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**CRaTER**

Cosmic Ray Telescope for the Effects of Radiation

Detector Specification

Drawing Number: 32-05001

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1 Scope
This document shall serve as the procurement specification for the CRaTER detectors and shall take precedence over detector descriptions found in other documents and prior quotations.

2 Detector Supplier
Micron Semiconductor Lim, whose contact information is provided below, shall be named as the sole source supplier for the CRaTER detectors. The CRaTER program was awarded in large part due to the heritage of Micron’s detectors obtained from other NASA and DOD programs including POLAR/CEPPAD, WIND, ACE, IMAGE, STEREO, and HiLET.

2.1 Contact Information
Micro Semiconductor Limited
1 Royal Buildings
Marlborough Road
Lancing
Sussex
BN15 8SJ
UK

Telephone: 01903 755252
Fax: 01903 754155
Email: microndirect@btconnect.com
Website: www.micronsemiconductor.co.uk

2.2 Initial Quotation
During the proposal phase of the CRaTER project, Micron prepared a detector quotation (No. 5455A). The detectors for CRaTER utilize the same mask designs as the COMPASS detectors (MSD035) used as a baseline for the original proposal. While there have been NO changes to the detector silicon design and technical proposal, some additional information on its design and operation have been included in this document. Therefore, this Detector Specification document shall take precedence over the specifications found in the former quotation and a new quotation shall be prepared by Micron.
3 Points-of-Contact

3.1 Procurements and Quality Assurance POC
The point-of-contact for the procurement and quality assurance is MIT.

3.1.1 Funding
Rick Foster (Project Manager)
MIT Kavli Institute for Astrophysics and Space Research
NE80-6063 1 Hampshire Street
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bk@space.mit.edu

3.2 Technical POC
The technical point-of-contact for the CRaTER detectors is The Aerospace Corporation.

3.2.1 Detector Physics and Requirements
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The Aerospace Corporation The Aerospace Corporation
2350 E. El Segundo Blvd. 15049 Conference Center Drive,
El Segundo, CA 90245 CH3/210
M/S M2-259 Chantilly, VA 20151
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JBernard.Blake@aero.org Joseph.E.Mazur@aero.org

3.2.2 Engineering
Bill Crain (Electrical) Albert Lin (Mechanical)
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El Segundo, CA 90245 El Segundo, CA 90245
M/S M2-255 M/S M2-255
Tel: 310-336-8530 Tel: 310-336-1023
Fax: 310-336-1636 Fax: 310-336-1636
Bill.Crain@aero.org Albert.Y.Lin@aero.org
4 Detector Overview

4.1 Detector Description
There are two detector types being requested from Micron that shall be referred to as the thin detector (140um) and thick detector (1,000um). Both detectors are ion implanted totally depleted structures formed from an N-type substrate. The Phosphorous-implanted N-type substrate is referred to as the ohmic side of the detector and the Boron-implanted P-side is referred to as the junction. These implants require lower energy and result in low implant depths of ~0.3 um.

Figure 1 depicts a simplified detector cross-section. Both detectors are circular, have thin junction and ohmic windows, and have fast timing capability (i.e., although fast timing is not critical for CRaTER, it is desired to have the metallization made in such a fashion to reduce surface resistivity). There is a guard ring (Gd) around the active junction to improve edge uniformity and a neighboring field plate (FP) ring to aid discharge of oxide stray charge. Each thin and thick detector is mounted to its own small passive PCB and connected to the electronics board by shielded wire.

![Figure 1: Simplified Detector Cross-section (for reference only)](image)

4.2 Electronics Description
The external electronics (not the responsibility of Micron) will be an Amptek Charge Preamplifier A250 device with external JFET selected for low noise and high transconductance. These electronics reside on a separate printed circuit board in the CRaTER Telescope assembly and connect to the Micron detector PCB via small shielded wire. The JFET will be AC coupled to the detector junction contact, enabling collection of holes and thus positive current flow into the preamplifier. The ohmic side of the detector will be grounded and the junction will be biased negatively through a resistor sized to provide minimal drift in bias over the mission and contribute minimal noise. To avoid charge collection in the guard region, the guard will be biased independently with a dedicated resistor chosen to match the operating voltage of the junction. Figure 2
CRaTER Detector Specification

illustrates the detector interface circuit (for reference) being used in the CRaTER electronics.

Figure 2: Detector Interface Circuit (for reference only)

Table 1 summarizes the main detector specifications. Table 1 is to be used as a quick reference and not meant to supersede the actual specification text found in the body of this document.

Table 1: Primary Design and Performance Specifications Summary (for reference only)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Active area</td>
<td>9.6 cm² circular</td>
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<tr>
<td>Active dimension</td>
<td>35 mm</td>
</tr>
<tr>
<td>Active dimension tolerance</td>
<td>+/- 0.1 mm</td>
</tr>
<tr>
<td>Thickness</td>
<td>Thin = 140 um, Thick = 1000 um</td>
</tr>
<tr>
<td>Thickness tolerance</td>
<td>+/- 10 um</td>
</tr>
<tr>
<td>Thickness uniformity</td>
<td>+/- 10 um</td>
</tr>
<tr>
<td>Window</td>
<td>0.1 um ohmic, 0.1 um junction</td>
</tr>
<tr>
<td>Metalization</td>
<td>Ohmic surface and junction grid 3000 Å +/- 1000 Å</td>
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<td>Full depletion (FD)</td>
<td>Thin = 20 – 40V, Thick = 150 – 200V</td>
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<tr>
<td>Operating voltage max</td>
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</tr>
<tr>
<td>Capacitance</td>
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<tr>
<td>Leakage current max (20C)</td>
<td>Thin = 300 nA junction, 200 nA guard</td>
</tr>
<tr>
<td></td>
<td>Thick = 1,000 nA junction, 700 nA guard</td>
</tr>
<tr>
<td>Drift (max leakage @ 40C)</td>
<td>6 x Ileak @ 20C</td>
</tr>
<tr>
<td>Stability</td>
<td>1% Ileak @ 40C for 168 hours</td>
</tr>
<tr>
<td>Alpha resolution</td>
<td>Thin = 45 KeV, Thick = 35 KeV FWHM</td>
</tr>
</tbody>
</table>
5 Detector Design Specifications

5.1 Silicon Resistivity

5.1.1 Thin
The thin detector shall be constructed from an N-type silicon wafer whose resistivity is in the range 5K to 10Kohm-cm.

5.1.2 Thick
The thick detector shall be constructed from an N-type silicon wafer whose resistivity is in the range 20K to 30Kohm-cm.

5.2 Active Area
Both thin and thick detectors shall be circular with a nominal active area of 9.6 cm². The active dimension (diameter) is 35mm.

5.3 Active Dimension Tolerance
The diameter tolerance and uniformity around the circumference shall be within +/- 0.1 mm.

5.4 Thickness

5.4.1 Thin
The thin detector shall have a nominal thickness of 140 um +/- 10 um. The anticipated tolerance of the wafer prior to implantation and other processing is +/- 5 um according to Micron.

5.4.2 Thick
The thick detector shall have a nominal thickness of 1,000 um +/- 10 um. The anticipated tolerance of the wafer prior to implantation and other processing is +/- 5 um according to Micron.

5.5 Thickness Tolerance
See Section 5.4 for tolerance on detector thicknesses.

5.6 Thickness Uniformity
The uniformity of the thickness of the thin and thick detectors over the active area shall be within +/- 10 um. The anticipated tolerance is +/- 1um according to Micron.

5.7 Window

5.7.1 Ohmic side
The ohmic window shall be 0.1 um (Type 9M – see metallization Section 5.8.1).
5.7.2 Junction side
The junction implant window shall be 0.1 um (Type 9G – see metallization Section 5.8.2).

5.8 Metallization

5.8.1 Ohmic side
Metallization on the ohmic side shall be Aluminum at 3000 Å +/- 1000 Å in thickness and shall cover the entire area of the detector within manufacturing tolerance.

5.8.2 Junction side
Metallization on the junction side shall be Aluminum at 3% grid of Aluminum with thickness 3000 Å +/- 1000 Å.

5.9 Solar Blindness
There will be NO solar blind features required on either the thin or thick detector.

5.10 Guard Ring
A multi-guard ring shall be incorporated around the active junction in the space between the edge of the active area and the chip edge per Micron standard processing. A separate connection to the electronics shall be provided by Micron for the guard ring. Note on implementation: The guard ring will be biased by the external electronics at the same operating voltage as the active detector area. It is CRaTER’s understanding that the thin detector guard may be floated without degradation in performance whereas floating the thick detector guard will result in double pulsing.

5.11 Cover Layer
A protective layer of oxide with nominal thickness of 1 um shall be grown on the junction and ohmic sides of each detector for protection against environmental contaminants per Micron standard processing.

5.12 Field Plate
A field plate ring shall be incorporated on the junction side in the space between the edge of the guard ring and the chip edge per Micron standard processing. The field plate is used to aid the discharging of the oxide. The field plate will not be connected externally.

5.13 Cutting
Detector chips will be cut with a diamond edge saw. There will be no passivation after cutting, just high resistivity silicon on the edge surface.
6 Detector Performance Specifications

6.1 Full Depletion (FD)

6.1.1 Thin
The thin detector FD voltage shall be typically 20V but no greater than 40V.

6.1.2 Thick
The thick detector FD voltage shall be typically 150V but no greater than 200V.

6.2 Operating Voltage
The operating voltage supplied by the electronics will be larger than the full depletion voltage so that good uniformity of the electric field inside the active volume is obtained.

6.2.1 Thin
The minimum operating voltage of the thin detector shall be its full depletion voltage (FD). The maximum safe operating voltage (i.e., the voltage that is at least 10 volts below the knee in the I-V characteristic) shall be at least 2 x FD.

6.2.2 Thick
The minimum operating voltage of the thick detector shall be its full depletion voltage (FD). The maximum safe operating voltage (i.e., the voltage that is at least 10 volts below the knee in the I-V characteristic) shall be at least FD + 30V.

6.3 Capacitance
The detector capacitance is determined by the thickness, active area, dielectric constant of the silicon, detector mount, and parasitics.

6.3.1 Thin
The capacitance of the thin detector will be nominally 700 pF and shall not exceed 770 pF (i.e., 110% of nominal), not including cable capacitance.

6.3.2 Thick
The capacitance of the thick detector will be nominally 100 pF and shall not exceed 120 pF (i.e., 120% of nominal), not including cable capacitance.

6.4 Leakage Current

6.4.1 Thin
The leakage current drawn through the active junction of the thin detector at 20 deg C shall not exceed 300 nA (i.e., note - typical is 150 nA) at the maximum operating voltage of 2xFD. The leakage current drawn through the guard ring of the thin detector at 20 deg C shall not exceed 200 nA at the maximum operating voltage of 2xFD.
6.4.2 Thick
The leakage current drawn through the active junction of the thick detector at 20 deg C shall not exceed 1,000 nA (i.e., note - typical is 500 nA) at the maximum operating voltage of FD+30V. The leakage current drawn through the guard ring of the thick detector at 20 deg C shall not exceed 700 nA at the maximum operating voltage of FD+30V.

6.4.3 Drift
The leakage current at 40 deg C shall not exceed six times the leakage current at 20 deg C for each detector. This is based on the knowledge that leakage current will increase by about a factor of 2 for every 8 deg C rise in temperature. For example, a thin detector whose leakage at 20 deg C is measured at 150 nA shall have a measured leakage at 40 deg C of no more than 6x150nA = 900 nA. The leakage current at 20 deg C and 40 deg C shall be measured for all detectors.

6.4.4 Stability
The stability of DC leakage current for each thin and thick detector at the maximum safe operating voltage shall be within 1 % at 40 deg C over 168 hours of continuous bias.

6.4.5 Radiation – For Information Only
Radiation damage will result in an increase in leakage current. The CRaTER project, not Micron, will be responsible for testing a subset of detectors to determine the relationship between proton/heavy ion dose and leakage current.

6.5 Alpha Resolution

6.5.1 Thin
The measured pulse-height distribution due to an alpha source located in front of the junction side of the thin detector shall not exceed 45 KeV FWHM at the optimum shaping time for the test system at 20 deg C.

The measured pulse-height distribution due to an alpha source located in front of the ohmic side of the thin detector shall not exceed 45 KeV FWHM at the optimum shaping time for the test system at 20 deg C.

6.5.2 Thick
The measured pulse-height distribution due to an alpha source located in front of the junction side of the thick detector shall not exceed 35 KeV FWHM at the optimum shaping time for the test system at 20 deg C.

The measured pulse-height distribution due to an alpha source located in front of the ohmic side of the thick detector shall not exceed 35 KeV FWHM at the optimum shaping time for the test system at 20 deg C.
7 Detector Mount Specifications

A conceptual illustration of the detector mount is shown in Figure 3. Micron will provide the PCB design drawings and fabrication.

Figure 3: Detector Mounting Concept (for reference only)

7.1 Detector PCB

Each thin and thick detector shall be mounted to their own small FR4 (G10) PCB. The dimensions of this PCB are specified in Figure 4A (shown with detector) and 4B (shown without detector). All conductive surfaces shall be plated with soft Gold on 1oz Copper. Black solder resist shall be incorporated on the front and rear. The front side of the mount will contain the detector-mounting shelf. Since two detectors will be stacked in the CRaTER telescope (similar to COMPASS design), the PCB depth on the backside will be routed around the rim of the detector to provide room for the rear bond wires and a path for out-gassing.

7.2 Detector Attachment

The detector shall be attached to the substrate around the entire circumference with TBD adhesive. The adhesive will be chosen to provide necessary compliance and pliability to mitigate thermal mismatch of the PCB and detector, and to dampen mechanical resonances at the detector interface.
7.3 Bond Wires
There shall be 3 bond wires per contact. The bond wires will be ultrasonic 50um Aluminum. – TBR

7.4 Connections
Detectors shall be delivered with two 20cm-long Junkosha miniature coaxial cables, one for the junction and one for the guard connections. The shield of each connection shall be connected to the ohmic ground on the detector PCB. These wires will be cut to the proper length by the CRaTER project during the CRaTER telescope assembly.

7.5 Connector
The CRaTER project will install the connector that mates the detector wires with the electronics during the Telescope assembly. This will be done at The Aerospace Corporation.

The connector will be an Airborn 2-row strip connector with four contacts. One contact will be used for the junction wire, one for the guard wire, and one for each of the two shields. The part number is MA-221-010-215-A5300. It is a polyphenylene sulfide body with mounting holes and with straight 50 um gold plated solder cups. The mating connector on the electronics board is MA-2D1-010-325-A5200. – TBR.

7.6 Housing
The CRaTER project will design and manufacture the metallic housing for the detectors. This will be done at The Aerospace Corporation. The critical dimensions for the PCB are based on the CRaTER Telescope design.
Figure 4A: Detector Mount Detail with Silicon Detector shown (dimensions in mm)
Figure 4B: Detect Mount Detail without Silicon Detector (dimensions in mm)
8 Verification and Qualification

8.1 Verification
The verification matrix of Table 2 specifies the verification method and program responsibilities for proving that the detector design and performance specifications are satisfied. The verification method is classified as demonstration (D), inspection (I), analysis (A), or test (T). The acceptance criteria are that all requirement specifications, as referenced by the verification matrix, are satisfied by the results of the verification method. The verification matrix also lists the required tests for engineering grade (E-grade) detectors and flight grade (F-grade) detectors. E-grade detectors require fewer verification steps than the F-grade. The verification matrix further specifies whether the requirement is verified before or after qualification tests (see next section). In some cases, verification is required both before and after qualification.

8.2 Qualification
In addition to the verification process, F-grade detectors shall be subjected to a series of environmental qualification tests as follows. Qualification tests are NOT requested for E-grade detectors. The sequence of qualification tests shall be as listed below starting with the non-destructive wire bond pull test.

8.2.1 Non-destructive Wire Bond Pull Test
Each flight detector shall demonstrate wire bond integrity by a non-destructive wire bond test.

8.2.2 Random Vibration
A 3-axis random vibration test shall be performed on all flight detectors in accordance with CRaTER-supplied vibration levels.

8.2.3 Thermal Cycling
A thermal cycling test shall be performed on all flight detectors for 10 cycles at –40 C to +40 C and biased at the maximum safe operating voltage. One additional cycle shall be performed with zero bias on the detector over the range –50 C to +60 C.

8.2.4 Thermal Vacuum
Not required.

8.2.5 Pulser Noise Test
A pulser noise test shall be performed to determine the noise contribution of the detectors in an electronic system. A pulser shall be injected into the preamp electronic system with biased detectors. The resulting FWHM of the pulse height distribution shall be documented for each detector.

8.2.6 Test Criteria
Qualified detectors shall have demonstrated compliance before and after qualification according to the verification matrix of Table 2 for F-grade detectors.
8.2.7 Flight Acceptance
Final acceptance of F-grade detectors shall include documentation of inspection and test results proving compliance to the specifications for pre and post qualification according to the methods described in the verification matrix. Pulser noise test results shall be documented for each detector.
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9 Quality Assurance Requirements
The detectors shall be built in accordance with ISO9001. All detectors shall be serialized and batch travelers shall be maintained. Test documentation shall be maintained for each detector containing test results and graphs as described in the deliverables section. The CRaTER QAM (Quality Assurance Manager) shall be given a tour of the facility prior to acceptance of deliverables and preferably prior to start of manufacturing. This is to be in compliance with NASA Mission Assurance Requirements.

10 Statement of Work
Micron will purchase the silicon wafers, fabricate the detectors, develop detailed design drawings of the detector PCB, manufacture the detector PCB, purchase and install interface wiring, attach detectors to PCBs, and perform functional and environmental testing as required by the grade of detectors being procured.

Micron will provide a suitable shipping container for each detector shipment.

Micron will supply test documentation and batch travelers upon delivery of the detectors.

Micron will perform these duties according to the technical requirements specified in this document.