NASA-STD-8739.11 Tutorial
D1: Detectors

Prepared by Dan Kelly, NASA GSFC

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Acronyms

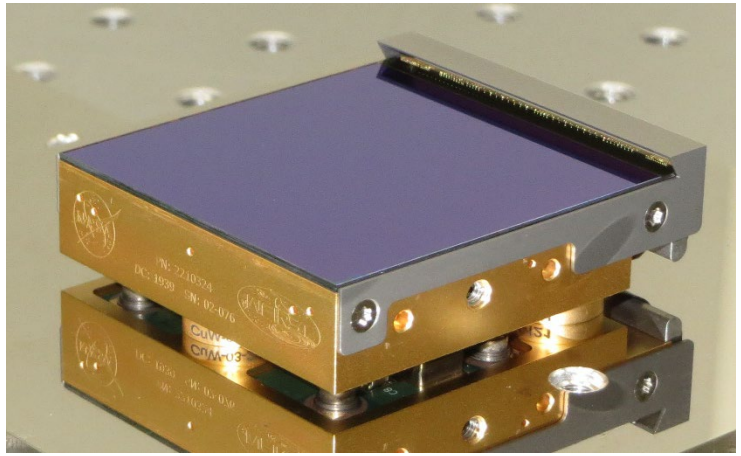
CCD	Charged-Coupled Device
CMOS	Complimentary Metal-Oxide Semiconductor
CTE	Coefficient of Thermal Expansion
DPA	Destructive Physical Analysis
FPA	Focal Plane Assembly
HgCdTe	Mercury Cadmium Telluride
InGaAs	Indium Gallium Arsenide
IR	Infrared
mKID	Microwave Kinetic Inductance Detector
MMC	Metallic Magnetic Calorimeter
NASA	National Aeronautics and Space Administration
NEPP	NASA Electronic Parts & Packaging (Program)
NESC	NASA Engineering & Safety Center

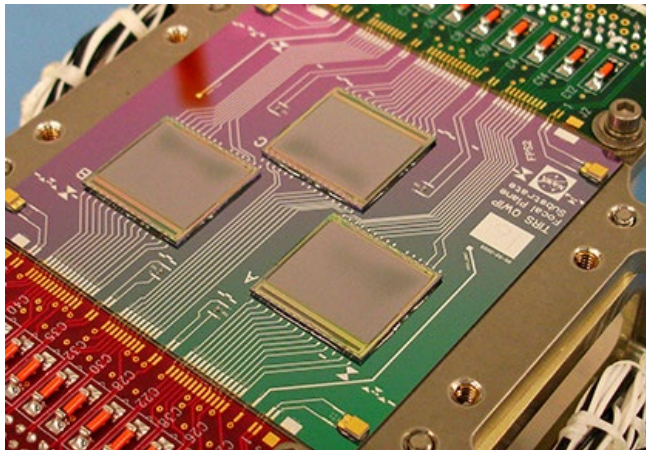
NSC	NASA Safety Center
QWIP	Quantum Well Infrared Photodetector
SCA	Sensor Chip Assembly
SCD	Source Control Document
SLS	Strained-Layer Superlattice
SME	Subject Matter Expert
SNSPD	Superconducting Nanowire Single Photon Detector
TES	Transition Edge Sensor
TIRS	Thermal Infrared Sensor instrument
ROIC	Read-Out Integrated Circuit
RST	*[Nany Grace]* Roman Space Telescope
VICD	Vendor Item Control Drawing
WFI	Wide Field Instrument

Covered Part Type Description

- This is a new category for 8739.11, which was not previously addressed in EE-INST-002
- This section covers devices consisting of multi-pixel sensors for a portion of the electromagnetic spectrum
  - Examples include CCDs, CMOS sensors, SLS, InGaAs, HgCdTe, and QWIPs
  - May be monolithic or hybrid devices, includes the CMOS ROIC that forms part of a hybrid. Frequently uses non-hermetic packaging
  - Superconducting detectors such as TES, mKIDS, SNSPDs, and MMCs are a highly specialized subclass and may need considerable tailoring of the requirements and guidelines in this section
- The requirements for these devices can be highly specialized. Thus, 8739.11 Section D1 is less prescriptive and instead provides general guidelines to consider when these parts are used. Consultation with a detector SME is highly recommended to tailor requirements.

Teledyne HgCdTe H4RG-10 SCA for the RST WFI





QWIP Detectors on the TIRS FPA for Landsat 8

Key Considerations

- Many IR Detectors operate at cryogenic temperatures below standard -55/+125 °C qualification range, as low as 20K (-253 °C)
  - Reliability at cryogenic temperatures is not driven by the same mechanisms as normal temperature ranges. For example, hot electron effects may cause degradation at cryogenic temperatures that is not captured in standard temperature screening or lifetime tests – may result in deratings not typically encountered at normal operating temperatures
  - Additionally, detector and construction materials in hybrid assemblies may constrain hot-side thermal limits. Consult manufacturer for specs
  - Lifetime and thermal cycle qualification tests should be tailored to the detector operating temperature range and thermal limitations
  - Storage at cold or cryogenic temperatures may extend the life of some devices

Key Considerations

- Detectors are often produced in low quantities and may be the result of new technology developments
  - Process and material composition details are often proprietary, however appropriate understanding of manufacturing processes and materials is critical and may require additional qualification and documentation of individual process steps
  - Flagship missions often include extended technology development, however most missions make use of detector technologies closely related to those that have flown before, or even use spare detectors from other missions. In these cases exceptional care is required to ensure heritage claims are supported and no process improvements or vendor changes have been overlooked
  - Qualification tests frequently leverage detectors that have faulty electro-optical performance or are deemed “engineering grade”

Key Considerations

- Custom packaging may be required for some missions, which could use novel attachment techniques and/or materials. These packages shall be subject to rigorous testing and analysis to determine acceptability:
  - Analysis of material usage and compatibility
  - Materials and thermal cycling – delamination, cracking or other CTE mismatch concerns
  - Bonding agent reliability and temperature limits (e.g. ensure glassification temperatures are well above maximum survival temperature)
  - Contamination (outgassing, intrinsic radioactivity)
  - Adhesive voids, particularly underfill in hybrid construction where voids may affect performance or reliability
  - Space charging

Major Changes from EEE-INST-002

- This section is new, introduced in 8739.11 D1
- D1 Table 1 specifies required evaluation, screening, acceptance, and DPA depending on detector construction:
  - Monolithic Microcircuit Construction
  - Hybrid Microcircuit Construction
  - Semiconductor
- Includes guideline for electrical inspection and test characteristics to be defined in SCD and VICD

Inspection/Tests as Defined in SCD and VICD
Dark current (Leakage)
Forward resistance
Noise Spectral density
Capacitance
Quantum Efficiency
Sensitivity
Responsivity (As Applicable)
Spectral response
Gain
Frequency response
Nonlinearity

DRAFT

Send email to address below for questions

Daniel.P.Kelly@nasa.gov