GL SCIENTIFIC TECHNICAL REPORT

Title: **GSAOI H2RG 4Kx4K Detector Mosaic Module Design Description**

Report Number: **GLSTR-0301**
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Date: **26-Oct-03**

This document describes the design and construction of the 4Kx4K Pixel Detector Mosaic Module for the Gemini South Adaptive Optics Imager (GSAOI) Instrument being built by the Mount Stromlo Observatory for the Gemini South Telescope. The module is designed to house four H2RG Infrared SCAs (Sensor-Chip-Arrays) from Rockwell Scientific.

H2RG SCA Package

The Rockwell H2RG package was developed to allow the safe mounting of an H2RG SCA hybrid infrared imager and its subsequent incorporation into a mosaic focal plane array (FPA). The design owes much of its heritage to mosaic CCD packaging developed and employed in numerous large CCD mosaic focalplanes by GL Scientific and others over the last decade. The design includes the following features:

- Package material chosen to provide the best CTE match to the SCA hybrid.
- Close edge buttability on 3 sides to match the 3-edge buttable layout of the H2RG ROIC.
- Reduced structure on the 4th edge to minimize the footprint of the individual detectors as well as reduce the overall size of the final mosaic FPA. Enables construction of close-packed mosaics of arbitrary size.
- Mechanical mounting using removable, thermally-conductive spacer/shims that can be adjusted to tune the height of the SCA detector surface.
- Robust wirebond ceramic electrical interconnect circuit optimized for cryogenic cycling and designed to provide the best possible device performance with the incorporation of detector bias filtering.
- Flexcircuit interconnect that mates to the wirebond ceramic and terminates in a 37-pin Micro-D connector.
- Incorporation of attachment points for fixtures to allow safe handling of the packaged devices and their safe installation into a mosaic FPA.

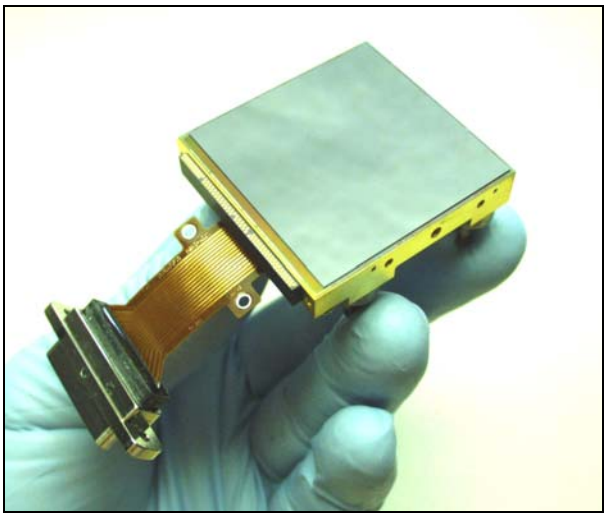
The H2RG SCA Package consists of 3 major components:

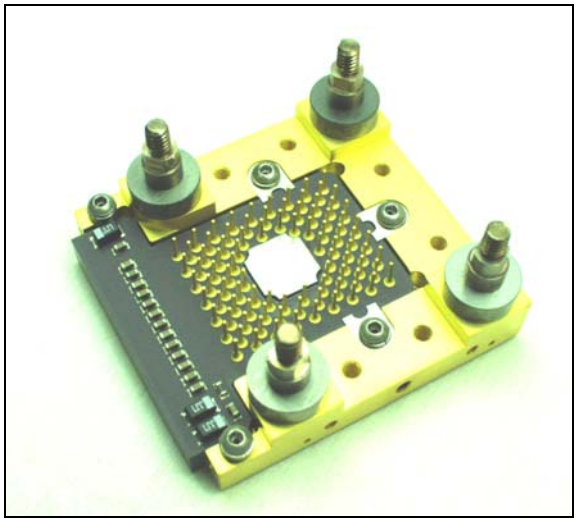
1. The TZM/Molybdenum hybrid mount.
2. The TZM/Molybdenum spacer disks and copper/tungsten (Cu/W) stud/pin legs.
3. The wirebond ceramic PGA.

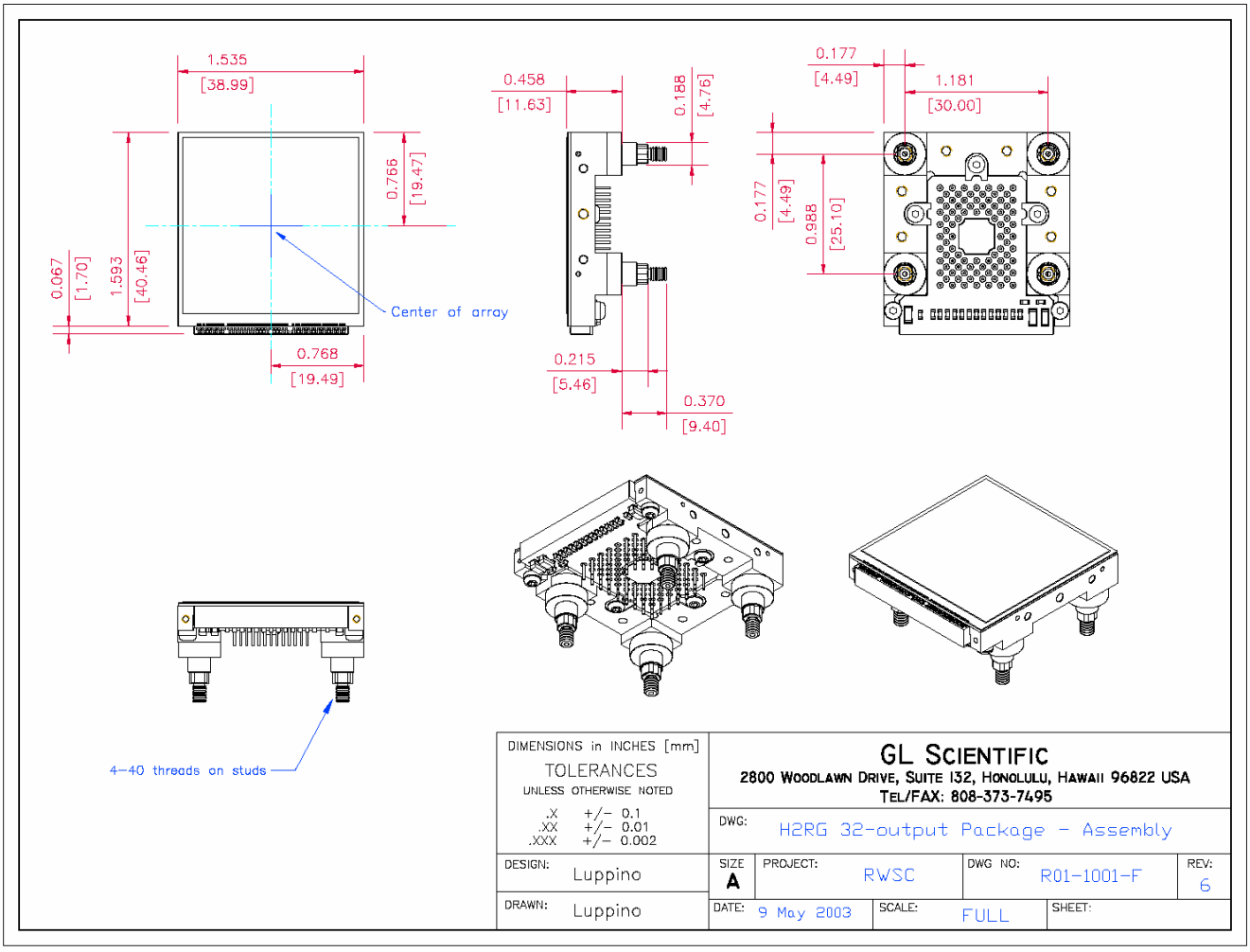
Thermal modeling of the H2RG CdZnTe-HgCdTe-BCS hybrid structure indicates that the best material choice for the hybrid mount is TZM/molybdenum (TZM is a molybdenum alloy with trace components

of titanium and zirconium). The current H2RG hybrid mount consists of a machined TZM block with four mounting pads on the bottom surface. The dimensions of the footprint of the block slightly exceed the footprint of the diced hybrid insuring that the mounted hybrid lies within the boundary of the block and does not overhang at any point. This is important as it reduces the risk of damaging the hybrid when mounting multiple SCAs in a mosaic FPA. The thickness of the block at the mounting pads is 9 mm. The block is surface ground on all six sides to a precision of +/- 5 microns. The top surface on which the hybrid is attached is flat and co-planar to the mounting pads to a precision of +/- 5 microns. A tapped hole (4-40) with a precision reamed counterbore is located in the center of each mounting pad. A copper/tungsten (Cu/W) stud/pin and TZM spacer disk are screwed into each mounting pad. The stud/pin has single-point-turned 4-40 threads on each end and two precision cylindrical surfaces coaxial with the threaded studs. The smaller diameter cylinder inserts through a hole in the TZM spacer disk and engages the precision counterbore in the TZM base. The larger diameter cylinder retains the TZM spacer disk in place and serves as a locating pin when inserted into the focalplane mounting plate of the FPA. The device is pulled onto the FPA mounting plate by attaching a Belleville washer and locking nut. The TZM spacer disks have a diameter of 9 mm and are machined to a thickness of 3 mm +/- 5 microns. These disks set the height of the detector surface with respect to the focalplane mounting plate. This design offers several advantages over a fixed-thickness package base by allowing (limited) tuning of the height of the SCA detector surface to compensate for small variations in epoxy bondlines in the hybrid stackup or small variations in the thickness of the hybrid die attach bondline. Once a hybrid is attached to a TZM base with its four spacer disks and Cu/W legs, the detector surface height is measured to a precision of 1 micron using a non-contact optical metrology microscope. If needed, the surface height of each packaged hybrid can be adjusted by removing and lapping the individual spacer disks. This proven design has been used extensively with large CCD mosaic focalplanes, and has achieved focalplane co-planarity tolerances of +/- 5 microns.

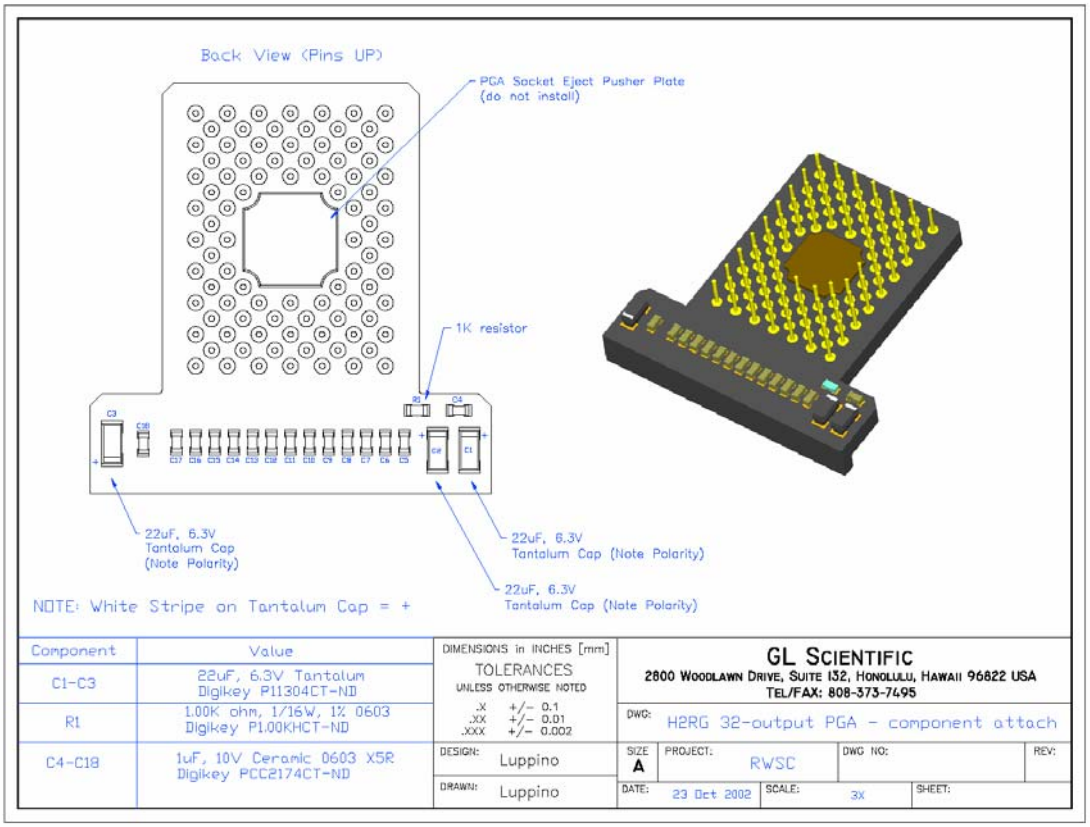
Thermal connection to the package base is made through the TZM spacer disks and Cu/W stud/pins. Cu/W was chosen for the stud/pins because of its high strength and close CTE match to TZM. While a 3-point mount would seem to be preferred over a 4-legged version, this design insures the detector is thermally connected to the FPA focalplane mounting plate in a symmetrical fashion so that thermal gradients across the package are minimized during temperature cycling. Steps have been taken in the design of the FPA focalplane mounting plate to insure the mechanical mounting of the 4 legs is not over-constrained. Vacuum vent holes or vented fasteners are used for all blind, tapped holes.







A cavity is machined into the bottom surface of the TZM base between the mounting pads to allow the attachment of a custom wirebond ceramic pin grid array (PGA). After experimenting with various ceramic technologies and geometries, we have adopted a high-temperature co-fired ceramic (HTCC) ceramic manufactured by Kyocera (A440). Bondpads are located on a ledge of the ceramic that extends out and up along the 4th edge of the package, adjacent to the ROIC bondpads. This design only requires an additional 2 mm of space along this edge. HTCC ceramic technology is well-suited for cryogenic operation, and many similar ceramics have been used successfully in other cryogenic applications. This ceramic has been extensively tested for its cryogenic suitability. The current multilayer ceramic design routes all of the H2RG bondpads to a 90-pin interstitial PGA. The ceramic includes an internal groundplane, and traces are routed to maintain the separation of digital and analog. Surface mount filter capacitors for the detector biases are attached to the bottom side of the ceramic. Electrical connection to the PGA is made using a flexcircuit terminated in a 37-pin micro-D connector. Although the 90 pin PGA carries all the signals necessary for full 32-ouput operation of the device, only a fraction of the 90-pins on the PGA are needed for 4-output operation. The wirebond ceramic is held in place with spring clamps and mounting screws. This allows the ceramic to mechanically ``float'' so it does not influence the mechanical properties of the TZM base when thermally cycled.



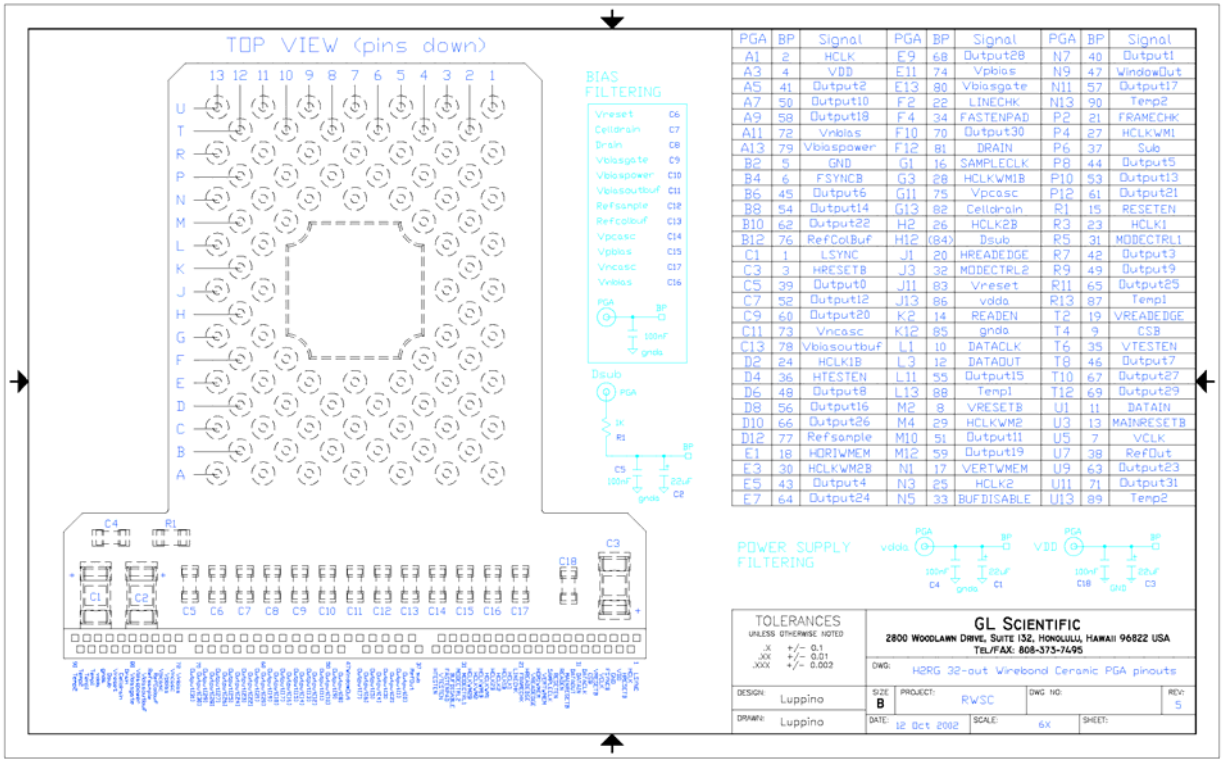
Component	Value
C1-C3	22uF, 6.3V Tantalum Digikey P11304CT-ND
R1	1.00K ohm, 1/16W, 1% 0603 Digikey P1.00KHCT-ND
C4-C18	1uF, 10V Ceramic 0603 X5R Digikey PCC2174CT-ND

DIMENSIONS in INCHES [mm]
TOLERANCES
UNLESS OTHERWISE NOTED
.X +/- 0.1
.XX +/- 0.01
.XXX +/- 0.002

GL SCIENTIFIC
2800 WOODLAWN DRIVE, SUITE 132, HONOLULU, HAWAII 96822 USA
TEL/FAX: 808-373-7495

DWG: H2RG 32-output PGA - component attach

DESIGN:	Luppino	SIZE: A	PROJECT: RWSC	DWG NO:	REV:
DRAWN:	Luppino	DATE: 23 Oct 2002	SCALE: 3X	SHEET:	



PGA	BP	Signal	PGA	BP	Signal	PGA	BP	Signal
A1	2	HCLK	E9	68	Output28	N7	40	Output1
A3	4	VDD	E11	74	Vpbias	N9	47	WindowOut
A5	41	Output2	E13	80	Vbiasgate	N11	57	Output17
A7	50	Output10	F2	22	LINECHK	N13	90	Temp2
A9	58	Output18	F4	34	FASTENPAD	P2	21	FRAMECHK
A11	72	Vnbias	F10	70	Output30	P4	27	HCLKWM1
A13	79	Vbiaspower	F12	81	DRAIN	P6	37	Sub
B2	5	GND	G1	16	SAMPLECLK	P8	44	Output5
B4	6	FSYNCB	G3	28	HCLKWM1B	P10	53	Output13
B6	45	Output6	G11	75	Vpcasc	P12	61	Output21
B8	54	Output14	G13	82	Celldrain	R1	15	RESETEN
B10	62	Output22	H2	26	HCLK2B	R3	23	HCLK1
B12	76	RefColBuf	H12	(84)	Dsub	R5	31	MODECTRL1
C1	1	LSYNC	J1	20	HREADEDGE	R7	42	Output3
C3	3	HRESETB	J3	32	MODECTRL2	R9	49	Output9
C5	39	Output0	J11	83	Vreset	R11	65	Output25
C7	52	Output12	J13	86	vdda	R13	87	Temp1
C9	60	Output20	K2	14	READEN	T2	19	VREADEDGE
C11	73	Vncasc	K12	85	gnda	T4	9	CSB
C13	78	Vbiasoutbuf	L1	10	DATACLK	T6	35	VTESTEN
D2	24	HCLK1B	L3	12	DATAOUT	T8	46	Output7
D4	36	HTESTEN	L11	55	Output15	T10	67	Output27
D6	48	Output8	L13	88	Temp1	T12	69	Output29
D8	56	Output16	M2	8	VRESETB	U1	11	DATAIN
D10	66	Output26	M4	29	HCLKWM2	U3	13	MAINRESETB
D12	77	Refsample	M10	51	Output11	U5	7	VCLK
E1	18	HORIWMEM	M12	59	Output19	U7	38	RefOut
E3	30	HCLKWM2B	N1	17	VERTWMEM	U9	63	Output23
E5	43	Output4	N3	25	HCLK2	U11	71	Output31
E7	64	Output24	N5	33	BUFDISABLE	U13	89	Temp2

TOLERANCES
UNLESS OTHERWISE NOTED
.X +/- 0.1
.XX +/- 0.01
.XXX +/- 0.002

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2800 WOODLAWN DRIVE, SUITE 132, HONOLULU, HAWAII 96822 USA
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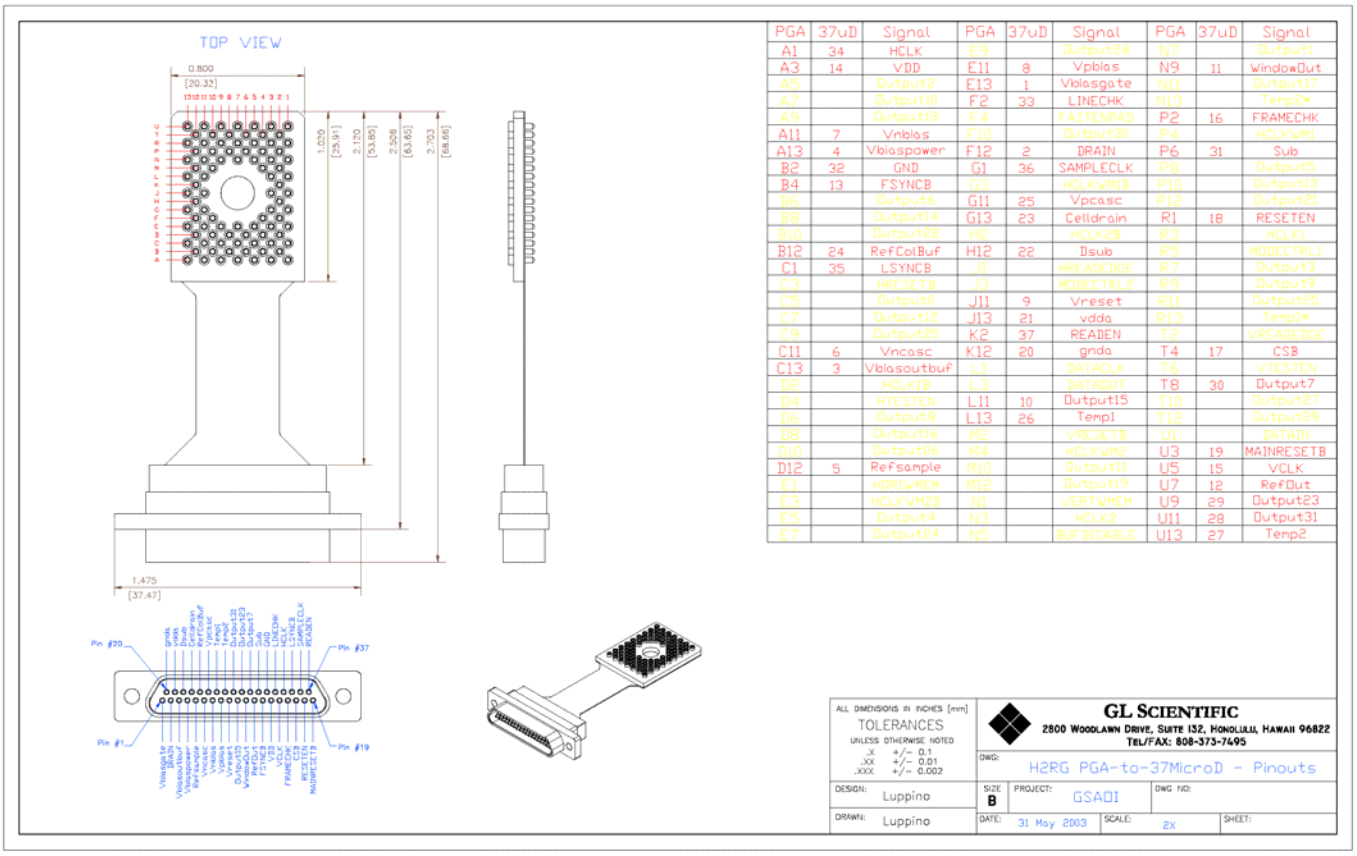
DWG: H2RG 32-out Wirebond Ceramic PGA pinouts

DESIGN:	Luppino	SIZE: B	PROJECT: RWSC	DWG NO:	REV: 5
DRAWN:	Luppino	DATE: 12 Oct 2002	SCALE: 6X	SHEET:	

H2RG Flexcircuit

Electrical connection to the wirebond PGA is made using a custom interstitial PGA socket manufactured by Advanced Interconnections, Inc. The socket consists of an array of discrete, gold-plated machined socket contacts attached to a peel-away polyimide (kapton) sheet. The socket contacts are soldered into a polyimide flexcircuit that is supported in this area by a rigid polyimide stiffener. After soldering, the peel-away sheet is removed leaving an array of socket contacts supported by the polyimide stiffener on the flexcircuit.. Various options for flexcircuits exist. For the GSAOI application, only 4-output mode is needed and the flexcircuit is terminated with a 37-pin micro-D connector (an alternative flexcircuit with a 92-pin Hirose surface-mount connector is available to allow access to all of the 90 pins on the PGA for full 32-output operation of the H2RG).

Installation of the flexcircuit is done with the device mounted on its handling bracket as provided in the H2RG shipping/storage container. The bracket is set onto a flat surface with the device hanging upside-down, the PGA pins are lined up with the flexcircuit socket contacts, and the flexcircuit is pressed into place by hand. The flexcircuit is properly engaged when the PGA pins bottom-out in the socket contacts with about 1-2 mm of space between the top of the pins and the bottom surface of the ceramic. To remove the flexcircuit, an M3 screw is threaded into the tapped ejection bushing mounted in the center region of the PGA socket contacts on the flexcircuit. The screw contacts a metal plate epoxied onto the ceramic (to avoid stressing and possibly cracking the ceramic) and jacks the socket off of the PGA pins. Care is needed to insure the socket is lifted off the PGA pins in a uniform manner to avoid bending the PGA pins.

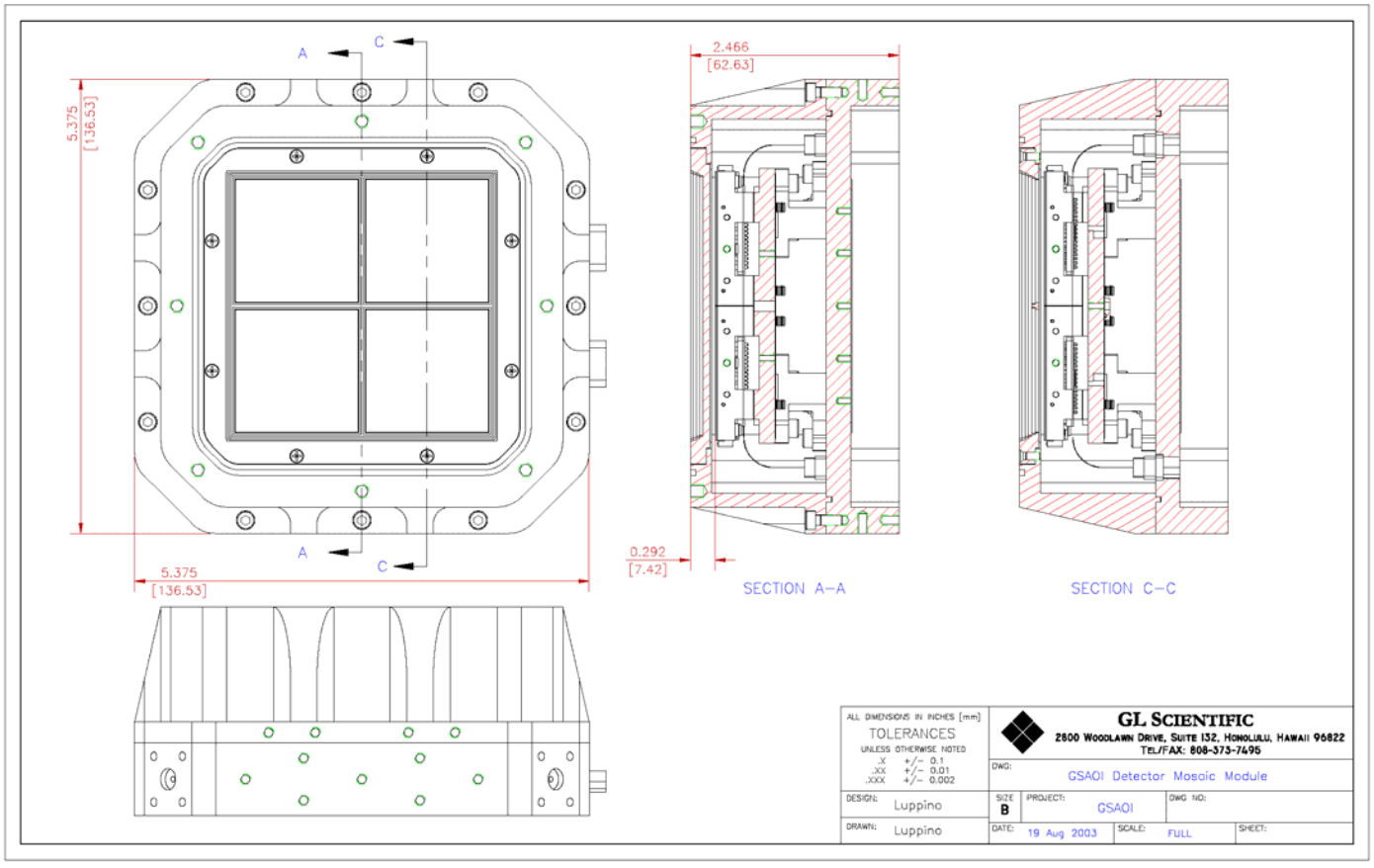


PGA	37uD	Signal	PGA	37uD	Signal	PGA	37uD	Signal
A1	34	HCLK	F9		Output28	N7		Output1
A3	14	VDD	E11	8	Vpbias	N9	11	WindowOut
A5		Output32	E13	1	Vbiasgate	N11		Output17
A7		Output10	F2	33	LINECHK	N13		Temp0*
A9		Output18	F4		FASTENPAD	P2	16	FRAMECHK
A11	7	Vnbias	F10		Output30	P4		HCLKWM1
A13	4	Vbiaspower	F12	2	DRAIN	P6	31	Sub
B2	32	GND	G1	36	SAMPLECLK	P8		Output5
B4	13	FSYNCB	G3		HCLKWM1B	P10		Output13
B6		Output6	G11	25	Vpcasc	P12		Output21
B8		Output14	G13	23	Celldrain	R1	18	RESETEN
B10		Output22	H2		HCLK2B	R3		HCLK1
B12	24	RefColBuf	H12	22	Dsub	R5		MODECTRL1
C1	35	LSYNCB	J1		HREADENDE	R7		Output3
C3		HRESETB	J3		MODECTRL2	R9		Output9
C5		Output0	J11	9	Vreset	R11		Output25
C7		Output12	J13	21	vdda	R13		Temp1*
C9		Output20	K2	37	READEN	T2		VREADENDE
C11	6	Vncasc	K12	20	gnda	T4	17	CSB
C13	3	Vbiasoutbuf	L1		DATACLK	T6		VTESTEN
D2		HCLK1B	L3		DATAOUT	T8	30	Output7
D4		HTESTEN	L11	10	Output15	T10		Output27
D6		Output8	L13	26	Temp1	T12		Output29
D8		Output16	M2		VRESETB	U1		DATAIN
D10		Output24	M4		HCLKWM2	U3	19	MAINRESETB
D12	5	Refsample	M10		Output11	U5	15	VCLK
E1		HORIWMEM	M12		Output19	U7	12	RefOut
E3		HCLKWM2B	N1		VERTWMEM	U9	29	Output23
E5		Output4	N3		HCLK2	U11	28	Output31
E7		Output26	N5		BUFDISABLE	U13	27	Temp2

Design Description of 2x2 H2RG Detector Mosaic Module

The 2x2 Detector Mosaic Module design described in this document has evolved from a focal plane array (FPA) design developed as a prototype for the NGST/JWST satellite. This particular design is the 4th iteration of the NGST/JWST FPA design and has been tailored for use in ground-based astronomical instruments. This design was driven by the following primary requirements:

- The design should allow the mounting of four H2RG SCAs to form a close-packed 2x2 mosaic FPA.
- The detector surfaces of the mounted SCAs should be co-planar to the required tolerance.
- It should be possible to remove, and replace or re-install individual SCAs from the FPA without disturbing adjacent SCAs.
- The design should achieve temperature control of the mosaic focalplane to mK levels.
- The design should provide a convenient electrical interface to the SCAs and allow for the (future) option of incorporation of the Rockwell SIDECAR ASIC.

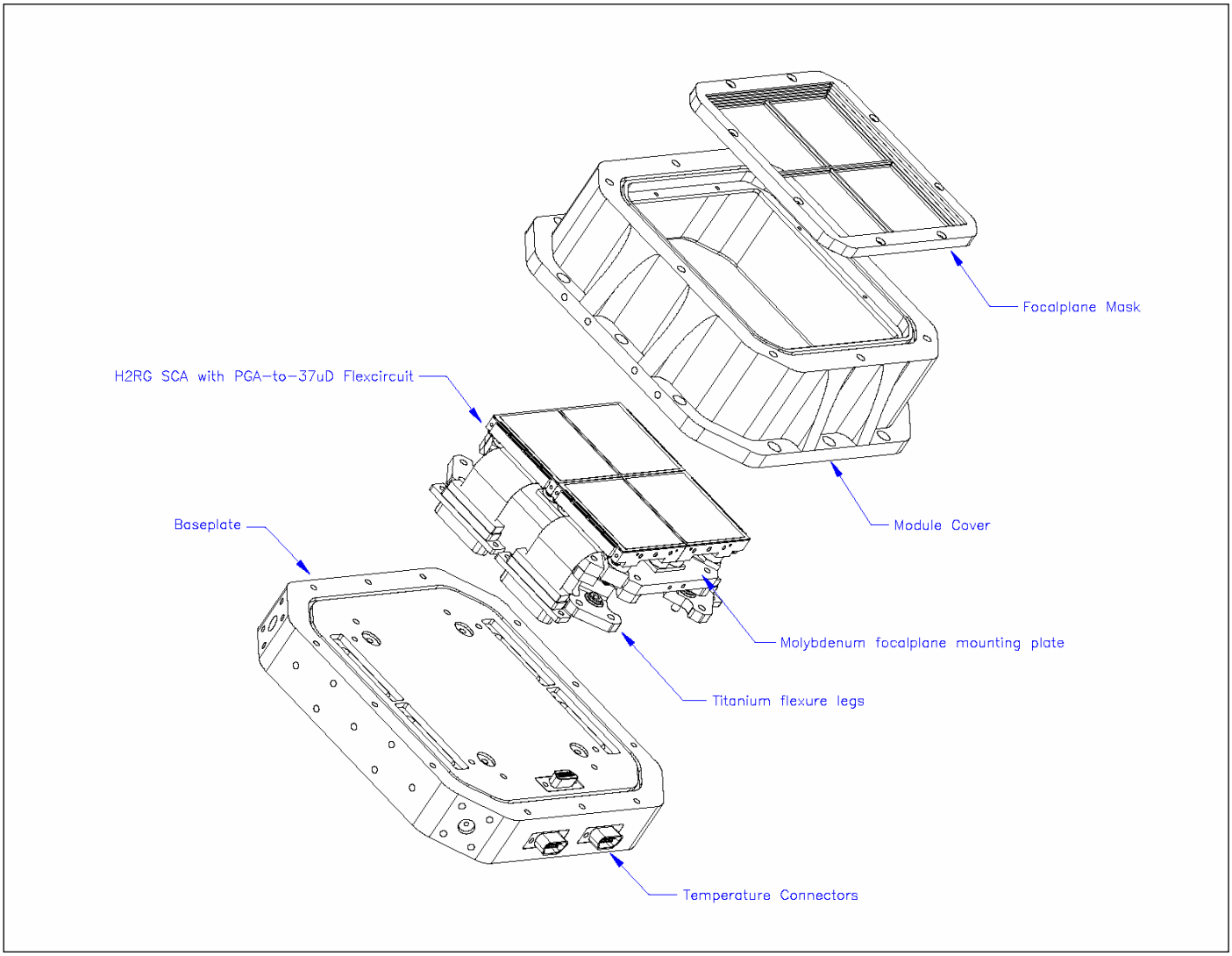


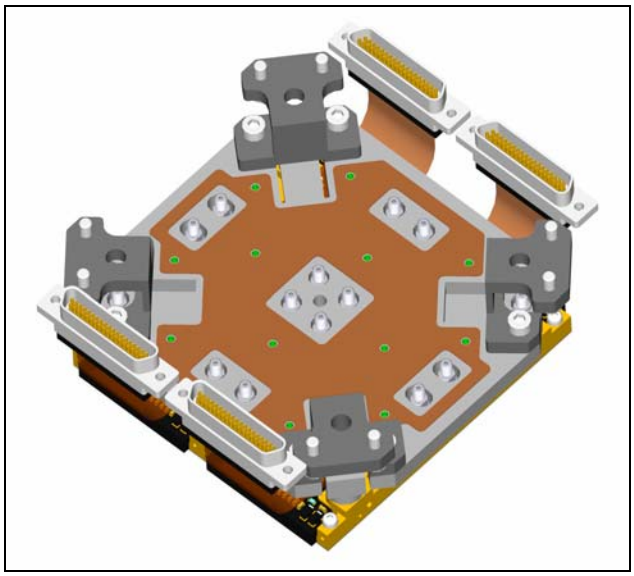
The resulting design is a compact module that meets all of the requirements listed above. The H2RG SCAs are mounted onto a common TZM/molybdenum focalplane mounting plate. The mounting plate has four sets of four holes into which the SCA Cu/W stud/pins are inserted. Each set of holes consists of a precision hole that fixes the location of the SCA, a precision slot that constrains the rotation of the SCA, and two slightly oversized holes for the remaining two mounting studs. The height of each SCA is set by the molybdenum spacer disks

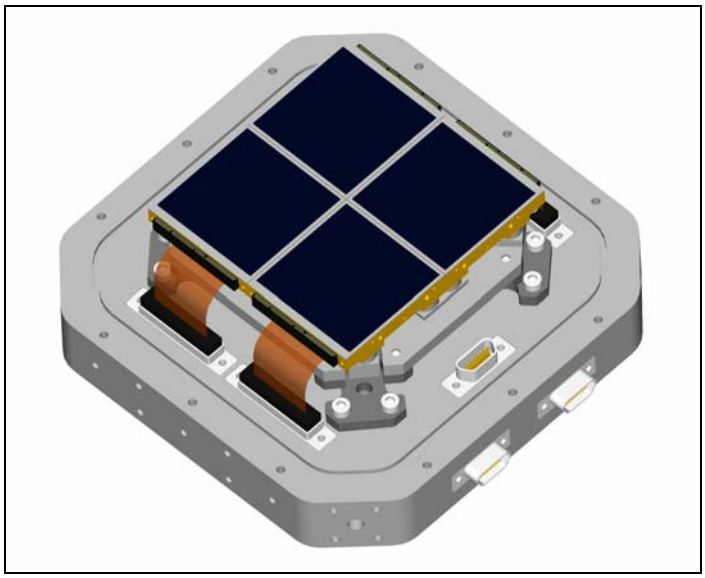
located coaxial to each of the stud/pins. Thermal contact to the moly plate is made through the moly spacers and Cu/W stud/pins, and four mounting points are used for each SCA to insure the thermal contact is symmetrically distributed around each SCA package. The moly plate is flexured at one of the hole locations so that SCA is not over-constrained when pulled down onto the plate. The focalplane mounting plate is attached to the module baseplate using four titanium standoffs. The standoffs set the height of the focalplane, and combine stiffness with limited thermal connection between the focalplane and the module baseplate. Holes are cut into the baseplate to allow mounting of the 37 micro-D connectors at the end of the detector flexcables. Connectors are also provided for the thermal control circuitry.

In order to keep stray light to a minimum, a gold-plated aluminum module cover attaches to the baseplate and surrounds and protects the focalplane. A stepped mask with a stepped central spider is attached into a recess in the front of the module cover. This part is lightly bead blasted to a matte finish and is black anodized. The purpose of this part is to reduce reflections and scattered light from the exposed, reflective portions of the the H2RG detectors (e.g. the 1mm regions around the edges of the ROIC, the bondpads and wirebonds, etc.).

Attachment points are provided so that the module can be mounted from the front, the back, or from the faces of the four corners of the baseplate.







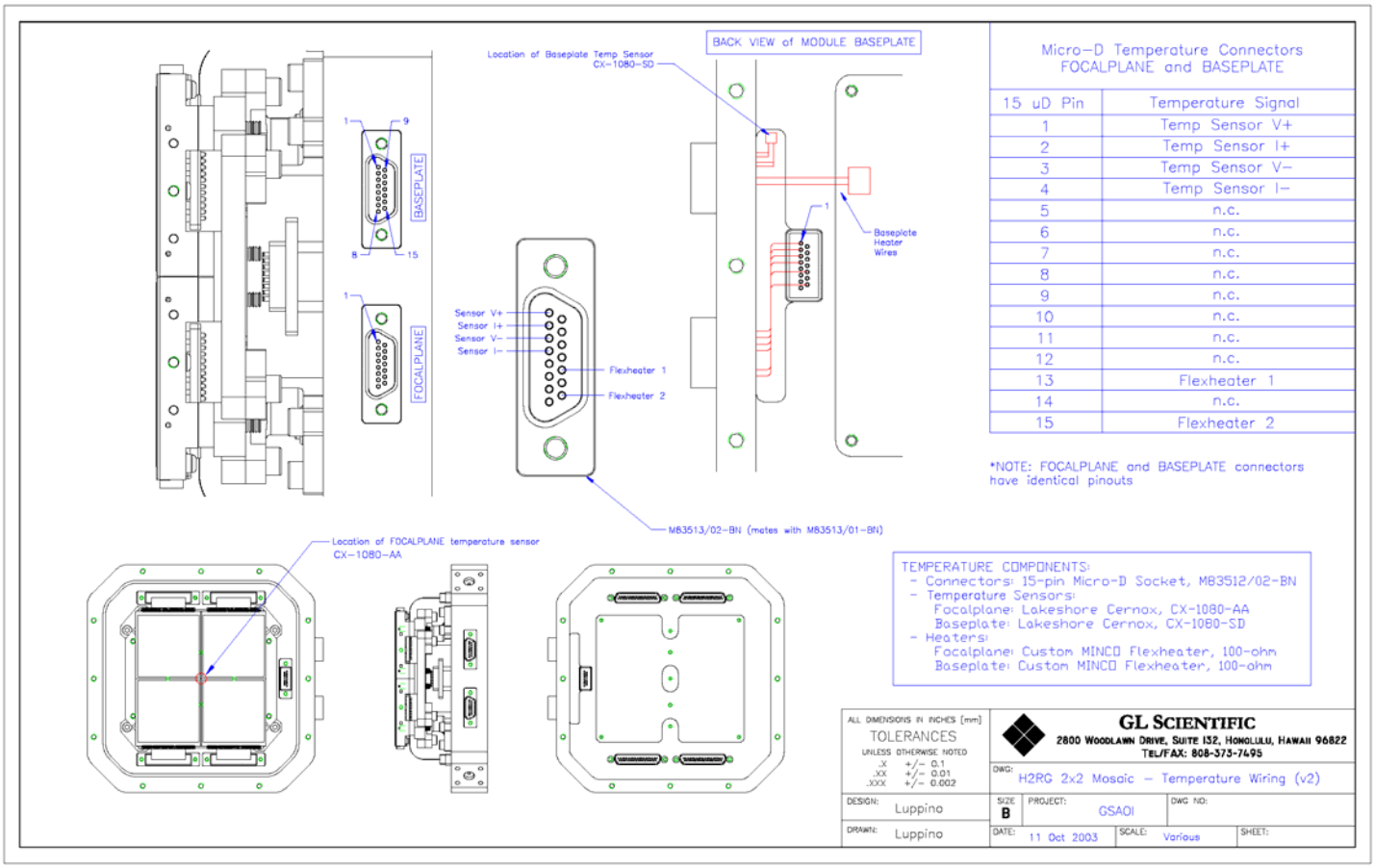
Detector Module Thermal Design

One of the primary goals of this module design is to enable mK temperature control of the mosaic focalplane. Such thermal stability can be achieved using a 2-stage approach: the module baseplate is connected to the instrument cryocooler or cold work surface and its temperature is regulated using a single control loop of a temperature control servo (e.g. a Lakeshore controller). The focalplane is operated several degrees warmer using a separate control servo. This approach requires that the baseplate and focalplane mounting plate each have their own independent temperature sensors and heaters, and that the focalplane be in partial thermal contact with the baseplate. The titanium legs serve as both thermal and mechanical standoffs for the focalplane. The baseplate, whose temperature can be regulated at the 0.1K level, provides a degree of thermal ballast and isolates the focalplane from large scale temperature fluctuations of the cryocooler or the rest of the instrument. It is then possible, using the independent temperature control loop for the focalplane, to regulate the detector temperature at the mK level.

Temperature measurement is carried out using calibrated Lakeshore Cryotronics Cernox sensors. There is a single cernox sensor (model number CX-1080-AA) epoxied into a hole in the center of the moly focalplane mounting plate and a second cernox sensor (model number CX-1050-SD) epoxied onto the backside of the baseplate near one of the temperature connectors. In order to avoid thermal gradients in the baseplate or the focalplane, custom kapton flexheaters were designed with geometries matched to the geometries of the baseplate and focalplane. These heaters were manufactured by Minco Products, and designed to have a resistance of 100 ohms with a power output of 15W and 50W for the focalplane and baseplate respectively (100 ohms is the optimal heater resistance for use with a Lakeshore temperature controller). The heaters and temperature sensors are bonded to the moly focalplane and aluminum baseplate using a special cryogenic epoxy that is thermally conductive and electrically insulating, while remaining mechanically compliant down to 4K (Masterbond EP37-3FLFAO). This epoxy also meets NASA outgassing specifications for use in a high vacuum environment.

There are two identical 15-pin micro-D connectors provided on one of the sides of the baseplate. One connector is connected to the baseplate flexheater and temperature sensor, while the other is connected to the focalplane

flexheater and temperature sensor via a pass-through connector that penetrates the bottom of the baseplate and can be mated to a micro-D connector attached to the focalplane mounting plate. The pinouts of the two temperature connectors are identical.



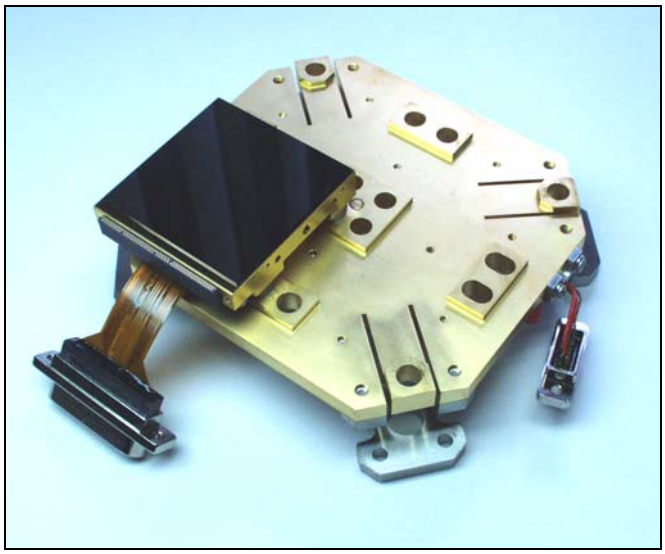
Description of the Individual Components in the Mosaic Module

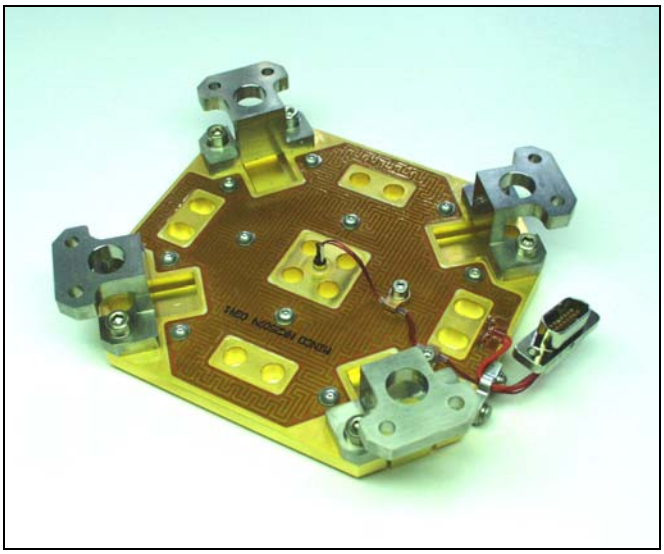
The mosaic module consists of the parts listed in the table below.

COMPONENT	QTY	MATERIAL	NOTES
H2RG Detectors	4		Supplied by Rockwell Scientific
H2RG PGA-to-37uD Flexcircuits	4		Supplied by Rockwell Scientific
Focalplane Mounting Plate	1	TZM/Molybdenum	Gold Plated
Focalplane Titanium Legs/Standoffs	4	Titanium AL6V4	
Module Baseplate	1	Aluminum	Nickel Plated
Module Cover	1	Aluminum	Nickel and Gold Plated
Focalplane Mask	1	Aluminum	Bead blasted matte and black anodized
Focalplane Locator Pins	4	SS	
Focalplane Kapton Flexheater	1	Kapton/Polyimide	Manufactured by Minco Products
Baseplate Kapton Flexheater	1	Kapton/Polyimide	Manufactured by Minco Products

Focalplane Mounting Plate and Titanium Legs/Standoffs

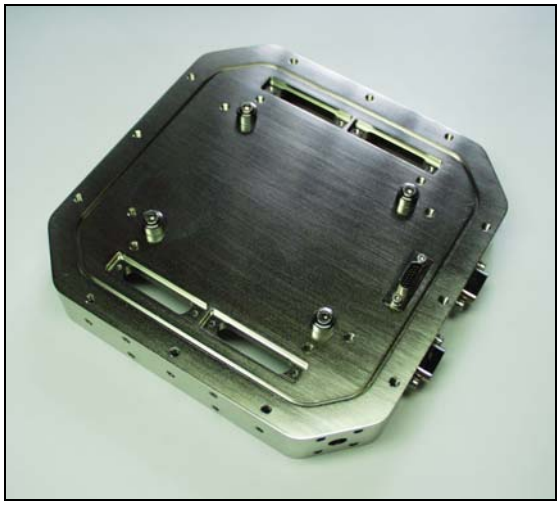
The focalplane mounting plate is manufactured from TZM/molybdenum to match the CTE of the SCA packages. It contains the mounting holes for the H2RG SCA packages (one precision hole, a precision slot and 2 oversize holes) with one of the holes mounted on a flexure to avoid over-constraining the 4-point mount on the SCA package. The plate is ground on all sides and is flat to a precision of +/- 5 microns. The manufacturing process includes cryo and heat treating to achieve thermal stability, and the plate is nickel and gold plated. The titanium standoffs are attached under the 4 corners of the plate under the flexures. Access holes are provided to allow installation of Belleville washers and nuts to pull down the SCA packages. The kapton flexheater and temperature sensor are attached to the bottom of this plate and wired to a 15-pin micro-D connector that allows the removal of the focalplane from the baseplate to enable device installation and removal. These features are illustrated in the photos below.

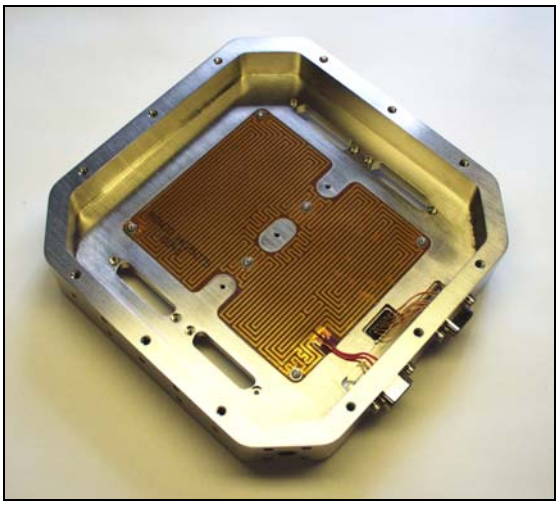




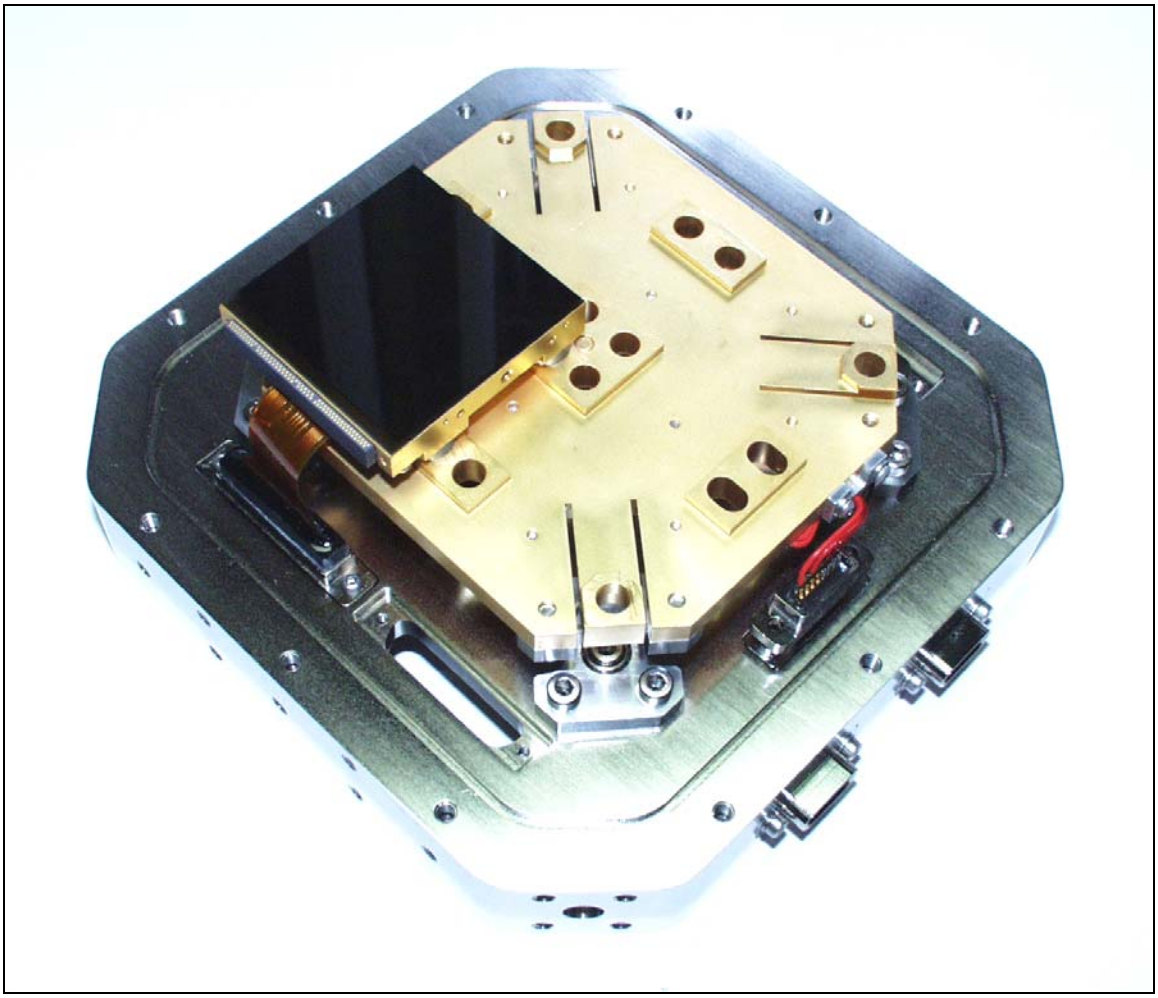
Module Baseplate

The focalplane assembly is mounted on an aluminum baseplate that has been nickel plated. Four SS locator pins set the position of the focalplane assembly.





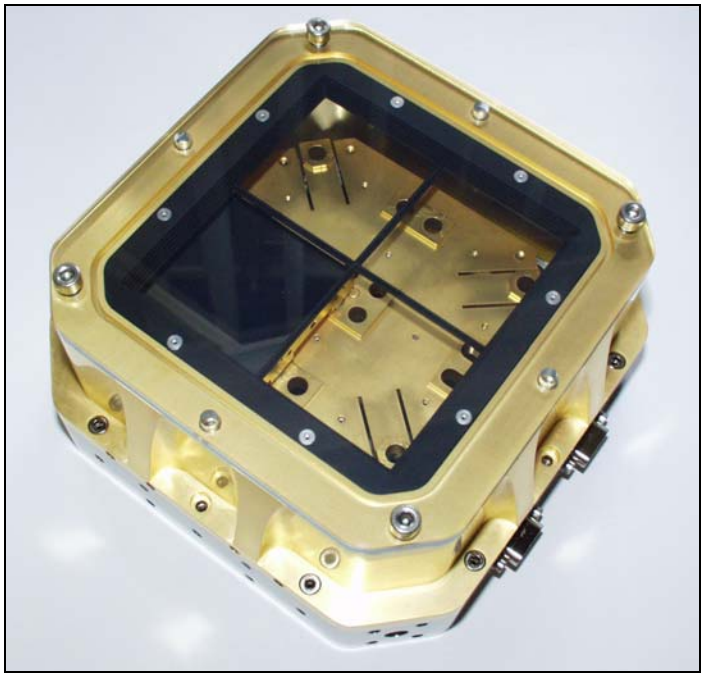
SS helical inserts are used for all tapped holes that will undergo frequent screw insertion and removal. This avoids any damage to the aluminum threads and the generation of particulate contamination. Additional holes provided on the sides and back of the baseplate can serve as alternative mounting points or for the attachment of thermal straps.

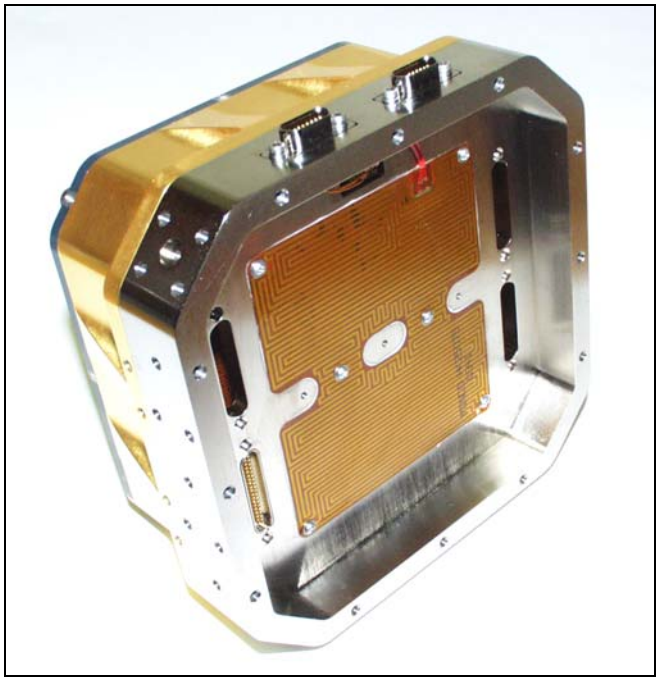


Module Cover and Focalplane Mask

The module cover is manufactured from aluminum that has been nickel and gold plated. This part surrounds and protects the focalplane and provides shielding from unwanted stray light. The cover contains a small tongue that runs around lower base of the cover and mates with a corresponding groove in the baseplate. The cover also contains the mounting recess for the focalplane mask. M4 mounting holes and a groove are provided on the front of the cover should one desire to mount the module from the front and to allow a light-tight baffle to be attached to this surface if desired.

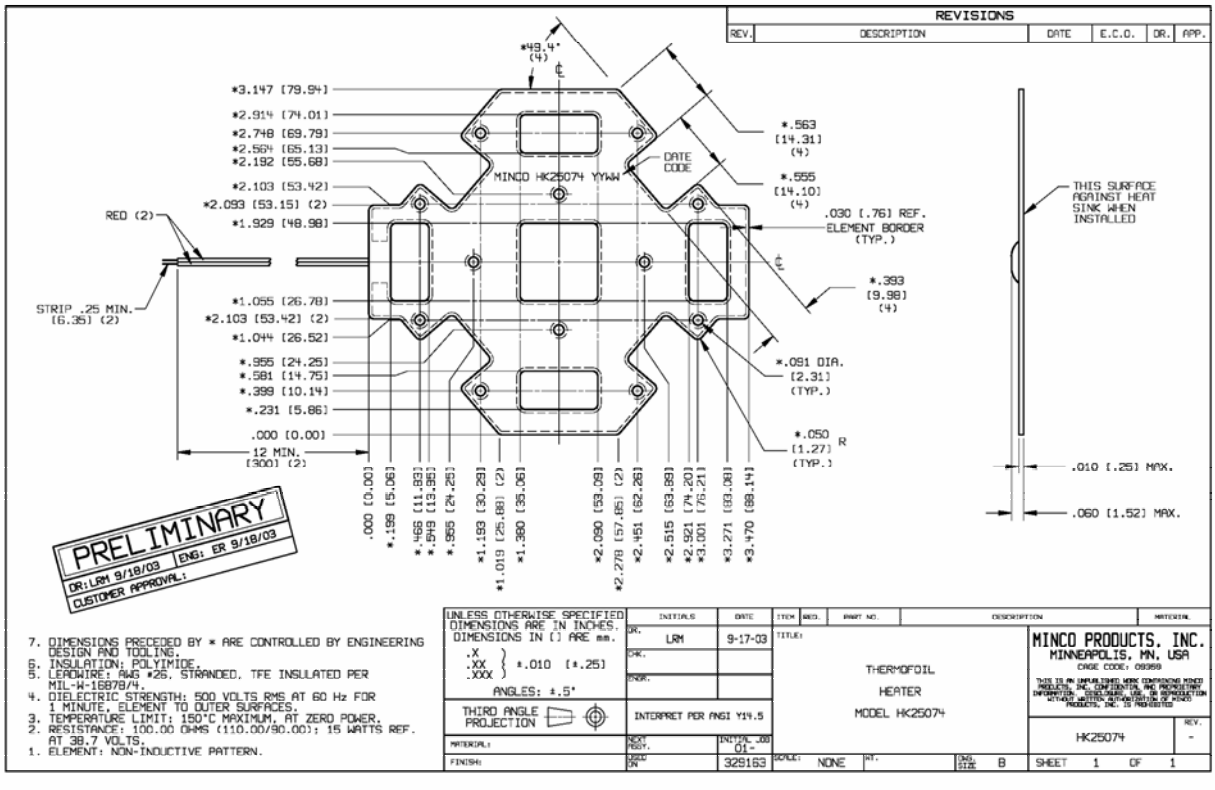
The purpose of the focalplane mask is to shield the highly-reflective surfaces in the focalplane from the incoming light thus avoiding scattering light back into the optical system. Examples of such reflective surfaces include the exposed metal lines on the 1mm periphery of the ROIC that extends beyond the active area of the HgCdTe detector, and the bondpads and bondwires. The mask is made from aluminum that has been bead blasted to a matte finish and black anodized.

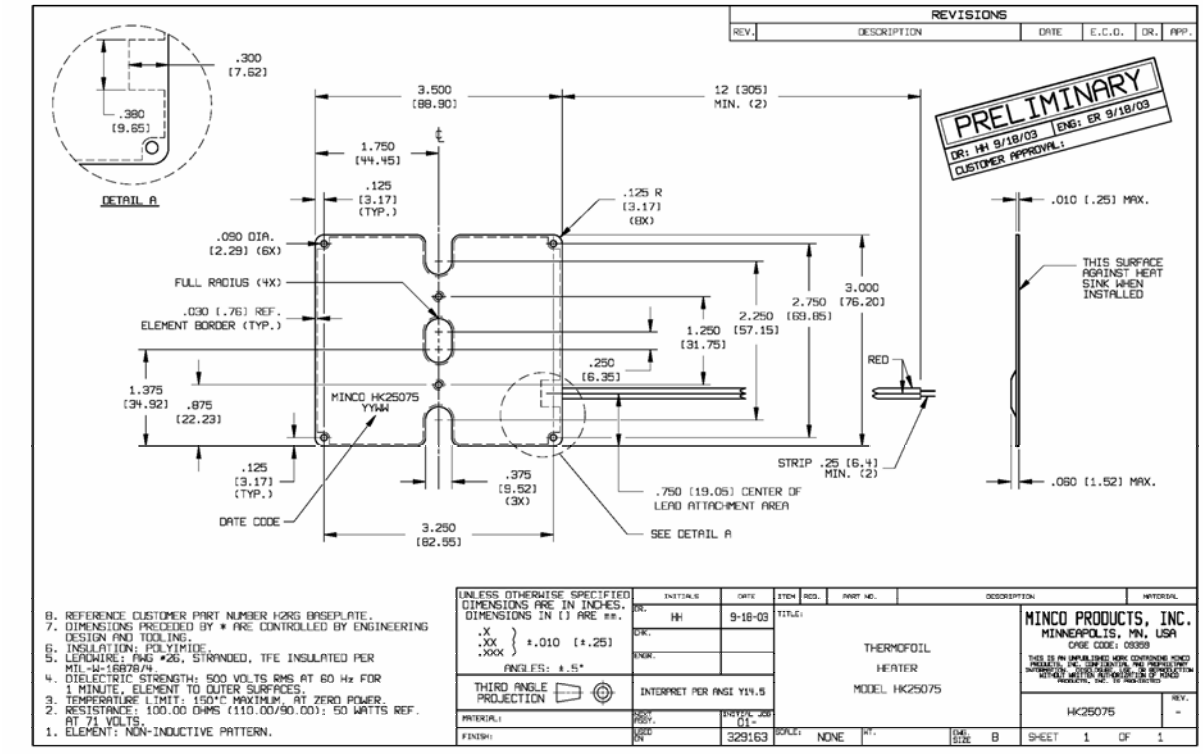




Kapton Flexheaters

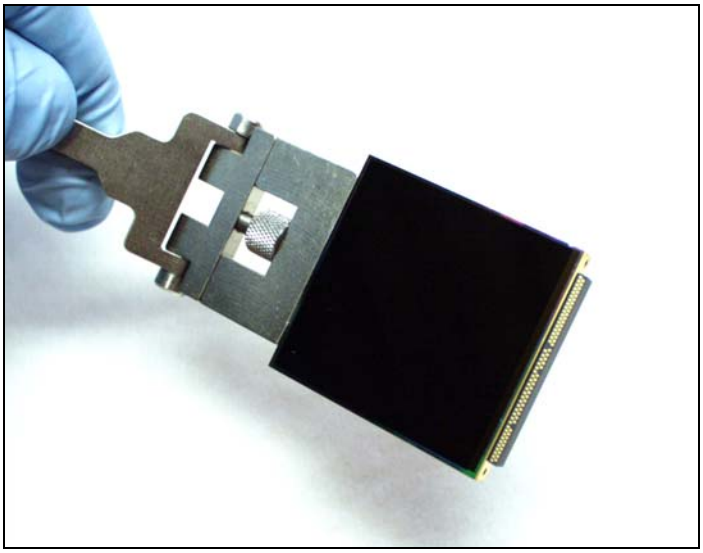
Custom kapton flexheaters were designed to allow spatially uniform heating of the focalplane plate and baseplate. These heaters were manufactured by Minco Products. The focalplane flexheater can provide 15W of heat and presents a 100-ohm load to the temperature controller. The base plate heater can provide 50W of heat and also presents a 100-ohm load to the controller.

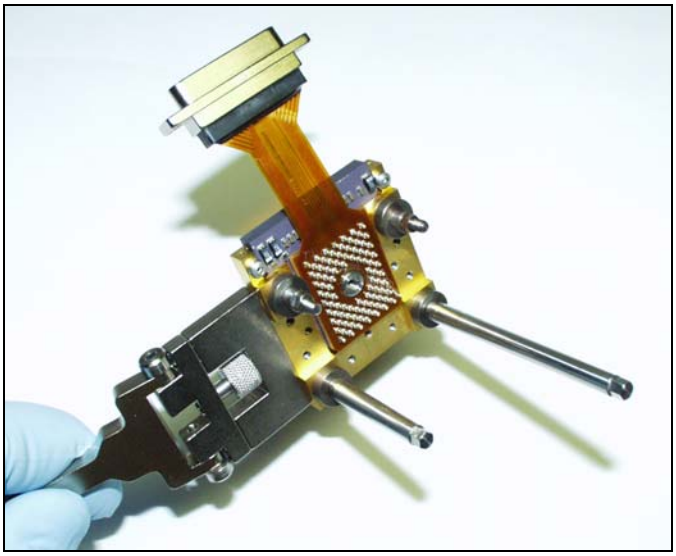




Installation of Devices into a Focal Plane Mosaic

Installation of H2RG SCAs can be carried out in a safe and straightforward manner using a combination of simple fixtures. Rockwell Scientific provides a handling fixture to each customer who orders an H2RG. This handling fixture is designed to attach to the H2RG SCA package using the fixture holes provided on the three buttable sides of the device. One attaches the fixture before removing the device from the mounting bracket in the shipping and storage container.





In order to install or remove a device from the module, the focalplane assembly consisting of the focalplane mounting plate and the four titanium legs is detached as a unit from the module baseplate by removing the eight M3 screws and Belleville washers and disconnecting the 15-pin micro-D connector for the focalplane temperature control. The focalplane assembly should then be mounted on a device installation stand as illustrated in the drawing below. Special tapered installation pins have been designed to attach to two of the stud/pins on the SCA. These tapered pins simply screw onto the ends of two of the studs as shown in the photo above and the drawing and photos below. While holding the SCA using the handling fixture, one can easily install the SCA onto the focalplane mounting plate. The longer of the pins should be mounted onto the stud that will insert into the precision hole on the center of the plate, while the shorter pin should mount onto the stud that will insert into the slot. The taper on the pins has been designed so that the pins will fully engage the holes in the plate while the device is still well above than the surface of any neighboring SCA. Once fully engaged, the device being installed can be lowered carefully and cannot crash into any device already in place in the focalplane. Once installed, Belleville washers and 4-40 nuts are attached to the two studs without the pins. The pins are then removed and the washers and nuts are attached to the remaining two studs. The clearance hole in each titanium leg is large enough to allow the use of a nutdriver to attach the nut onto the stud protruding through the flexure in the mounting plate. To remove a device from the focalplane, the procedure is reversed.