



## **Imaging Division**



**Rockwell Scientific Imaging Division** supplies state-of-the-art infrared (IR) and visible (VIS) focal plane arrays (FPAs) together with integrated camera systems & electronics to customers for industrial, commercial, scientific, satellite and optical communications applications.

Our product offerings include standard and custom products. We provide standard infrared focal plane arrays for use in such applications as remote sensing, astronomy, satellite guidance and thermal viewing. Our custom products line allows our customers the flexibility to specify detector cutoff wavelengths to meet the sensing needs of a given application. Also, the electronics can be chosen to meet system requirements such as frame rate, signal to noise and array format. In addition to supplying FPA's, we also offer control and read out electronics ("photon to bits") as well as fully integrated high-speed, multichannel camera systems.

Our steady growth over the last several years has enabled us to build expertise in areas relevant to the development, fabrication and implementation of infrared and visible light imaging detector arrays including:

- State-of-the-art detectors
- Imaging systems electronics
- Mixed signal state-of-the-art CMOS design
- Imaging system integration
- Cryogenics
- Ultra-large scale Hybridization
- FPA device characterization
- System integration
- Microelectronics processing
- ISO-9001 2000 certified assemblies and assembly procedures
  - Space- and flight-qualified FPAs and FPAs camera systems

Development, fabrication and testing of our FPA's are performed in our new state-of-the art R&D and manufacturing facility in Camarillo, California. This 67,000 square foot facility contains 23,000 square feet of cleanrooms including areas of class 100 cleanroom.. Our cleanrooms conform to the Federal Standard 209 and are monitored by our Quality Assurance department for compliance. The RSC QA system is ISO 9001 2002 certified to ensure the quality of the delivered product to the customer.

Our in house hybridization capability allows us full control over the hybridization of focal plane arrays ranging in size from 128x128 to 2048x2048 pixels and larger.



- **67,000 sq.ft. production facility dedicated to infrared and visible focal plane array production**
- **23,000 sq.ft. Clean Room**
- **15,000 sq.ft. Class 100**

RSC's Camarillo facility, opened in the fall of 2001, located approximately 10 miles west of our Thousand Oaks site, represents a cornerstone in our history as a provider of high technology innovations. A major operation at this facility is the R&D and production for our RSC Imaging Sensors business that specializes in state-of-the-art infrared and visible sensors and cameras for commercial, defense, and astronomy applications. Another key initiative involves the development and production of laser protective eyewear for military personnel. The facility has 67,000 square feet of floor space, including 23,000 square feet of clean rooms.

#### **Camarillo Site ISO 9001 Certified**

RSC's new Camarillo site went through an ISO 9001 certification audit on March 7, 2002 and passed with ZERO findings. RSC's current ISO 9001 certificate will now be revised to include both the Thousand Oaks and Camarillo locations. The auditor from KEMA Registered Quality noted that he was impressed with our new facility and on how smoothly the move has gone. RSC's Quality Management System remains strong and focuses on customer satisfaction and continual improvement.

## Rockwell Scientific Company Imaging Capabilities

*We know of no high sensitivity imaging or sensing application from near UV through VLWIR for which we cannot offer an approach competitive in performance and cost.*

- FPA's:**
- All bands: VIS, VNIR, SWIR, MWIR, LWIR, VLWIR, from less than 400nm to beyond 17 $\mu$ m
  - Can specify cut-off, cut-on (by both detector architectures and proximity filters)
  - Best detectors for the job (Si, InGaAs, HgCdTe, uncooled)
  - Operating Temperatures from 35 Kelvin to Room Temperature
  - Advanced FPA's simultaneously sensitive to full range Vis-IR
  - Multi-Color FPA's, simultaneous 2 (or more) colors
  - Engineered Thermal cycling reliability
- Formats:**
- <128x128 to 2048x2048 (2k HyViSI now available) for staring applications
  - Similar sizes for scanning with TDI
  - Single array sizes >4cm on a side pixel pitches from <4 $\mu$ m to >100 $\mu$ m depending on wavelength and array size
- Multiplexers:**
- Over 70 existing MUXes, more in design
  - SFD, CTIA DI, other advanced inputs
  - Multi-color
  - High-gain, low-noise (read noises below 3e-)
  - High background, high dynamic range (raw capacity >2E7 carriers in ~300 $\mu$ m<sup>2</sup>, greater with charge skimming)
  - Adaptive Optics (high frame rate, low noise) Mux
  - On-chip analog-to-digital conversion (up to 14 bit)
  - Low power even with on-chip ADC
  - Analog and digital on-chip TDI
  - Radiation hardness (upset correction, TID rad hardness)
- Microoptics:**
- Microlenses, filters, filter alignment

## **Imaging Capabilities continued**

**Packaging:** TE cooled, Stirling cooled, LN2 cooled  
Space-qualified packaging and integrated dewar assemblies, WFC-3, Deep Impact, NGST, 4096 x4096 mosaic package assemblies.

**Camera Systems / Electronics:**

NIR Emission Camera, Adaptive Optics Camera, Instrumentation,  
Discrete lab electronics Space Qualified ASICs and cables

**Applications:**

Imagers  
Spectrometers  
Hyperspectral Imagers  
Low background- Astronomy, low light level, instrumentation, LADAR and strategic applications  
High background-Tactical  
High frame rate Imaging for Adaptive Optics  
Imaging and Detection for Optical Telecommunications  
Ballistic imaging  
Infrared emission Microscopy  
Ground-based, Airborne, Space-based  
Enabling Technologies for Novel Applications

## **Astronomy** .....

A variety of RSC's infrared focal planes are currently in use by astronomers throughout the world. Our well-known products such as PICNIC (NICMOS) and HAWAII have served as cornerstones for continuing development of this all-important application of our sensors. As well as driving towards the lowest possible read noise in multiplexers, we also are implementing advanced detector materials for astronomical applications. The development of dual polarity source follower multiplexers such as PICNIC, HAWAII-1RG has allowed the use of MBE (HgCdTe on CdZnTe) detector arrays. MBE has some important performance advantages over PACE (liquid phase epitaxy of HgCdTe on Sapphire). The key advantages are lower dark current (by 2-3 orders of magnitude) at a given operating temperature and the ability to specify the desired cutoff wavelength during film growth. As instrument columns become cooler, the value of earth-based MWIR astronomy becomes more evident. With MBE HgCdTe detectors one can request a desired cutoff of approximately 4.2 microns and not be swamped with the background from 4.3 to 5 microns. This is an important contrast to InSb detectors where the band gap is fixed and the cutoff is predetermined by physics to be 5.3 microns. Also, the MBE HgCdTe detector arrays can be run at convenient liquid Nitrogen temperatures as opposed to 30K, which is typically the "required" operating temperature for InSb for astronomical applications.

### **Products**

PICNIC	256x256	SWIR, MWIR
HAWAII	1024x1024	SWIR
HAWAII-1RG	1024x1024	NIR, SWIR, MWIR
HAWAII-2	2048x2048	SWIR
HAWAII-2RG	2048x2048	NIR, SWIR, MWIR

## **Hyperspectral Imaging** .....

As a leading supplier of hyperspectral imagers for applications ranging from industrial instrumentation to airborne remote sensing and space exploration, we at RSC have developed a number of multiplexers with the key performance characteristics for use in these applications. Whether it's the TCM-6600 640x480 snapshot mode CTIA for SWIR or the TCM-8600 1024x1024 ripple read for push-broom or the TCM1140 128x128 32 output DI for long wave-high frame rate FTIR-based imaging spectrometers, we have solutions to every demanding technical requirement.

### **Products**

TCM-6600	640x480	SWIR
TCM-6604	640x480	SWIR (4 outputs)
TCM-8600	1024x1024	SWIR
TCM-1140/50	128x128	LWIR

## Industrial Instrumentation .....

RSC supplies a variety of high performance camera systems for industrial applications. These include LWIR high frame rate fpa/dewar/control electronics for all the major FTIR systems suppliers worldwide. We are also the leading supplier of ultra sensitive SWIR inspection microscopes for Semiconductor IC failure analysis. The "MicroCam" features the lowest noise characteristics possible to allow detection of low intensity band gap emission as well as the sensitivity to measure thermal effects in the short wave. By viewing thermal effects in the short wave, one eliminates the high photon flux normally associated with the 3-5 micron band with the added advantage of gaining higher thermal resolution (minimum resolvable Delta T).

### Products

PICNIC	256x256	NIR, SWIR, MWIR
TCM-1140/1150	128x128	LWIR

## Camera Systems

Space IDAs

RSC has been or will be the supplier for a number of space-based programs including:

\*\*NGST\*\*

HST NICMOS

TES

HST WFC3

CIVA (ESA)

EO-1 ACSM

Mars'05

CONTOUR

Deep Impact

GOES

Pluto

### Products

SWIR 512

MicroCam

AstroCam

A/O Cam 32 channel high-speed low noise electronics

ASICs

## **Focal Plane Arrays** .....



Rockwell Scientific Infrared CMOS Multiplexers													Material Compatibility		
Part #	Format	Input Circuit	Imaging Mode	Window Options	Video Outputs	* Pixel Rate (MHz)	Pitch (µm)	Well Capacity 1E6	Delta V (V)	Gain (uV/e-)	Read Noise (e-)	Power (mW)	PACE LPCVD HgCd on Sapphire	MBE HgCd on CdZnTe	HyV/ISI
<a href="#">HAWAII-2</a>	2048X2048	SFD	RIPPLE	na	4-32	.25	18	>0.1	0.4-1.0	3-6	9	<2	X		X
<a href="#">HAWAII</a>	1024X1024	SFD	RIPPLE	na	4	≤1	18.5	0.1	0.4-1.0	3-6	9	<1	X		X
TCM9000	1024X1024	A-DI	RIPPLE	na	4	40	18	100	2	SELECTABLE	<400	>100		X	
TCM8600	1024X1024	CTIA	RIPPLE	na	8	>4	18	0.4	2.5	2-7.4	<50	<200	X		X
TCM8050A	1024X1024	p-PCDI	SNAP/WINDOW	256,512	4	5	18	3	3	SELECTABLE	300	<150		X	X
TCM8000	1024X1024	n-CTIA	RIPPLE	na	2	12	18.5	0.58	2.5	3.6	<75	45	X		X
<a href="#">TCM6600</a>	640X480	p-CTIA	WINDOW/SNAP	Programmable	1	6.4	27	0.65	2.6	4	<100	70		X	X
TCM6000A	640X480	n-DI	RIPPLE	na	4	>10	27	26	2.0	0.077	<600	<60	X		
NICMOS3	256X256	SFD	RIPPLE	na	4	<1	40	0.25	0.4-1.0	1.5-2.5	25	<1	X	X	
<a href="#">PICNIC</a>	256X256	SFD	RIPPLE	na	4	<2	40	0.2	0.4-1.0	3-6	<20	<1	X	X	
TCM2620	256X256	p-CTIA	SNAPSHOT	64,128	4	>8	40	1.4	2	6.6/1.4	<120	<40		X	
<a href="#">TCM2550</a>	256X256	p-PCDI	SNAP/RIPPLE	32,64,128,Custom	1	>8	40	>40	2.4	SELECTABLE	<600	<50		X	
TCM2001	256X256	p-PCDI	RIP/SNAP/WINDOW	32,64,128,Custom	1	>10	40	40/20	2.4	SELECTABLE	<1000	<50		X	
TCM2000C	256X256	n-DI	RIPPLE	na	1	<6	40	28	2.1	0.05	650	<50	X		
TCM1610	128X128	CTIA	SNAP/WINDOW	64,128	32	10	40	0.12	2.4	5	150	<300		X	X
TCM1600	128X128	CTIA	SNAP/WINDOW	64,128	32	10	40	0.12/0.4	2.4	20/5	75	<300		X	X
SCM1240	128X128	RH-DCTIA	WINDOW&RIPPLE	64,128	1	2	60	4	2	1	100	<25		X	
TCM1150	128X128	p-PCBDI	SNAP/WINDOW	4 x 128	32	10	40	7	2.3	SELECTABLE	<250	<300		X	
TCM1140	128X128	p-PCDI	SNAP/WINDOW	4 x 128	32	10	40	20	2.3	SELECTABLE	800	<300		X	
<a href="#">TCM1050</a>	128X128	p-PCDI	MULTI-MISSION	64	1	10	40	55	2.5	SELECTABLE	<400	<25		X	
<a href="#">TCM1040</a>	128X128	p-PCBDI	MULTI-MISSION	64	1	10	40	21/18	1.3/1.9	SELECTABLE	<400	<50		X	

\* Note: Pixel rate is given in MHz per output

#### Glossary of Unit Cell Types:

**SFD** Source Follower per Detector  
**CTIA** Capacitive Transimpedance Amplifier  
**DI** Direct Injection  
**PCDI** Push Clock Direct Injection  
**A-DI** Adaptive-Direct Injection



### Modular Command and Control Electronics Unit

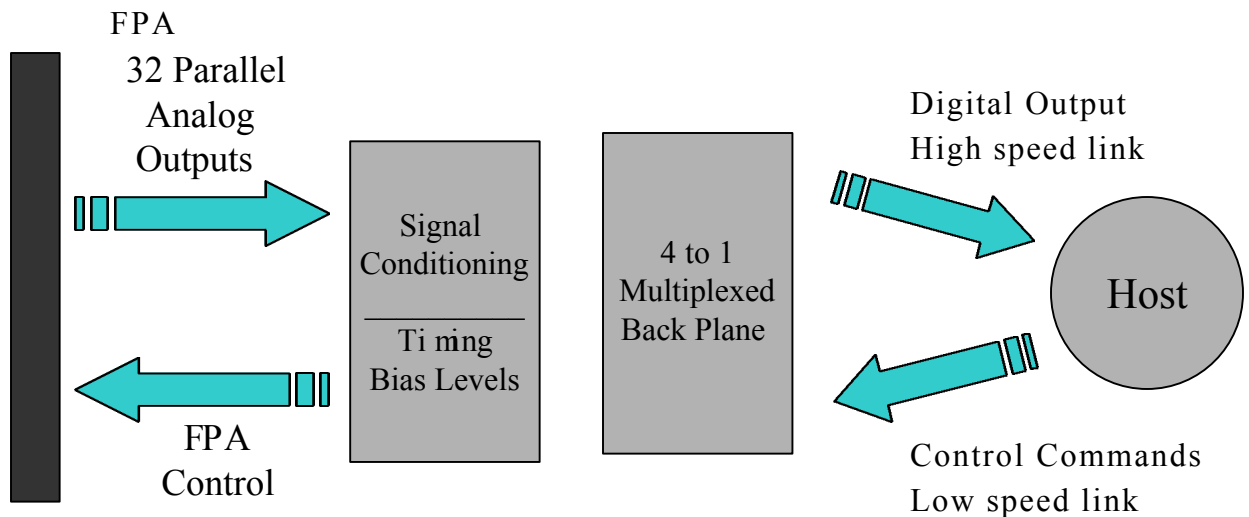
## Features

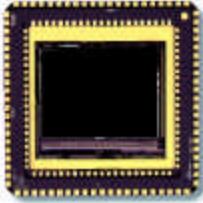
- Supports Rockwell Scientific's High Speed Multiple Output Multiplexers for Adaptive Optics
- Available with NIR, SWIR, MWIR or LWIR 128x128 Detector Arrays
- High Speed Digital Data Link
  - RS422 or Fibre Channel
- Standard Hosting Interfaces
  - Serial, Parallel or Fibre Link
- Standard Rack Mount
- 32 channel, massively parallel pre-processing
- 14 bit ADC (10 Msps)
- 4 to 1 multiplexed back plane



High Speed, modular electronics unit

Rockwell Scientific's A / O -Cam<sup>TM</sup> Electronics Module, the high performance electronics optimized for our Adaptive Optics Sensors, allows turn-key implementation of these Focal Plane Arrays in your optical system. All Clocks, Biases, Digitization and Communication Interfaces are included.

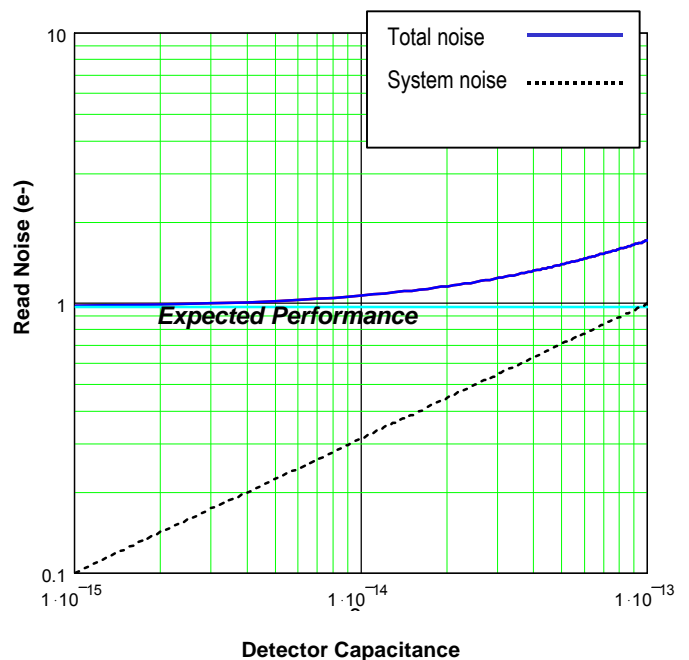
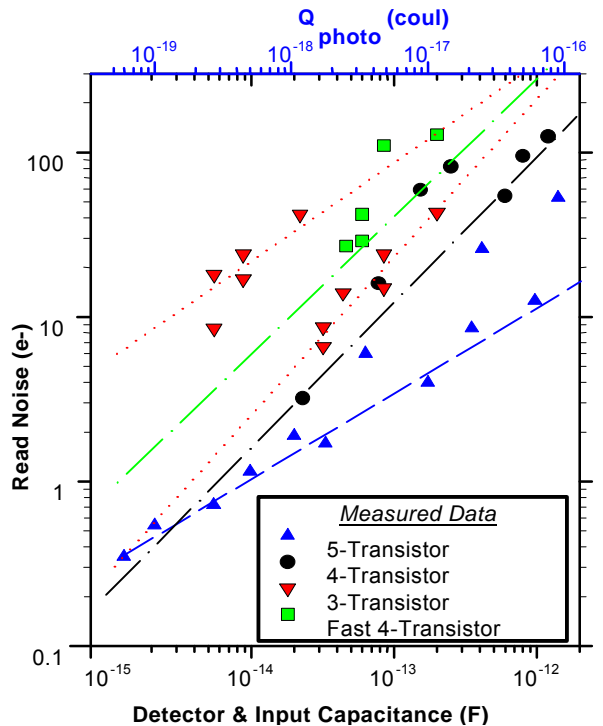




Rockwell Scientific's approach to low-noise readouts builds upon extensive CMOS imager design experience and access to the world's best CMOS fab for imagers. We use sub- 0.25  $\mu\text{m}$  mixed-signal CMOS design rules to allow high component density for improved performance.

### Demonstrated Performance

- 3 Transistors/pixel (SFD)
  - 8.5 e- (CDS)
  - 2.5 e- (Fowler sampling)
- $\approx$  4 Transistors/pixel (CTIA)
  - $\sim$  3 e- with 25 fF input Cap.
- $\approx$  5 Transistors/pixel
  - $<$  1 e- (speed limited by lag)
- High frame-rate readout (up to 10MHz)
- Ultra-low noise
  - $<$  5 e- at high frame rates
  - 1 e- achievable for A-O
- Negligible lag
- Suitable for Visible and Infrared (0.3-3mm)
- Array sizes from 8x8 to 256x256



\* Planned Availability Q1,2003

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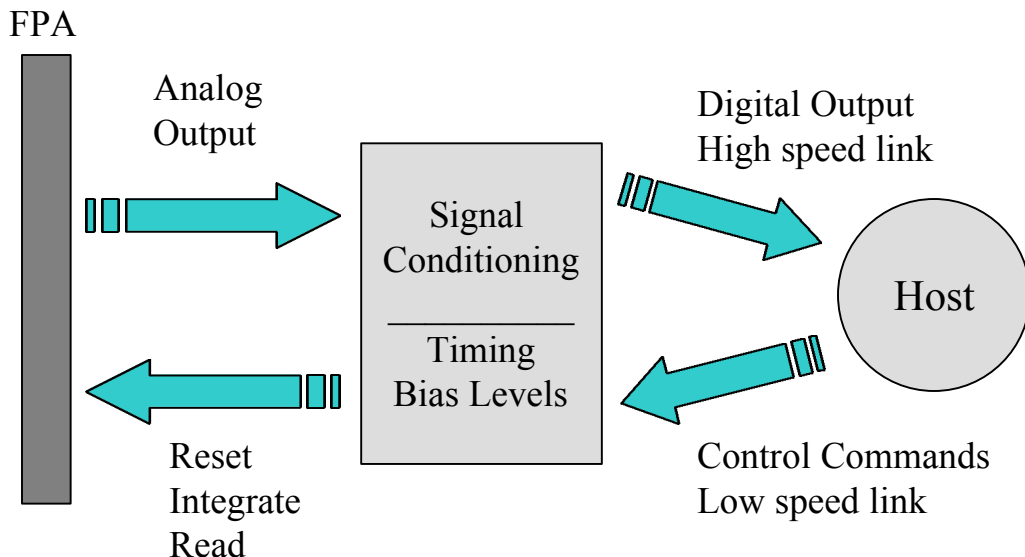
## Features

- Supports Rockwell Scientific's PICNIC, HAWAII, HAWAII 2 and Adaptive Optics Read Out ICs
- High Speed Digital Data Link
  - RS422 or Fibre Channel
- Standard Hosting Interfaces
  - Serial, Parallel or Fibre Link
- Standard Rack Mount
- Multiple channel configurations available
  - 4, 8, 16 or 32 parallel digitizers
- ADC Options
  - 16 bit 8 Msps or 14 bit 10 Msps



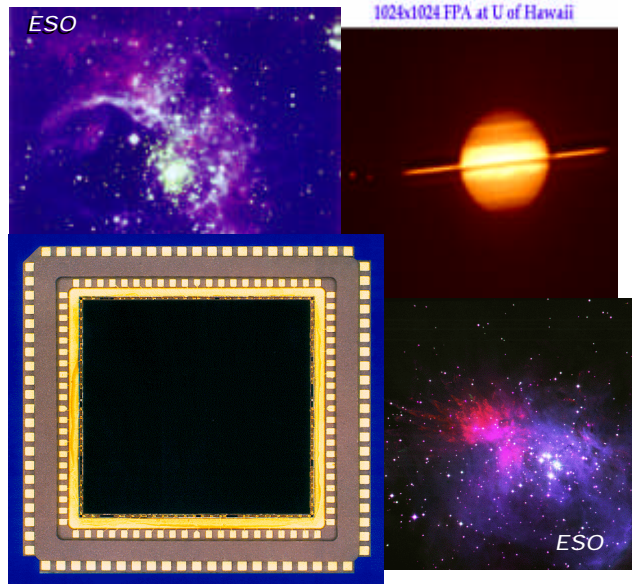
*Modular Command and Control Electronics Unit*

Rockwell Scientific's Astro-Cam™ Electronics Module, the high performance electronics optimized for our Astronomy Imaging Arrays and Adaptive Optics Sensors, allows turn-key implementation of these Focal Plane Arrays in your optical system. All Clocks, Biases, Digitization and Communication Interfaces are included. The modular architecture of these electronics allows for complete customization to meet your exact requirements.

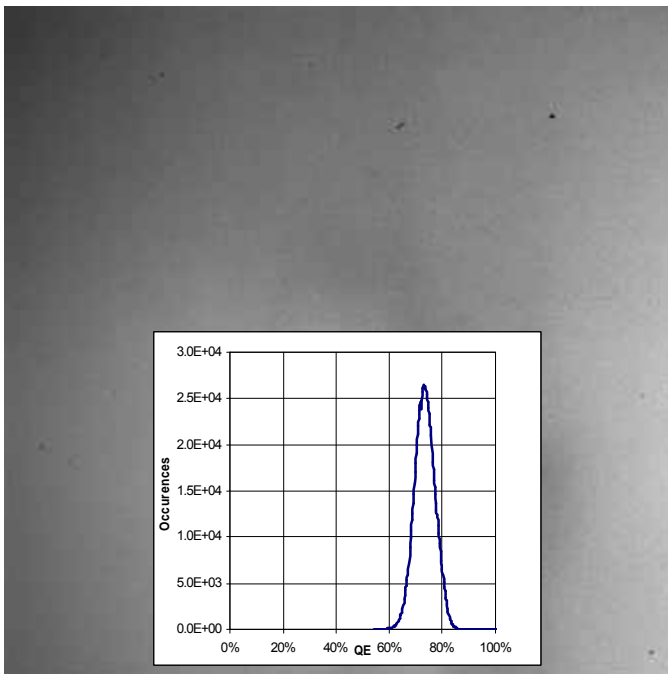


## Features

- High Resolution 18.5mm Pixel Pitch
- Ultra-Low Read Noise with Off-Chip CDS
- 3e- read noise measured with multiple reads
- Low Power ROIC/Readout Architecture
- 0.8mm CMOS with nearly 3.5 million Transistors
- Four Independent Quadrants with Source Follower or Direct Bus Outputs
- Spectral Response from 0.85-2.5mm
- Low Dark Current at a convenient 78K
- High-Reliability BCS Hybrid FPA Methodology
- Low MOSFET Self-emission (Glow)
- 3.4 to 6.8mV/e- Signal Conversion Gain



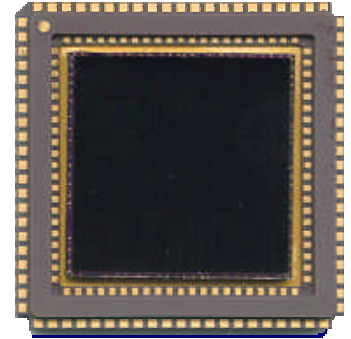
Rockwell Scientific's SWIR HAWAII™ HgCdTe FPA offers users low dark current and low noise needed for low background astronomical imaging.



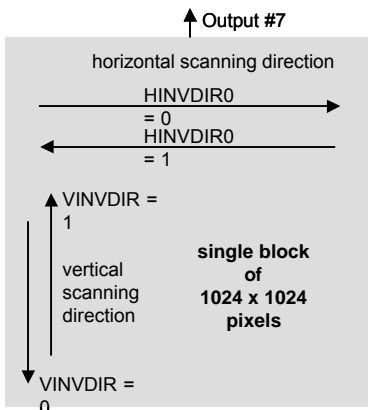
Parameter	Measured Values	Units
Detector Interface circuit	SFD	
Cell Pitch	18.5	μm
Die Size	<400	mm <sup>2</sup>
Integration Capacity	1.0x10 <sup>5</sup>	carriers
Integration Capacitance	18-35	fF
Signal Conversion Gain	3.4-6.8	μV/e-
Output Signal Excursion	0.4-1.0	V
Maximum Data Rate	>1	MHz
Maximum Slew Rate	400	nsec
Minimum Read Noise (CDS)	<10	e-
Minimum Read Noise (Fowler Sampling)	<3	e-
Quantum Efficiency	>60	%
Spectral Response	0.85-2.5	μm
Dark Current @ 78K	<0.03	e-/sec
Power Dissipation	<1	mW

## Features

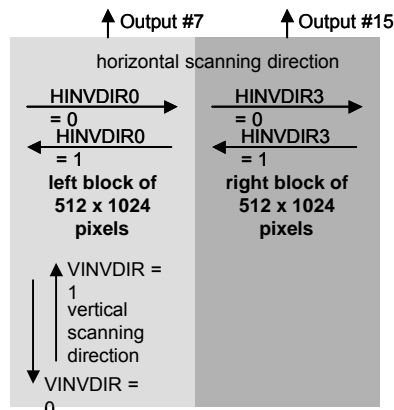
- Uses the new HAWAII-1RG™ ROIC with serial interface control capability
- Accepts MBE as well as PACE MCT detector arrays
- High Resolution 18mm Pixel Pitch
- Slow (100kHz) or Fast (5MHz) readout mode (selectable)
- 1, 2 or 16 outputs (selectable)
- Window Mode -- arbitrary size and location window
- Separate reference output; Separate guide window output
- Reference pixels around perimeter
- Non-destructive reads
- Glow reduction features remove any circuit glow pick-up
- <math>10^{-6}</math> rms CDS Read Noise in Slow readout mode
- <math>50^{-6}</math> rms CDS Read Noise in Fast readout mode
- Low Power ROIC/Readout Architecture
- 1.9-5mm Detector Cutoff Wavelength
- Low Dark Current of <math>0.1e^{-}/sec</math> @ 50K (5mm MBE)
- High-Reliability BCS Hybrid FPA Methodology
- Low MOSFET Self-emission (Glow)
- 2.0 to 4.0mV/e- Signal Conversion Gain (detector material dependent)



Rockwell Scientific's new HAWAII-1RG™ is a state of the art multiplexer for advanced astronomy and space telescope applications. Providing the ability to choose detector material (MBE or PACE or HyViSi) allows the user access to any band from 350nm to 5mm. Multiple output modes (1,2,16) with user selectable scan directions provide complete flexibility in data acquisition. The "Guide Mode" allows for a user programmable window which may be read out continuously at up to 5MHz for guiding the telescope. The readout is designed to allow interleaved readout of the guide window and the full frame science data. The HAWAII-1RG™ represents one quadrant of the new HAWAII-2RG™.



*Illustration of the single output mode*

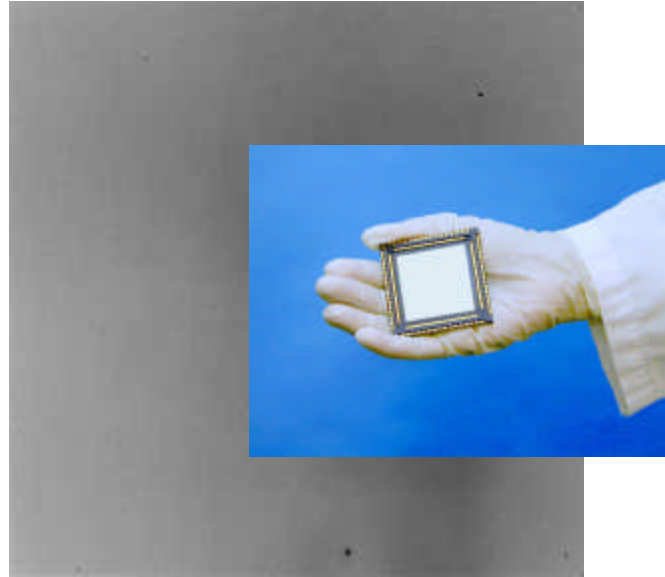


*Illustration of the 2-output mode*



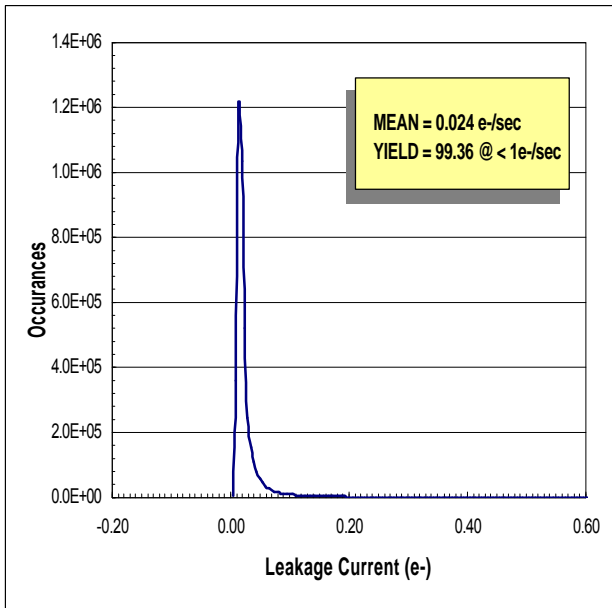
## Features

- High Resolution 18mm Pixel Pitch
- Ultra-Low Read Noise with Off-Chip CDS
- Low Power ROIC/Readout Architecture
- 0.8mm CMOS with greater than 13 million transistors
- Four Electronically Independent Quadrants with Source Follower Output Amplifiers
- Multiple Output modes
- Spectral Response from 0.85-2.5mm
- Low Dark Current at a convenient 78K
- High-Reliability BCS Hybrid FPA Methodology
- Low MOSFET Self-emission (Glow)
- 3.0 to 6.0mV/e- Signal Conversion Gain



Quantum Efficiency Map of 2048x2048

Rockwell Scientific's HAWAII-2™ is the largest HgCdTe infrared focal plane array in the world! With an array size of 40mm x 40mm, the 18mm, 2048 x 2048 format provides unparalleled spatial resolution and sensitivity for astronomical imaging. The HAWAII-2™ multiplexer provides 3 output modes, finer control of clocking to reduce self-emission "Glow" and circuitry to minimize crosstalk.

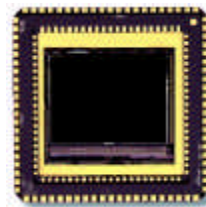
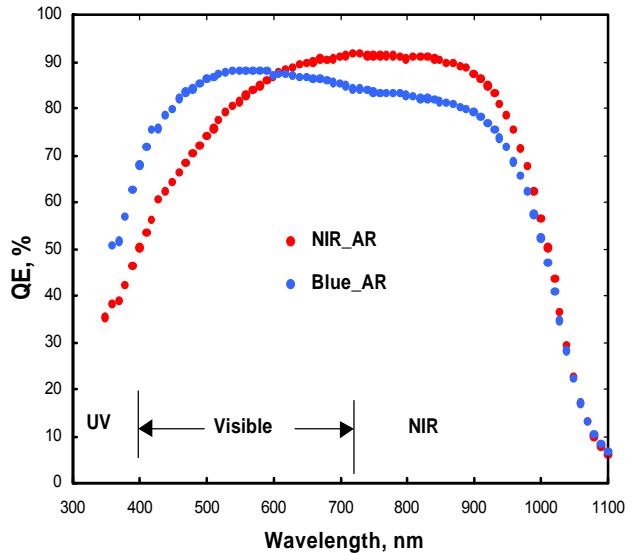


Parameter	Performance	Units
Detector Interface circuit	SFD	
Cell Pitch	18	μm
Die Size	1600	mm <sup>2</sup>
Integration Capacity	1.0x10 <sup>5</sup>	carriers
Integration Capacitance	18-35	fF
Signal Conversion Gain	3.0 -6.0	μV/e-
Output Signal Excursion	0.4-1.0	V
Data Rate (Frame Rate)		
4 Output Mode	100 (.25)	kHz (Hz)
32 Output Mode	225 (2)	kHz (Hz)
Minimum Read Noise (CDS)	<10	e-
Minimum Read Noise (Fowler Sampling)	<3	e-
Quantum Efficiency	>60	%
Spectral Response	0.85-2.5	μm
Dark Current @ 78K	<0.03	e-/sec
Power Dissipation	<2	mW

Rockwell Scientific's new HyViSI is a very-high performance visible imager technology recently developed at the Rockwell Scientific. In addition to the performance, this device offers an unprecedented advantage for applications with both IR and visible channels: CMOS readout multiplexer commonality with any Rockwell infrared focal plane array!

## Features

- ~100% Optical fill-factor
- High, broad-band QE
- Non-Blooming
- Low dark current
- High inherent radiation hardness
- Leverages extensive CMOS heritage
- Available in multiple formats
  - Many with Windowing (see table)
- Customized designs available
- Custom filters available
  - AR, LVF, Order Blocking



**HyViSI Detector Arrays**  
Now Available in multiple formats!

Parameter	TCM 6600	TCM8000	TCM8050	TCM8600	HAWAII	HAWAII 2	Units
Input Circuit	CTIA	CTIA	PCDI	CTIA	SFD	SFD	
Array Format	640x480	1024x1024	1024x1024	1024x1024	1024x1024	2048x2048	
Cell Pitch	27	18.5	18	18	18.5	18	μm
Number of Outputs	1	2	4	8	4	4 or 32	
Max. Frame Rate	22	12	25	50	2	0.5 to 16	Hz
Read Out Modes	Snapshot	Ripple	Snapshot	Ripple	Ripple	Ripple	
Window Mode	Programmable	na	4 presets	na	na	na	
Integration Capacity	650,000	580,000	3,000,000	>200,000	>100,000	>100,000	e-
Signal Conversion Gain	4	3.6	1	2-7.4	6.0-10.0	6.0-10.0	μV/e-
Read Noise	<100	<50	<300	80	5	5	e-
Dark Current @ -15C	9.10E+03	4.30E+03	4.00E+03	4.00E+03	4.30E+03	4.00E+03	e-/sec-pixel
Power Consumption	70	45	150	100	<1	<2	mW

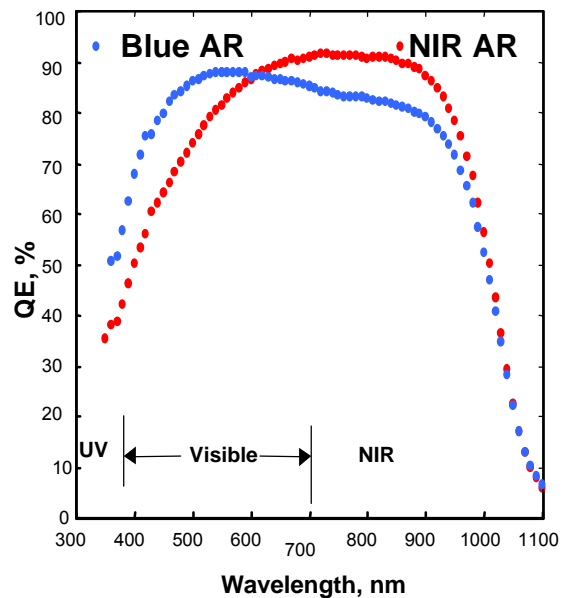
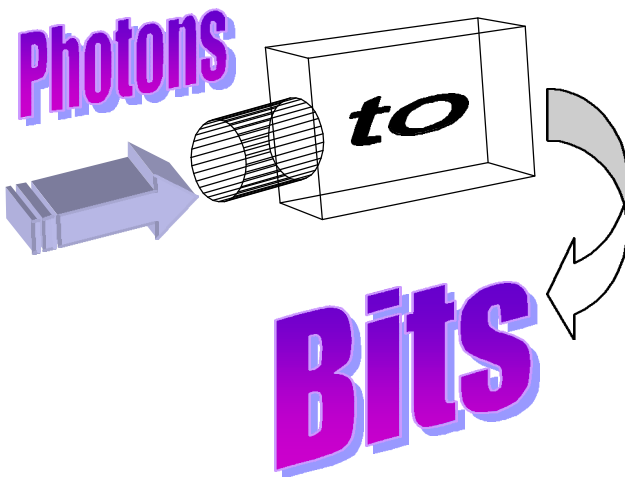


## Features

- Utilizes State-of-the-Art ROIC's and Rockwell Scientific's line of Visible Si Detectors
- New electronics include preset clocks, biases and ADCs
- Integral TE cooler
- Adjustable Frame Rate
- Variable Integration time
- On-the-Fly Programmable Windowing
- High inherent radiation hardness
- Available in 640x480 TCM6600 format
- Other formats available on request
- Several Anti-Reflection Coatings Available



Rockwell Scientific's new HyViSI, a very-high performance visible CMOS imager technology, is combined with an hermetic package including integral TE cooler and compact control electronics. In addition to the performance, this device offers an unprecedented advantage for applications with both IR and visible channels: CMOS readout multiplexer commonality with any Rockwell infrared focal plane array!



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[www.rockwellscientific.com/imaging](http://www.rockwellscientific.com/imaging)

# Micro-Cam<sup>TM</sup>

*Infrared Camera System  
for Very Low Background Instrumentation*



## Features

- SWIR focal plane array sensor housed in liquid nitrogen cooled dewar
- Liquid nitrogen auto-fill and sensor system
- Motor driven, 4-position filter wheel
- Drive electronics with PC interface included
- Power supply necessary to operate the camera
- Temperature sensor electronics
- LN2 auto-fill control electronics

## Specifications

Sensor:	PICNIC SWIR 256x256 HgCdTe
Min. Integration:	100 msec
Coolant:	LN2 with autofill system
Hold Time:	> 6 hours
Cold Optics f#:	f/2
Orientation:	Down-looking or side-looking available
Cold Filter Wheel:	4 position computer controlled
Electrical Interface:	AIA 16 bit RS422 w/ RS232 serial link
PC Interface:	Off-the-shelf PCI card

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