 4 connection pins positions, width, length.

11.2 Delivery Acceptance/Refusal

11.2.1 Pre-reception

There will be a pre-reception at the arrival of the lot at CEA, France. Nonconformity related to checking step “a” to “f”, in section 11.1, will lead to the refusal of the entire delivery and to organize a meeting. Nonconformity related to checking step ”g”, in section 11.1, will lead to the refusal of the concerned DPD.

11.2.2 Final reception

There will be a final reception after the acceptance tests performed in 11.1, step “h” and “i” will need a delay of 15 days. Nonconformity related to checking step “i” will lead to the refusal of the entire delivery and to organize a meeting. Nonconformity related to checking step ”h” will lead to the refusal of the concerned DPD.

12 PRODUCT ASSURANCE

12.1 Processes

A list of qualified processes to be used for the manufacturing of the DPD will be submitted for approval to the prokect. If a non-qualified process is mandatory, Hamamatsu shall be responsible of its qualification with the approval by the project. This list includes, for each process, the following indications:

- Name of the process
- Specification or procedure
- Brief description of the process
- Name of the subcontractor (if applicable)
- Related materials or components
- Critically of the process and associated risks (FMECA)

The project shall be informed within one week by the manufacturer of any changes made to the list.

12.2 Reliability

To calculate the overall reliability of the GLAST LAT instrument, Hamamatsu shall provide the reliability of each diode, and if possible, and estimation for each DPD. This reliability is a number a FITs, taking into account that the DPD, during the flight, will be working at +10°C.

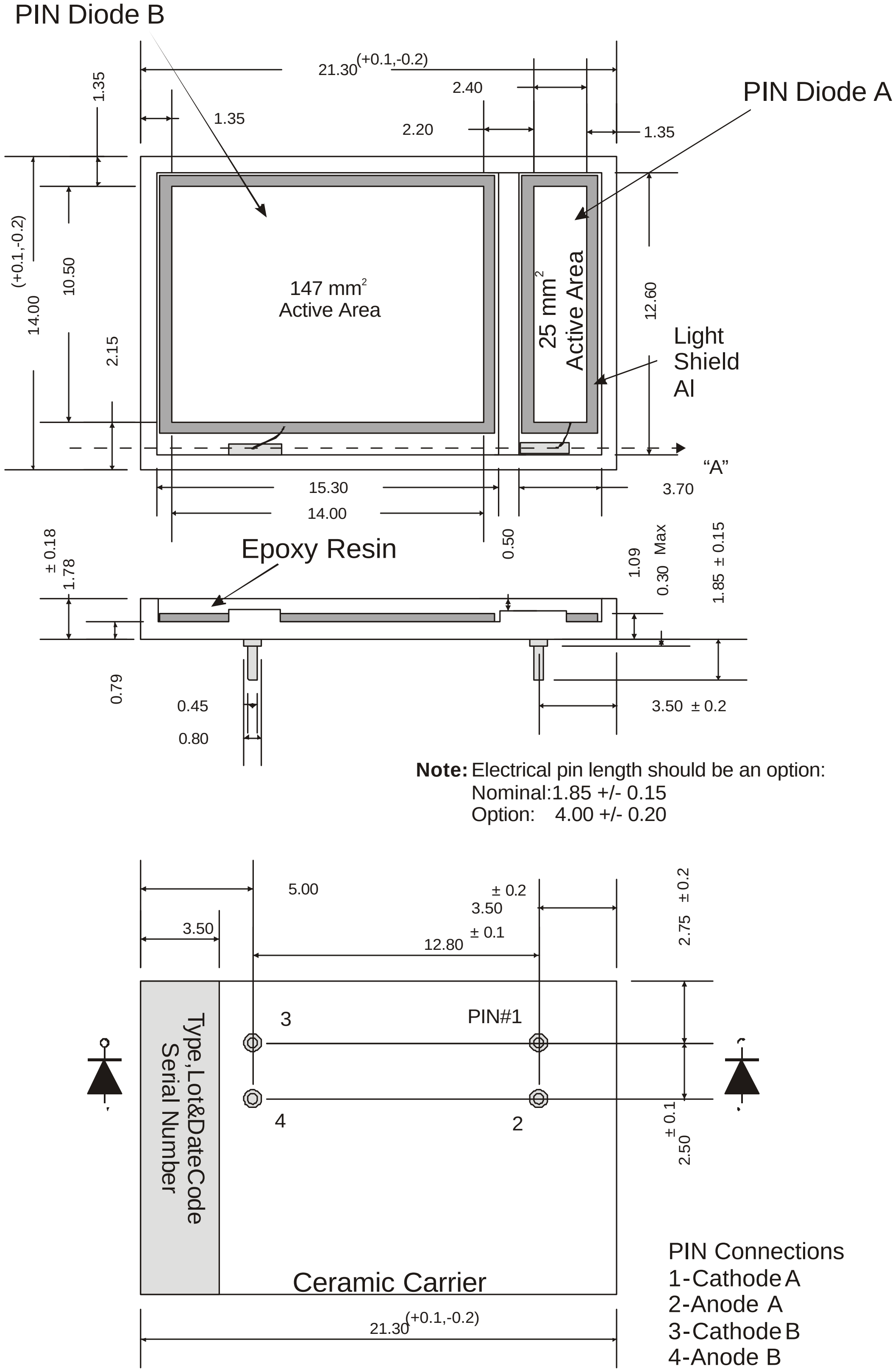

Figure 1. Daigram of the Dual PIN Photodiode Mechanical Specifications

APPENDIX A

HAMAMATSU QA CHECKLIST

HAMAMATSU'S QA ASSESSMENT

1.0 Process Controls

1.1 Quality Management

1.1.1	Does the Hamamatsu's QA have a quality management plan?	Yes ______	No ______	N/A ______
1.1.2	Does the Hamamatsu's QA have support and involvement of management in implementing and maintaining the quality management plan?	Yes ______	No ______	N/A ______
1.1.3	Does the Hamamatsu's QA have a documented and implemented plan to select?	Yes ______	No ______	N/A ______
1.1.4	Does the Hamamatsu's QA review their supplier's (ceramic substrate, epoxy, die attachment, bondwire, etc.) quality management plan?	Yes ______	No ______	N/A ______
1.1.5	Does the Hamamatsu's QA verify that their supplier's quality management plan has the support and involvement of Hamamatsu's management in implementing and maintaining the plan?	Yes ______	No ______	N/A ______
1.1.6	Does the Hamamatsu's QA verify that communication exists between design, fabrication, test and field regarding performance, quality, reliability, and failure analysis using statistical techniques?	Yes ______	No ______	N/A ______
1.1.7	Does the Hamamatsu's QA determine if quality management plan charters an internal control board or procedure that maintains communication between groups, evaluates data (SPC, reliability, screening, failure analysis, etc.) determines corrective action, and maintains records?	Yes ______	No ______	N/A ______
1.1.8	Does the Hamamatsu's QA have the name of a key contact in the internal control board?	Yes ______	No ______	N/A ______
1.1.9	Does the Hamamatsu's QA verify that the quality plan establishes clear lines of authority and responsibility?	Yes ______	No ______	N/A ______
1.1.10	Does the Hamamatsu's QA verify that the quality plan provides for periodic internal audits?	Yes ______	No ______	N/A ______
1.1.11	Does the Hamamatsu's QA review the quality documentation procedures?	Yes ______	No ______	N/A ______
1.1.12	Has the Hamamatsu's QA completed a self-assessment of their quality management plan?	Yes ______	No ______	N/A ______
1.1.13	Does the Hamamatsu's QA evaluate the self-assessment program?	Yes ______	No ______	N/A ______
1.1.14	Is the Hamamatsu's QA certified for ISO-9001 or equivalent standard?	Yes ______	No ______	N/A ______
1.1.15	Does the Hamamatsu's QA evaluate the preventive maintenance procedure?	Yes ______	No ______	N/A ______

1.2 Statistical Process Control (SPC)

1.2.1	Are the wafer fabrication and assembly lines in continuous, high volume production?	Yes ______	No ______	N/A ______
1.2.2	Does the Hamamatsu's QA have documented and implemented a plan of SPC for wafer and assembly process steps?	Yes ______	No ______	N/A ______

1.2.3 Does the Hamamatsu's QA evaluate the SPC to determine if sufficient control exists for at least the following wafer fabrication steps: Yes ______ No ______ N/A ______

Wafer
EPI Layers
Wafer backside preparation
Masks
Photolithography
Diffusion
Ion Implantation
Annealing
Oxide deposition/growth
Nitride deposition
Poly deposition
Metal deposition
Dielectric etch
Poly etch
Metal etch
Rework
Wafer parametric data
Lot acceptance results
Reliability test results

1.2.4 Does the Hamamatsu's QA evaluate the supplier's internal / SPC to determine if sufficient control exists for at least the following assembly steps: Yes ______ No ______ N/A ______

Materials
Wafer mount
Wafer saw
Visual
Wirebond
Visual
Electrical test
Mark
Dimensions

1.2.5 Does the Hamamatsu's QA's supplier evaluation criteria recognize the effectiveness of computer automated SPC chart generation. Yes ______ No ______ N/A ______

1.2.6 Does the Hamamatsu's QA request copies of current SPC control charts? Yes ______ No ______ N/A ______

1.2.7 Does the Hamamatsu's QA review the supplier's documented SPC goals and metrics? Yes ______ No ______ N/A ______

1.2.8 Does the Hamamatsu's QA review the supplier's periodic progress reports on SPC goals? Yes ______ No ______ N/A ______

1.2.9 Does the Hamamatsu's QA review the supplier's procedures for determining target values at critical process nodes? Yes ______ No ______ N/A ______

1.2.10 Does the Hamamatsu's QA review the supplier's procedures for responding to deficiencies? Yes ______ No ______ N/A ______

1.2.11 Does the Hamamatsu's QA ensure that the dies are protected and segregated at the wafer level before cutting? Yes ______ No ______ N/A ______

1.3 Continuous Improvement

1.3.1 Does the Hamamatsu's QA verify that the supplier has a documented and implemented plan for continuous improvement? Yes ______ No ______ N/A ______

1.3.2 Does the Hamamatsu's QA verify that a continuous improvement feedback loop exists from test and field operations to design and fabrication regarding yield, performance and reliability? Yes ______ No ______ N/A ______

1.3.3 Does Hamamatsu's QA review the supplier's process/product improvement projects? Yes ______ No ______ N/A ______

1.3.4 Does the Hamamatsu's QA review process/product improvement metrics? Yes ______ No ______ N/A ______

1.3.5 Does the Hamamatsu's QA request data on specific process/product improvements and the resulting feedback from field data? Yes ______ No ______ N/A ______

1.3.6 Does the Hamamatsu's QA's supplier evaluation criteria recognize the effectiveness Design of Experiments (DOE)? Yes ______ No ______ N/A ______

1.3.7 Does the Hamamatsu's QA have expertise to review and evaluate the supplier's use of wafer fabrication and assembly of PIN photodiodes yield models? Yes ______ No ______ N/A ______

1.4 PIN Photodiode Development

1.4.1 Does the Hamamatsu's QA review the supplier's use of proven design rules and standard cells that incorporate process variation statistics? Yes ______ No ______ N/A ______

1.4.2 Does the Hamamatsu's QA review the supplier's methodology of incorporating reliability data from testing, production and field into design rules? Yes ______ No ______ N/A ______

1.4.3 Does the Hamamatsu's QA determine if it is supplier (ceramic substrate, epoxy, die attachment, wirebond, etc.) policy to qualify all new parts through reliability testing? Yes ______ No ______ N/A ______

1.4.4 Does the Hamamatsu's QA have an acceptable procedure to qualify industrial grade ceramic substrate and assembly? In particular, regarding the following: Yes ______ No ______ N/A ______

Does the supplier produce equivalent MIL part?
Is industrial grade part fabricated on same wafer fabrication line as MIL part?
Is industrial grade part assembled on same line as MIL part?
Verify that industrial grade part is not a downgraded MIL part.
Pre-cap visual performed on 100% parts?
Final electrical tests performed at -30°C, room temp., and +60°C or better?
High temperature operating life
Temperature cycling
Vibration
Acceleration
ESD sensitivity
Solvent resistance
Bond strength
Die shear
Solderability
Lead integrity
External visual on 100% parts?

1.5 Quality Control

1.5.1	Does the Hamamatsu's QA have an acceptable procedure to screen PIN photodiodes? In particular regarding: Pre burn-in electrical Burn-in Final electrical External visual	Yes ______	No ______	N/A ______
1.5.2	If the Hamamatsu's QA allows the deletion of a qualification or screening step listed above, does the Hamamatsu's QA have sufficient test data to justify omitting the step?	Yes ______	No ______	N/A ______
1.5.3	Does the Hamamatsu's QA obtain copies of the supplier qualification test data for new parts (i.e., ceramic substrate, etc.)?	Yes ______	No ______	N/A ______
1.5.4	Does the Hamamatsu's QA re-qualify a part when processes or materials are changed?	Yes ______	No ______	N/A ______
1.5.5	Does the Hamamatsu's QA have sufficient expertise to review and evaluate the supplier's failure analysis on failed parts to determine the physics of failure?	Yes ______	No ______	N/A ______
1.5.6	Does the Hamamatsu's QA review the supplier's corrective action plan to correct defects or out of control processes?	Yes ______	No ______	N/A ______
1.5.7	Does the Hamamatsu's QA review the supplier's change control program for designs, processes, and materials?	Yes ______	No ______	N/A ______
1.5.8	Does the Hamamatsu's QA receive notification when changes to designs, processes or materials occur?	Yes ______	No ______	N/A ______
1.5.9	Does the Hamamatsu's QA receive notification when problems with parts are identified and subsequently resolved?	Yes ______	No ______	N/A ______
1.5.10	Does the Hamamatsu's QA require the supplier to have a quality monitoring program that periodically performs reliability tests on samples taken from the production lines?	Yes ______	No ______	N/A ______
1.5.11	Does Hamamatsu's QA receive copies of the periodic quality monitor reports?	Yes ______	No ______	N/A ______
1.5.12	Does Hamamatsu's QA use industry standard packages?	Yes ______	No ______	N/A ______

2.0 Assembly Process Controls

2.1 Quality Management Plan

2.1.1	Does Hamamatsu have a documented and implemented quality management plan?	Yes ______	No ______	N/A ______
2.1.2	Does Hamamatsu have support and involvement of management in implementing and maintaining the quality management plan?	Yes ______	No ______	N/A ______
2.1.3	Does the quality management plan require communication between design, fabrication, test and field regarding performance, quality, reliability, and failure analysis using statistical techniques?	Yes ______	No ______	N/A ______
2.1.4	Does the quality management plan charter an internal control board (i.e. similar to a review board) that maintains communication between groups, evaluates data (SPC, reliability, screening, failure analysis, etc.) determines corrective action, and maintains records?	Yes ______	No ______	N/A ______

2.1.5	Does the Hamamatsu's QA have the name of a key contact in the internal control board?	Yes ______	No ______	N/A ______
2.1.6	Does the quality plan establish clear lines of authority and responsibility?	Yes ______	No ______	N/A ______
2.1.7	Does the quality plan provide for periodic internal audits?	Yes ______	No ______	N/A ______
2.1.8	Does the quality plan require documentation of audits and follow-up actions?	Yes ______	No ______	N/A ______
2.1.9	Are the results of the self-assessment of the quality management plan available for review?	Yes ______	No ______	N/A ______
2.1.10	Does Hamamatsu have an effective preventive maintenance procedure?	Yes ______	No ______	N/A ______
2.1.11	Does Hamamatsu have sufficient SPC control for at least the following assembly steps:	Yes ______	No ______	N/A ______

Materials
Thick Film used on ceramic substrate
Wafer mount
Wafer saw
Visual
Die attach
Wirebond
Die optical epoxy encapsulation
Visual
Lead trim
Lead finish
Electrical test
Marking
Dimensions

2.1.12	Is Hamamatsu willing to provide copies of current SPC control charts?	Yes ______	No ______	N/A ______
2.1.13	Does Hamamatsu have documented SPC goals and metrics?	Yes ______	No ______	N/A ______
2.1.14	Does Hamamatsu have periodic progress reports on SPC goals?	Yes ______	No ______	N/A ______
2.1.15	Does Hamamatsu have documented procedures for determining target values at critical process nodes?	Yes ______	No ______	N/A ______
2.1.16	Does Hamamatsu have a documented procedure for responding to deficiencies?	Yes ______	No ______	N/A ______

3.0 DPD Part Qualification

3.1 Selection Criteria

3.1.1	Were proven design rules or standard cells used for the design of the DPD?	Yes ______	No ______	N/A ______
3.1.2	Was reliability data from testing, production and filed incorporated into design rules or standard cells for this part?	Yes ______	No ______	N/A ______
3.1.3	Did Hamamatsu exercise sufficient design control, verification, prototyping and qualification for the part?	Yes ______	No ______	N/A ______
3.1.4	Did Hamamatsu include the full operating temperature range in the part design?	Yes ______	No ______	N/A ______
3.1.5	Has material compatibility been addressed in part design? In particular, regarding dissimilar metals used in wire bonding, die attachment, and optical epoxy encapsulant?	Yes ______	No ______	N/A ______

3.1.6	Are cleaning materials compatible with part materials, both internal and external? In particular, will cleaning materials corrode part materials? Have long term effects been considered?	Yes ______	No ______	N/A ______
3.1.7	Were coefficients of thermal expansion considered when designing and processing parts?	Yes ______	No ______	N/A ______
3.1.8	Are there any potential areas where part reliability may be effected during environmental stress testing due to mismatches in coefficients of thermal expansion?	Yes ______	No ______	N/A ______
3.1.9	Does the next level assembly require performance of the part that is near the specification limits or is there sufficient margin?	Yes ______	No ______	N/A ______
3.4.1.10	Did the Hamamatsu's QA follow the supplier selection criteria described in the Hamamatsu's QA's parts management plan?	Yes ______	No ______	N/A ______
3.4.1.11	Did the Hamamatsu's QA follow the part selection criteria described in the Hamamatsu's QA's parts management plan?	Yes ______	No ______	N/A ______
3.4.1.12	Does the Hamamatsu's QA's evaluation of part qualification and screening data follow the documented procedures in the Hamamatsu's QA's parts management plan?	Yes ______	No ______	N/A ______

3.2 Manufacturing

3.2.1	Is the DPD a high volume, continuous production part?	Yes ______	No ______	N/A ______
3.2.2	Does Hamamatsu use statistical techniques to establish, control and verify fabrication and assembly processes and performance characteristics?	Yes ______	No ______	N/A ______
3.2.3	Are processes and equipment used to fabricate and assemble the part common to a family of DPDs?	Yes ______	No ______	N/A ______
3.2.4	Does Hamamatsu provide adequate assurance that the part will be available for both the short and long term? If not, is there an acceptable obsolescence plan?	Yes ______	No ______	N/A ______
3.2.5	Does Hamamatsu have documented procedures to inspect and control materials used to fabricate the part?	Yes ______	No ______	N/A ______
3.2.6	Does Hamamatsu have documented process instructions, lot travelers, and SPC control points for DPD part assembly? In particular, is there sufficient control for at least the following steps: Electrical test at min., room, and max. temps. Preconditioning procedures High temperature operating life Thermal cycling Bond pull Ball shear Die shear ESD sensitivity Solderability Lead integrity	Yes ______	No ______	N/A ______
3.2.7	Does Hamamatsu have internal test specification that adequately test the performance characteristics of the part?	Yes ______	No ______	N/A ______
3.2.8	Does Hamamatsu have a sufficient control in place to assure that no parts are shipped until all specified tests are complete?	Yes ______	No ______	N/A ______
3.2.9	Are tests systems and software of sufficient accuracy and precision to perform the specified tests?	Yes ______	No ______	N/A ______
3.2.10	Does Hamamatsu have sufficient maintenance, calibration, and repair procedures to maintain the required accuracy and precision of the test systems?	Yes ______	No ______	N/A ______

3.3 Reliability

3.3.1	Does Hamamatsu have sufficient data, both accelerated test data and field data, to support the reliability claims?	Yes ______	No ______	N/A ______
3.3.2	Does Hamamatsu correlate accelerated test data with filed data?	Yes ______	No ______	N/A ______
3.3.3	Does Hamamatsu destructively analyze failed parts to determine the failure mechanism?	Yes ______	No ______	N/A ______
3.3.4	Does Hamamatsu have a good understanding of the physics of failure for each of the failure mechanisms in the part?	Yes ______	No ______	N/A ______
3.3.5	Does Hamamatsu have sufficient enough understanding of the physics and the statistical methods of accelerated reliability tests to determine the realistic failure rates?	Yes ______	No ______	N/A ______
3.3.6	Does Hamamatsu have data on long term dormant storage of the DPD?	Yes ______	No ______	N/A ______
3.3.7	Does Hamamatsu have data on infant mortality rates for the DPD?	Yes ______	No ______	N/A ______

4.0 Handling and Shipping

4.1 Handling

4.1.1	Are Hamamatsu's handling procedures and storage areas sufficient to prevent damage or deterioration?	Yes ______	No ______	N/A ______
4.1.2	What is the moisture sensitivity level of the DPD?	Yes ______	No ______	N/A ______
4.1.3	Does Hamamatsu have recommended procedures for storing and handling of the part to avoid moisture-induced stress during soldering and bonding?	Yes ______	No ______	N/A ______
4.1.4	Do Hamamatsu's part handling procedures and areas prevent damage or deterioration to the part?	Yes ______	No ______	N/A ______

4.2 Shipping

4.2.1	Are parts shipped in containers to prevent moisture absorption and ESD damage?	Yes ______	No ______	N/A ______
4.2.2	If parts are moisture sensitive, are parts shipped with a moisture indicator?	Yes ______	No ______	N/A ______

APPENDIX B

PACKAGE SPECIFICATIONS

HAMAMATSU

HAMAMATSU PHOTONICS K.K.

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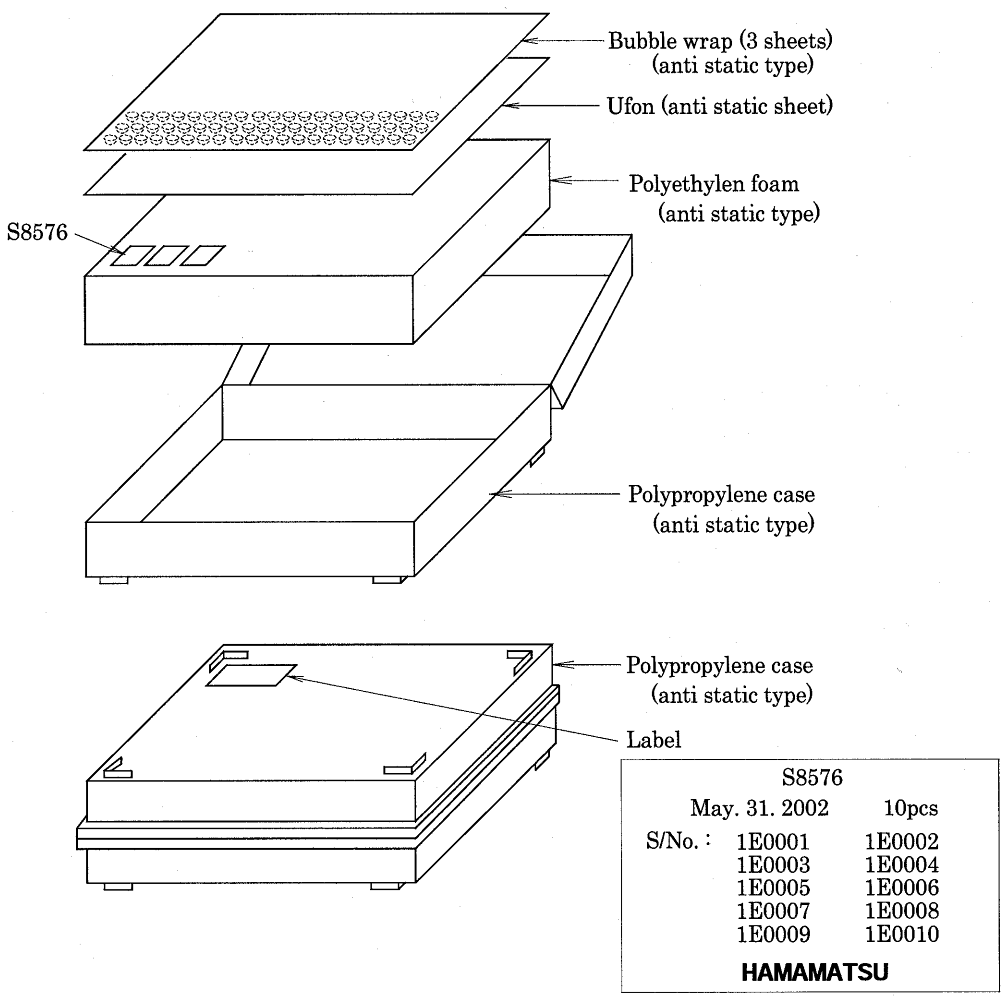
Type No. / DWG No.	ITEM	REVISIONS	DATE	APPROVED
Type No. S8576	a		. .	
	b		. .	
DWG No. KQC-B14514	c		. .	
	d		. .	
	e		. .	

7.Packing specifications

7.1 Inside packing

· Polypropylene case(Max.10pcs / case)



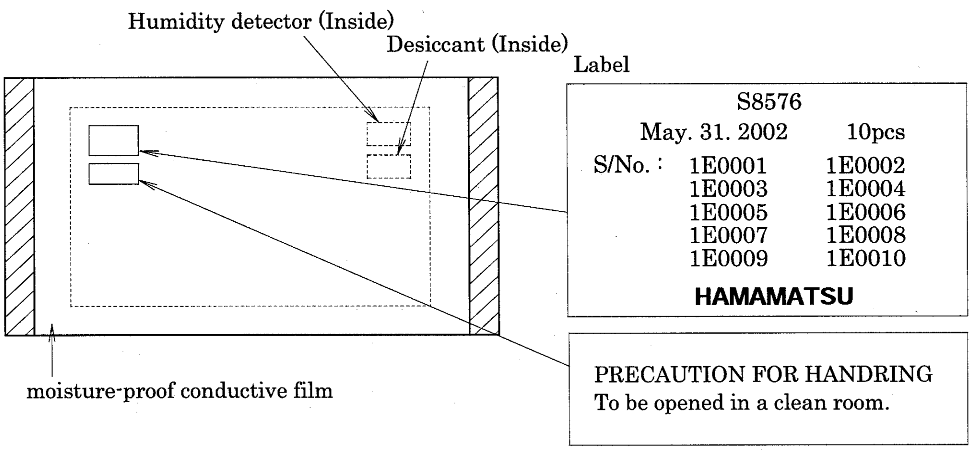
HAMAMATSU

HAMAMATSU PHOTONICS K.K.

Type No. S8576 / DWG No. KQC-B14514	ITEM	REVISIONS	DATE	APPROVED
Type No. S8576	a		. .	
	b		. .	
DWG No. KQC-B14514	c		. .	
	d		. .	
	e		. .	

7.2 Moisture-proof pack

· One humidity detector shall be included in the pack.



7.3 Outside Packing

· The devices are packed in a corrugated paper box for delivery.
· Shocks detectors shall be glued on each corrugated paper box.
· One temperature detector shall be glued on each corrugated paper box.
· Specific labels shall be glued on each corrugated paper box.