Development of a 1K x1K, 8-12 micrometer QWIP array

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Overview

- Background and Project Goals
- Instrument Overview
- Subassembly Description
- Operating Conditions
- Current System Performance Status
- Videos

Background

NASA Earth Science missions require long wavelength, high spectral resolution, compact instruments

The earth's thermal emission peaks in the 8-12μm spectral band--important spectral region in studying the solar radiation balance between the earth's surface and atmosphere

Critical spectral region for monitoring Global Warming

Additional scientific applications:

Cloud parameters such as:

Height, fraction, emissivity, ice/water content, particle size and phase

Earth surface parameters such as:

Soil and vegetation type, temperature, emissivity and pollutants

Atmospheric parameters such as:

Temperature sounding and composition of both major and trace species.

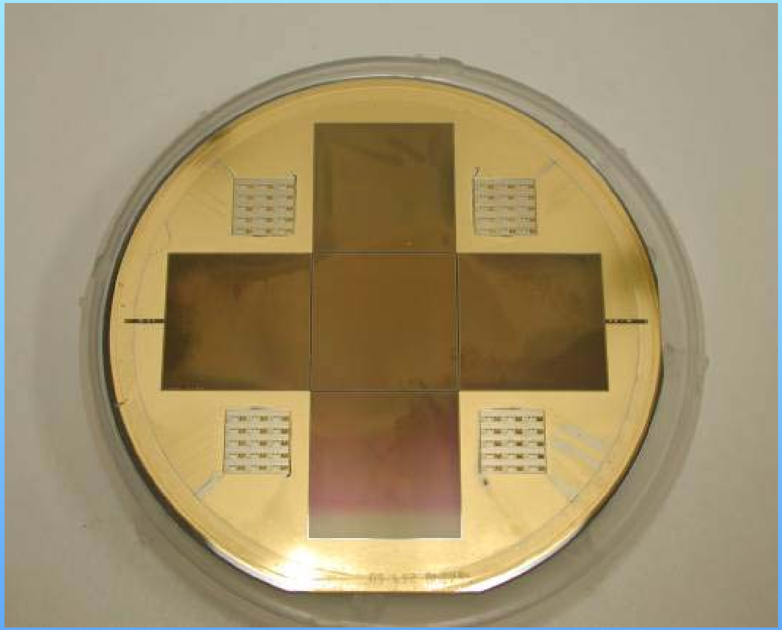
Global environmental monitoring (BASE-Asia project in SE Asia)

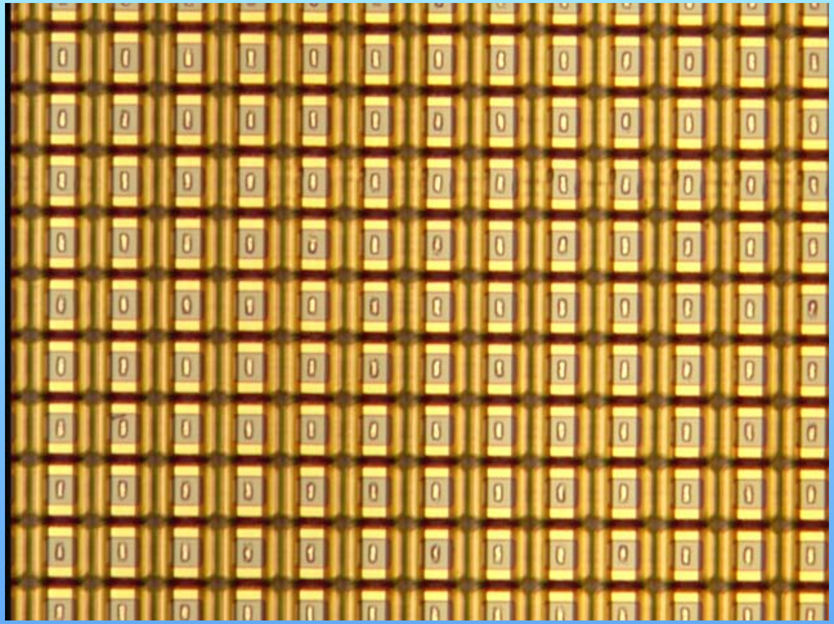
Three year funding granted to GSFC by competitive award from NASA's Earth Science Technology Office (ESTO). CO-I's are ARL and JPL.

PROJECT GOALS

1. Design a 1K x 1K, 8-12μm GaAs/silicon readout QWIP hybrid
2. Fabricate/procure 1K x 1K CMOS readout integrated circuit (ROIC)
3. Fabricate QWIP arrays and hybridize to the ROIC
4. Design and procure front end optics
5. Design and configure both LHe and Stirling cycle (mechanical) coolers
6. Develop test electronics
7. Characterize the array over the 8-12μm IR spectrum
8. Perform airborne experiments

Processed FPA



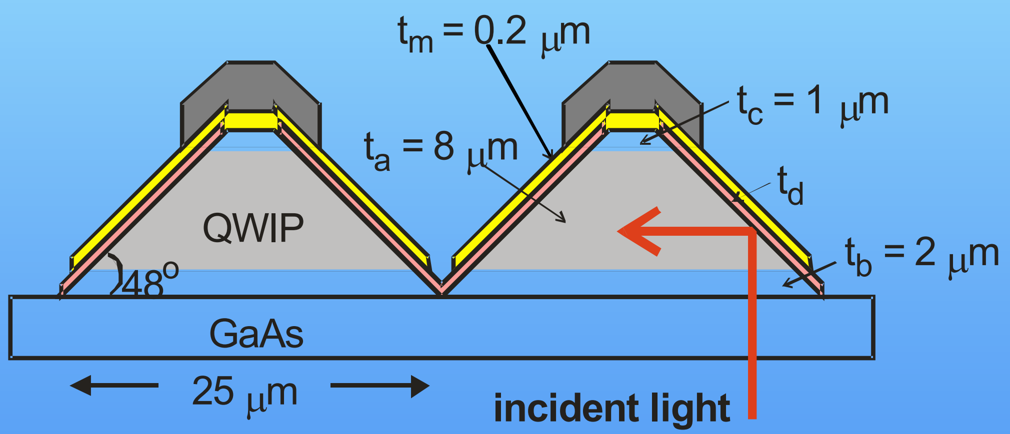


C-QWIP 4" Wafer LC2-259

Fabrication

- QWIPs do not interact with normal incidence radiation--require some form of structure to deflect radiation parallel to the surface.

- A corrugation (sawtooth) structure provides 90^0 deflection coupling light into the QWs.



- Dark current/sensitive volume is reduced which leads to an effective improvement in QE over other optical coupling methods.

LC2 Structure and Spectral Response

15,000 Å $n = 0.9 \times 10^{18}$ cm^{-3} GaAs

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50 Å undoped $Al_{0.12}Ga_{0.88}As$

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5 Å $n = 0.9 \times 10^{18}$ cm^{-3} GaAs

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40 Å $n = 0.9 \times 10^{18}$ cm^{-3} $In_{0.1}Ga_{0.9}As$

--- x 106

5 Å $n = 0.9 \times 10^{18}$ cm^{-3} GaAs

---

700 Å undoped $Al_{0.12}Ga_{0.88}As$

27000 Å $n = 0.9 \times 10^{18}$ cm^{-3} GaAs

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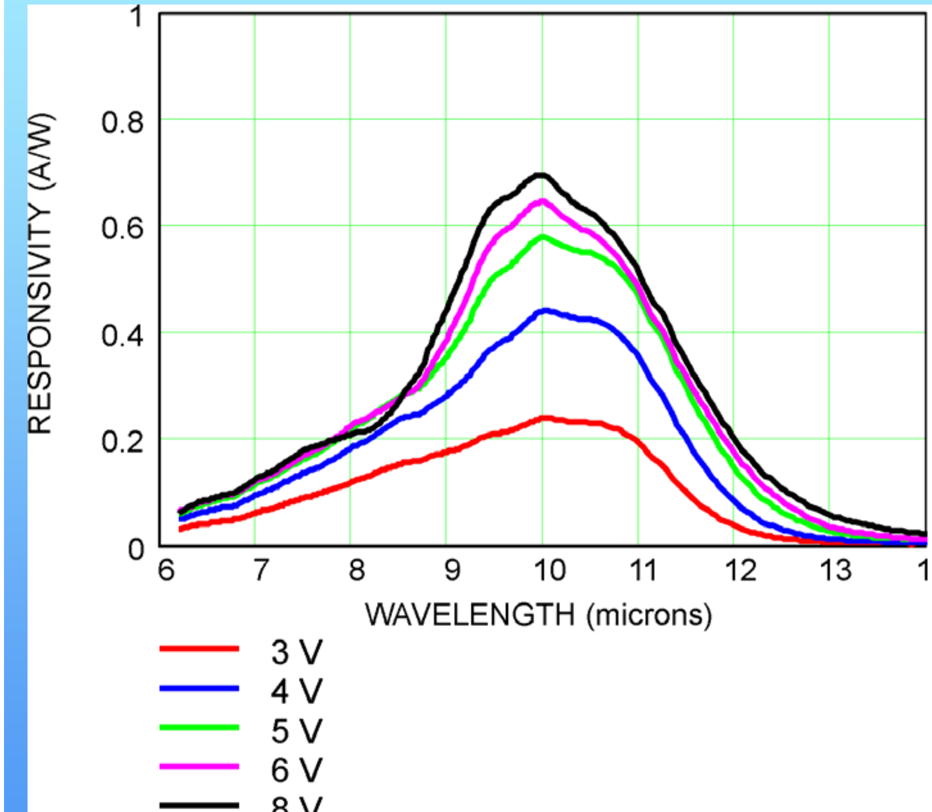
500 Å undoped $Al_{0.3}Ga_{0.7}As$ (stop etch layer)

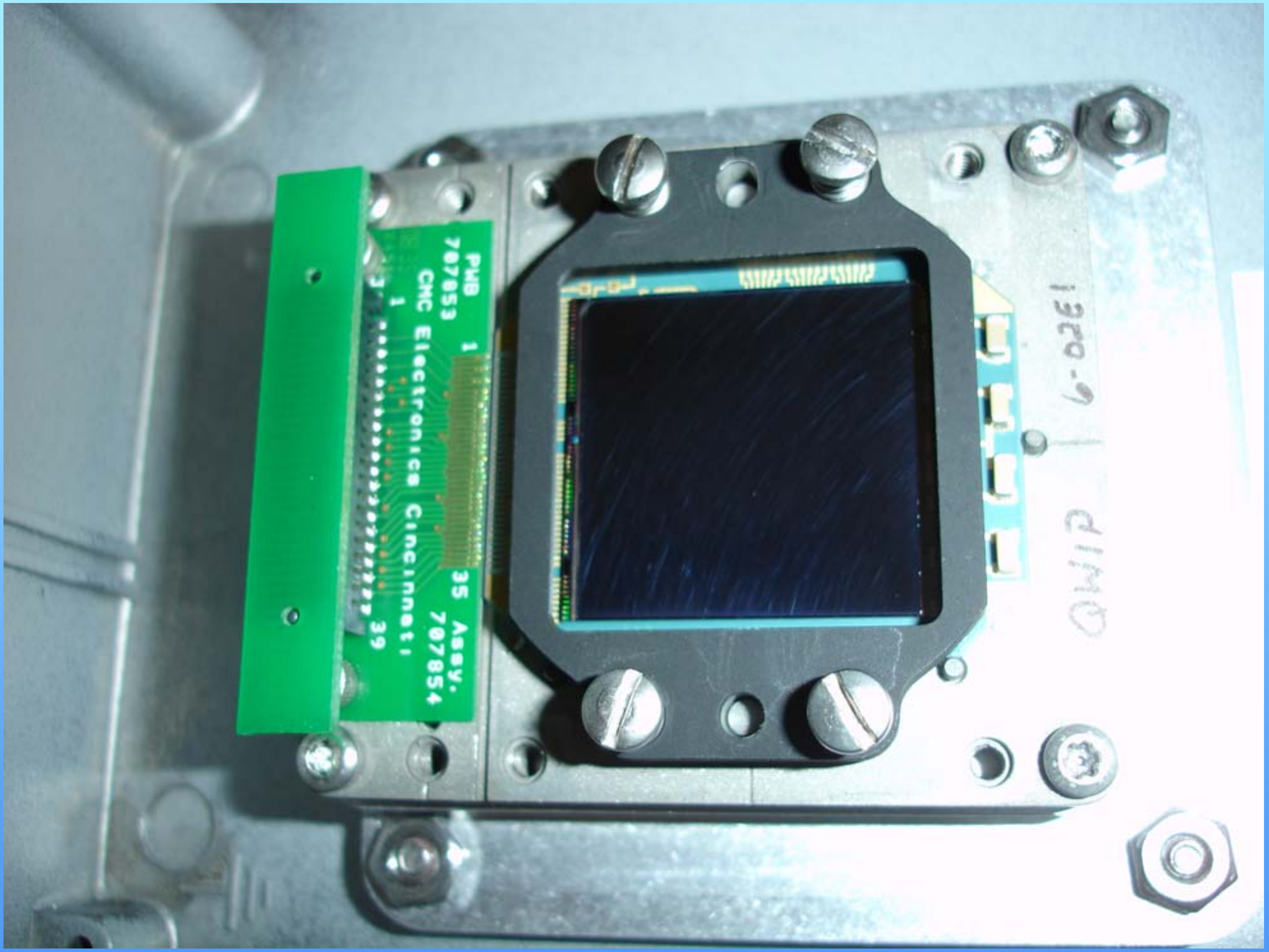
2500 Å undoped GaAs

GaAs semi-insulating substrate

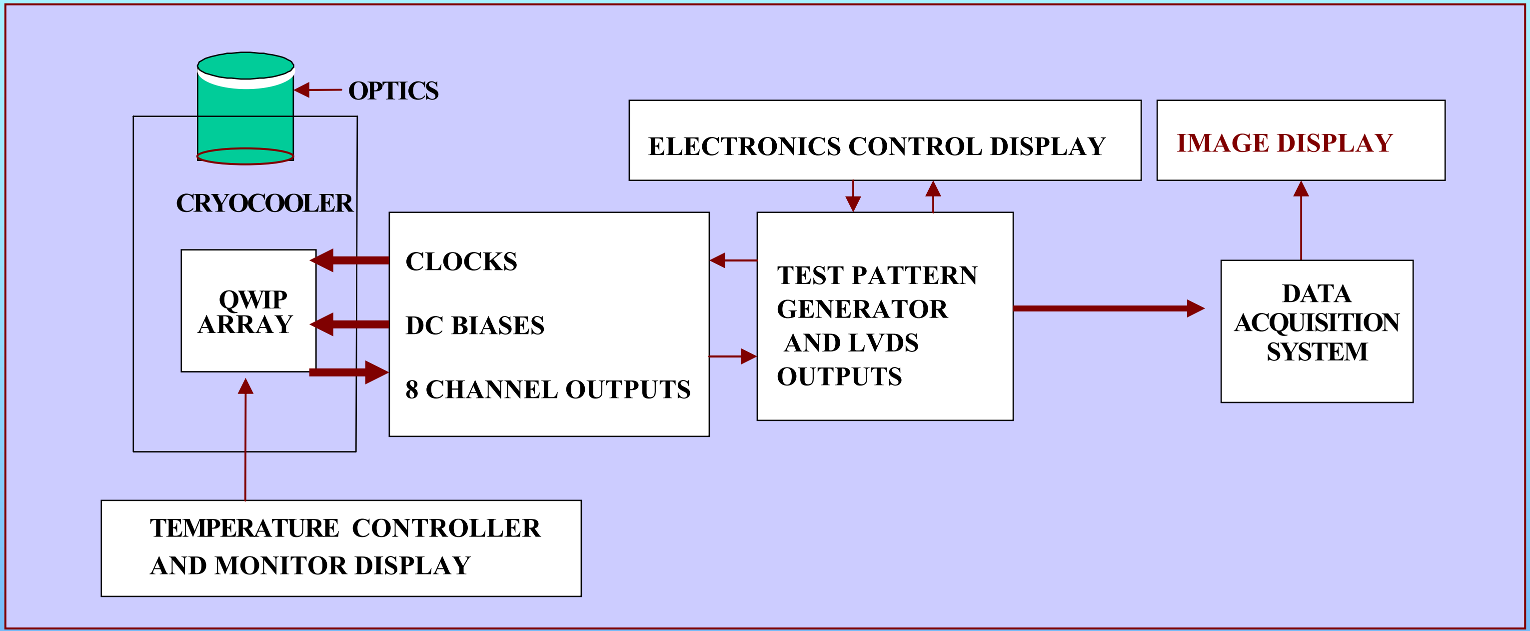
Test detector, edge coupling



LWIR 1K x 1K QWIP Focal Plane Array



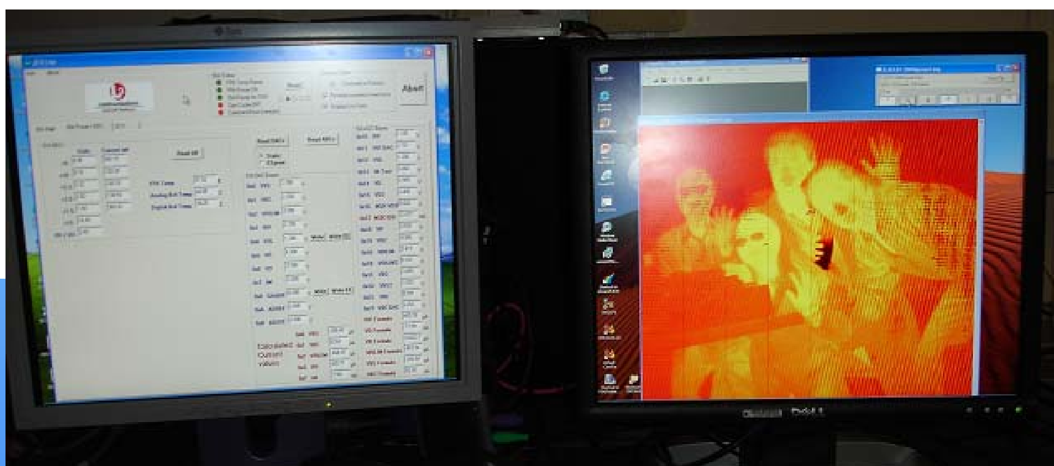
System Configuration

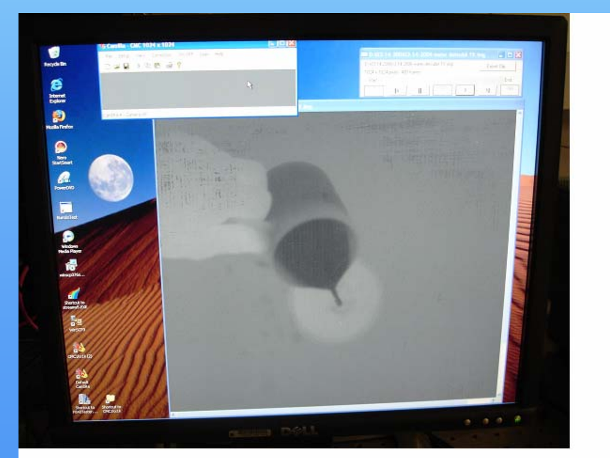


L3 Readout IC (and SE-IR data acquisition) with multiple features such as:

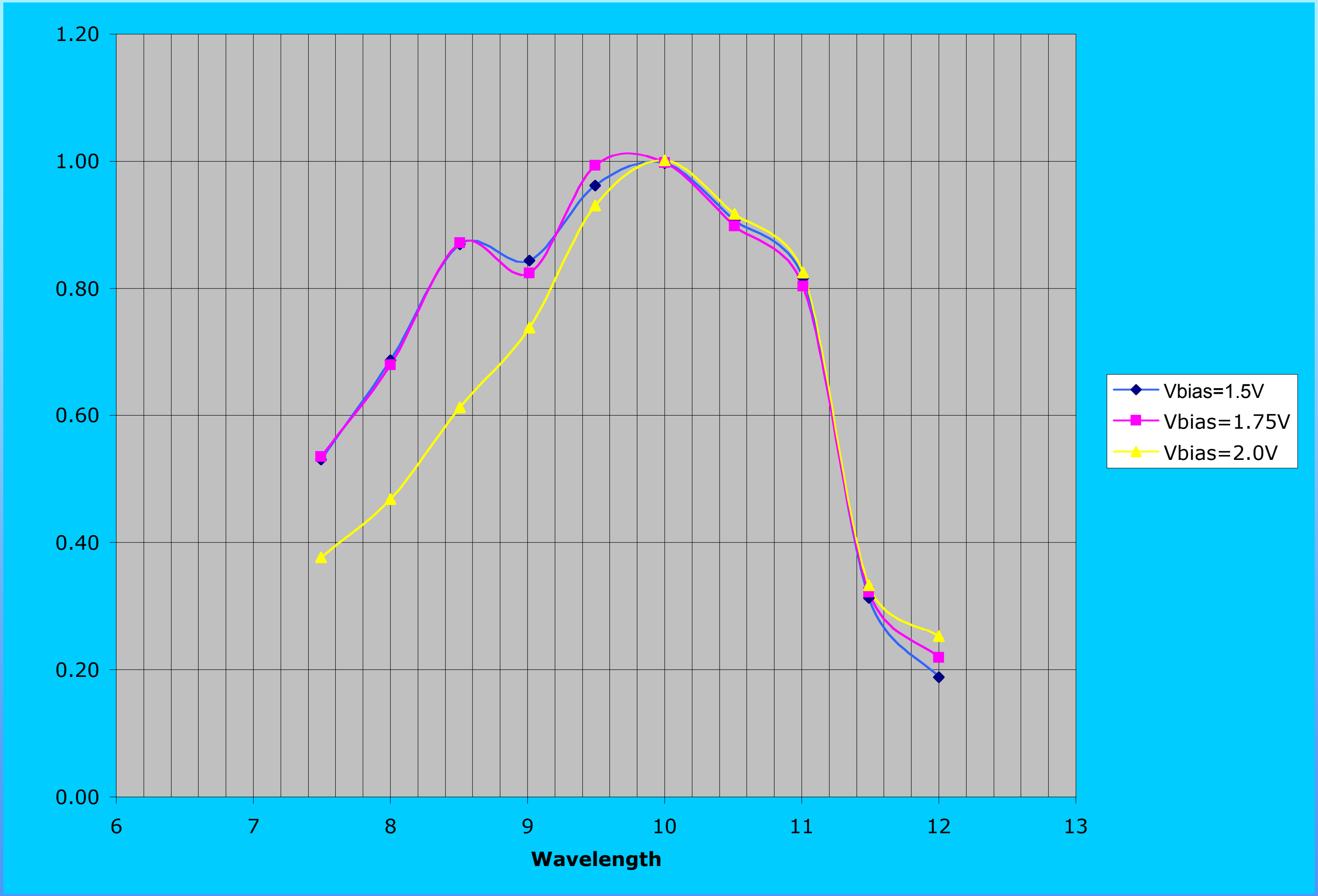
- 8 analog outputs
- Programmable integration time (from .016 ms to 16 ms)
- 13 million e- full well capacity
- Frame rates of up to 60Hz
- Internal gain 0.2μv/e or 750e/ADU

QWIP Camera and Electronics System

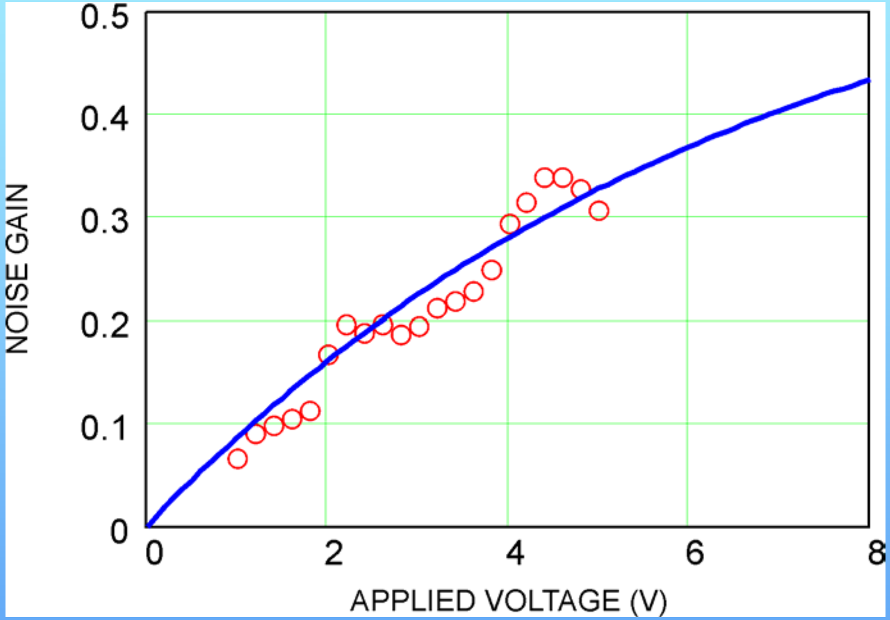


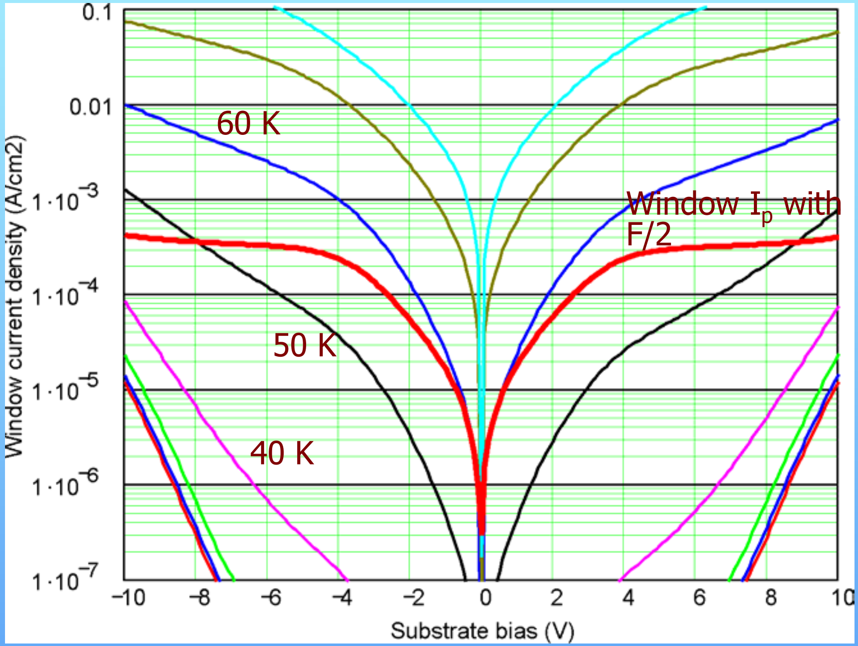


Measured Array Spectral Response

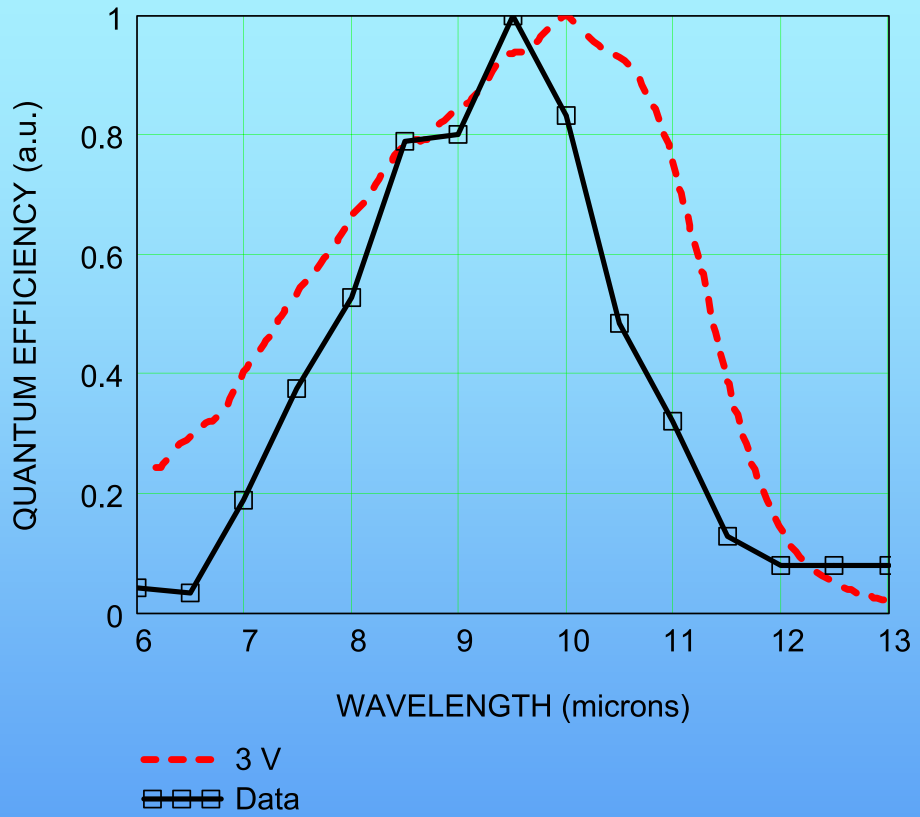


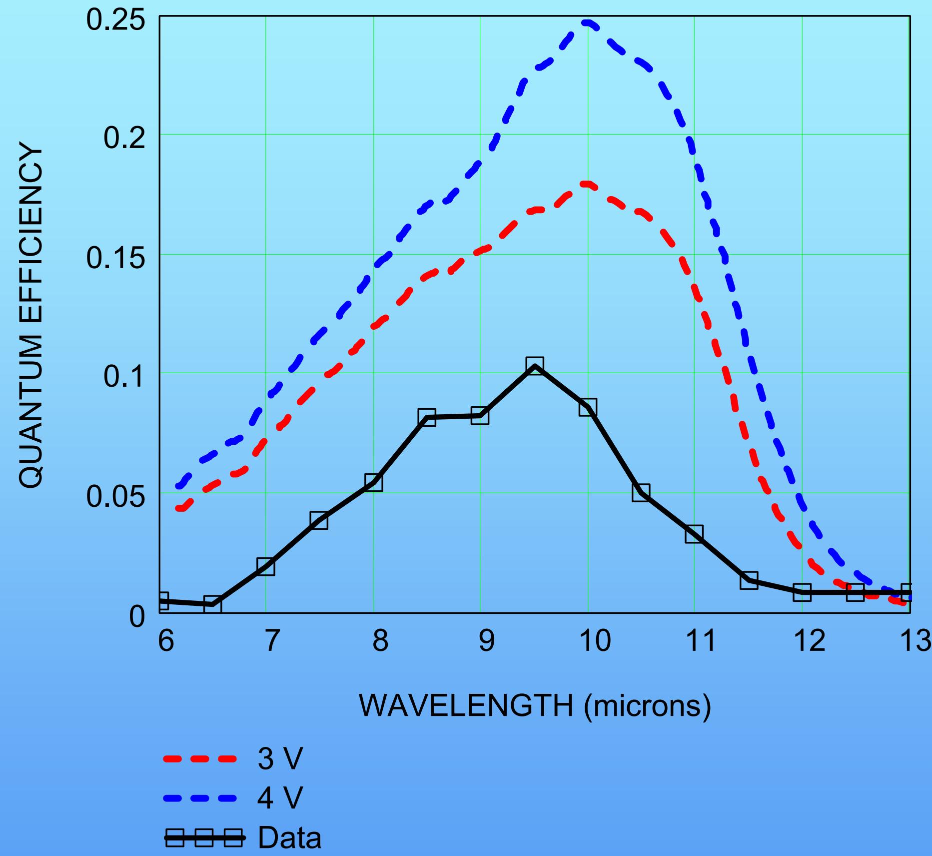
Noise Gain and Current Density





Predicted QE and Data





Dashed curves are predicted Q.E. based on single detector measurement.

Data is consistent with 2.4V QWIP FPA bias.

Quantum Efficiency

Conversion efficiency: $\dfrac{\text{number of electrons out}}{\text{number of incident photons (Q)}}$

g, conversion gain: $\dfrac{\text{number of absorbed photons}}{\text{number of electrons out}}$

η, (internal) quantum efficiency: $\dfrac{\text{number of incident photons}}{\text{number of absorbed photons}}$

$$Q = \int S(\lambda) W(\lambda) d\lambda \quad \text{(calculated)}$$

$$g = i_n^2/(4qI_d \Delta f) = .13 \quad \text{(measured)}$$

Spectral response:	8μm-12μm
Integration time:	16msec
Detector bias:	1.5v (?)
Blackbody temperature :	323K
F#:	f/2

η_{peak} (10μm): 1.4-2.0%

Quantum Efficiency

Conversion efficiency: $\frac{\text{number of electrons out}}{\text{number of incident photons}}$

g, photoconductive gain: $\frac{\text{number of absorbed photons}}{\text{number of electrons out}}$

η, (internal) quantum efficiency: $\frac{\text{number of incident photons}}{\text{number of absorbed photons}}$

g=.13

Spectral response:	8μm-12μm
Integration time:	16msec
Detector bias:	1.5v (?)
Blackbody temperature :	323K
F#:	f/2

η_{peak} (10μm): 1.2-1.6%

Acknowledgements

We would like to recognize the effort and support of L3/Cincinnati Electronics, SE-IR and the generous support and patience of NASA's Earth Science Technology Office

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Darrel Endres - L/3 FPA process engineer

Mark Stegall-SE-IR Corp.

Video Description
(about 3 minutes)

Four short clips illustrating various QWIP imaging features:

1. Clip of seeing eye dog and team members
2. Clip of soldering iron dipped into a dish of water
3. Clip showing engineer’s hand/lab coat encounter
4. Clip showing moisture effect on a lab coat