CRaTER Detector Specification

CRaTER
Cosmic Ray Telescope for the Effects of Radiation

Detector Specification

Drawing Number: 32-05001

Revision 01

July 14, 2005
CRaTER Detector Specification

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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 Ltd, 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. The detectors described in this document utilize the heritage and space qualified design of the MSD035 COMPASS project detectors.

2.1 Contact Information
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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 technical proposal, some additional information has been included on the design and operation of the detector, as well as tolerance specifications on some important properties. 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
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3.2 Technical POC
The technical point-of-contact for the CRaTER detectors is The Aerospace Corporation.

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Bill.Crain@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 substrate is referred to as the ohmic side of the detector and the implanted P-side is referred to as the junction.

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)

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 illustrates the detector interface circuit (for reference) being used in the CRaTER electronics.
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>
</tr>
</thead>
<tbody>
<tr>
<td>Active area</td>
<td>9.6 cm² circular</td>
</tr>
<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>
</tr>
<tr>
<td>Full depletion (FD)</td>
<td>Thin = 20 – 40V, Thick = 150 – 200V</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>FD + 30V</td>
</tr>
<tr>
<td>Capacitance</td>
<td>Thin = 700 pF, Thick = 100 pF</td>
</tr>
<tr>
<td>Leakage current (20C)</td>
<td>300 nA junction, 200 nA guard</td>
</tr>
<tr>
<td>Alpha resolution (junction)</td>
<td>Thin = 100 KeV, Thick = 35 KeV FWHM</td>
</tr>
<tr>
<td>Alpha resolution (ohmic)</td>
<td>Thin = 110 KeV, Thick = 40 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.

5.4.2 Thick
The thick detector shall have a nominal thickness of 1,000 um.

5.5 Thickness Tolerance
The thickness of the thin and thick detector shall be to specification within +/- 10 um.

5.6 Thickness Uniformity
The uniformity of the thickness of the thin and thick detectors over the active area shall be to specification within +/- 10 um.

5.7 Window

5.7.1 Ohmic side
The ohmic window shall be 0.1 um (Type 9M – see metallization Section 4.8.1).

5.7.2 Junction side
The junction implant window shall be 0.1 um (Type 9G – see metallization Section 4.8.2).
5.8 Metallization

5.8.1 Ohmic side
Metallization on the ohmic side shall be 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 a 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. The guard ring will be biased by the external electronics.

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 shall be laser cut.
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.

The minimum operating voltage of the detector, thin or thick, shall be its full depletion voltage (FD). The minimum safe operating voltage will be 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 Active contact
The leakage current for the thin and thick detectors drawn through the active junction contact at 20 deg C shall not exceed 300 nA.

6.4.2 Guard ring contact
The leakage current for the thin and thick detectors drawn through the guard ring contact at 20 deg C shall not exceed 200 nA.

6.4.3 Drift
Leakage current will increase by approximately a factor of 2 for every 8 deg C rise in temperature.
6.4.4 Radiation
Radiation damage will result in an increase in leakage current by approximately 1 nA / cm² / 100 Rads. This is a worst-case prediction with no consideration for annealing affects, which will likely result in a much lower rate.

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 100 KeV FWHM.

The measured pulse-height distribution due to an alpha source located in front of the ohmic side of the thin detector shall not exceed 110 KeV FWHM.

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.

The measured pulse-height distribution due to an alpha source located in front of the ohmic side of the thick detector shall not exceed 40 KeV FWHM.
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.

![Detector Mount Concept](image)

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 Test and Verification

8.1 Engineering Grade Detectors
Detectors procured for the CRaTER engineering model shall have limited testing prior to delivery. The test shall include measurement of full depletion voltage, guard and junction leakage current at 20 deg C, capacitance, and an alpha resolution measurement. No environmental testing is required on engineering detectors.

8.2 Flight Grade Detectors
Detectors being procured as flight grade shall be subjected to the following tests prior to delivery.

8.2.1 Random Vibration
A 3-axis random vibration test shall be performed on all flight detectors in accordance with CRaTER-supplied specifications. –TBR.

8.2.2 Thermal Cycling
A thermal cycling test shall be performed on all flight detectors in accordance with CRaTER-supplied specifications but no more than 10 cycles. –TBR.

8.2.3 Stability
The stability of each detector at the operating voltage shall be measured at 20 deg C in a Nitrogen environment for 168 hours.

8.2.4 Thermal Vacuum
A hot thermal vacuum test shall be performed at the CRaTER-supplied temperature (nominally 40 deg C) for 21 days at 10⁻⁶ Torr. This is to verify the operation of the field plate and stability of the leakage current at hot temperatures.

8.2.5 Test Criteria
Detectors shall be accepted based on measurements before, during, and after environmental tests that demonstrate stability of the I-V characteristics at the operating voltage and compliance to this document’s Design and Performance Specifications.

8.2.6 Flight Qualification
Final qualification tests shall include measurement of full depletion voltage, guard and junction leakage current at 20 deg C, capacitance, and an alpha resolution measurement. The final resolution measurement of each detector shall be made by an alpha source test and pulser noise test on both the junction and ohmic sides after completion of all environmental tests.

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 Detector Specification

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.