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VLT Instruments

NIRMOS DETECTORS AND
DATA ACQUISITION SYSTEM

FINAL DESIGN REVIEW

Doc.No. VLT-TRE-ESO-14620-2037

Issue prep1

Date 11/02/2000

Prepared for Review

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Name Date Signature
### Change Record

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1 SCOPE

For the NIRMOS final design review the status of the main deliverable components of the detector system is discussed and potential problems are outlined. A description of the data acquisition system IRACE and the NIRMOS test camera is given.

2 Background

ESO is providing the complete detector system for the NIRMOS instrument. The deliverables include four large format 2048x2048 pixel HgCdTe detector arrays having a cutoff wavelength of $\lambda_c=1.9 \, \mu m$, one data acquisition system to read out all four arrays simultaneously, and four detector cryostats each housing one detector and one cooled filter wheel. The cryostat window is the last lens of the objective.

The first NIRMOS science grade MBE HgCdTe array is scheduled to be delivered in September 2001 and all four NIRMOS science grade arrays will not be delivered before March 2002. Since the AIT phase will start by the end of this year, NIRMOS PAE is scheduled for June 2001 and installation at UT4 in August 2001, at these dates NIRMOS will only be equipped with a single 2048x2048 LPE array having a cutoff wavelength of $\lambda_c=2.5 \, \mu m$. This LPE array is the product of an ongoing detector development program not directly related to and optimized for NIRMOS. The upgrade with the NIRMOS MBE arrays can only start in 2002 and all four cameras of NIRMOS will be in operation not before mid 2002.

3 Introduction

Near infrared focal plane technology has developed rapidly during the past decade. The array format has grown exponentially and surpassed the megapixel threshold. In November 1998 the first 1028x1028 HgCdTe array was installed on the UT1 telescope of the VLT in the Infrared Spectrometer and Array Camera ISAAC. The same array is successfully operating since December 1997 at the NTT telescope in LaSilla in the SOFI instrument, which is a predecessor of ISAAC based on grisms. The combination of large detector format and improved pixel performance has largely expanded the scope of IR astronomy and allows to extend the wavelength range of a large multiobject spectrograph to the near infrared resulting in the demand for even larger detector formats than 1Kx1K.

To meet this demand the University of Hawaii and ESO are jointly funding the development of a 2048x2048 pixel HgCdTe array. A 2 year contract with Rockwell has been signed on a best effort basis. In the framework of this contract a bare multiplexer was delivered, an engineering grade array is expected within the next months, and a science grade array will be delivered in mid 2000. Based on the results of this contract and the experience with 1024x1024 HgCdTe arrays mounted in ISAAC and SOFI, a contract is placed with Rockwell to manufacture four 2048x2048 arrays optimized for NIRMOS.

A test cryostat was built to assess the performance of the 2Kx2K HgCdTe arrays. This test cryostat resembles the NIRMOS detector cryostat as far as possible and is used to prototype several key issues, such as the vacuum performance of the cryostat window, cryogenic performance of the continuous flow system and flexure.

The data acquisition system IRACE, which is in operation at the VLT instruments ISAAC and SOFI, has been upgraded to a 128 channel prototype system to read out simultaneously all channels of the four NIRMOS detectors. Each detector has 32 parallel video outputs.
3.1 APPLICABLE DOCUMENTS


[5] VLT-INS-00-0010, 1, 28/01/00--- NIRMOS Test Camera Optomechanical Test

[6] VLT-TRE-VIRD-14622-00xx--- NIRMOS Final Design Review Optical Box Sub-System Prototype Update

[7] VLT-TRE-ESO-14620-2048, 1 07/02/00--- NIRMOS Mechanical Interface between Detector Cryostat and Optical Assembly

3.2 REFERENCE DOCUMENTS


3.3 ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this document:

- BCS: Balanced Composite Structure
- FPA: Focal Plane Array
- PGA: Pin Grid Array
- DLPH: Double Layer Planar Heterostructure
- LPE: Liquid Phase Epitaxy
- MBE: Molecular Beam Epitaxy
- PACE1: HgCdTe grown on sapphire substrate by LPE
4 Goals for NIRMOS detector system

The goal for the NIRMOS detector system is to become photon shot noise limited for all observing modes. The sky emission in the J and H bands is dominated by OH airglow emission which severely restricts astronomical observations of faint objects in these spectral bands. The lowest flux levels are to be expected by the continuum emission between the OH lines. The intensity of this continuum emission has been measured by Maihara [8] et al. and can be as low as 590 photons s\(^{-1}\) m\(^{-2}\) arcsec\(^{-2}\) µm\(^{-1}\) at a wavelength of \(\lambda=1.665\) µm. For a spectral resolution of \(R=2000\) with a 1 arcsec slit, a pixel scale of 0.24 arcsec/pixel and an overall system efficiency of 23\%, the continuum emission generates a photon current of 0.33 e/s/pixel.

The continuum emission between the OH lines has also been measured with ISAAC. The spectrum shown in Figure 1 was taken with a slit of 1 arcsec and a pixel scale of 0.15 arcsec. The dispersion is 0.077 nm/pixel. The continuum emission intensity was deduced from the difference of the unvignetted continuum between the OH lines and the vignetted part of the image. The continuum emission generates a photon current of 0.167 e/s/pixel which corresponds to an intensity of the continuum emission of 1600 photons s\(^{-1}\) m\(^{-2}\) arcsec\(^{-2}\) µm\(^{-1}\).

The readout noise achieved with the 1Kx1K HgCdTe array is 10 e rms with double correlated sampling and 5 e rms with multiple nondestructive sampling. Assuming a continuum flux level of 0.33 e/s/pixel and a detector readout noise of 5 e rms, exposures with integration times longer than 80 s become photon shot noise limited by the continuum emission provided that the detector darkcurrent is small compared to the photon generated current.

The continuum emission is variable and may be lower in the J band. If the detector dark current is < 0.01 e/s/pixel it will be negligible in comparison with the photon generated current of even the darkest spectral regions of the sky. The cryogenic layout of the detector cryostat and the technology chosen for the production of the detector material have to meet the requirement of reducing the detector dark current to < 0.01 e/s/pixel.
Selection of 2048x2048 HgCdTe detector technology for NIRMOS

For the spectral range of 1 - 2.5 µm the HAWAII (HgCdTe Astronomical Wide Area Infrared Imager) array, a 1024x1024 HgCdTe array with a cutoff wavelength of $\lambda_c=2.5$ µm, was developed by Rockwell International Science Center in collaboration with the University of Hawaii. The device is now widely used for ground based astronomy. The excellent astronomical performance of this array has been well established at ESO during the last year by many observers using SOFI at the NTT telescope in LaSilla. First images and spectra obtained during the commissioning run of ISAAC at the VLT also demonstrated the unique characteristics of this device which has been described elsewhere [9].
5.1 LPE grown HgCdTe on Al₂O₃ (PACE1)

The HAWAII 1Kx1K array is produced by the standard PACE technology. The infrared active HgCdTe layer is grown on a sapphire substrate by liquid phase epitaxy (LPE). The diode junctions are formed by ion implantation utilizing a n-on-p process. The focal plane array is assembled by flip-chip hybridizing the infrared diode array to a silicon CMOS readout multiplexer using indium interconnects as shown in Figure 2.

To minimize the risk and maximize the yield the first 2Kx2K detector arrays will be produced by LPE grown material, which is the mature technology applied for the production of the 1Kx1K HAWAII arrays.

The first 2Kx2K LPE grown HgCdTe array will be delivered to ESO in September 2000. The array will have a cutoff wavelength of $\lambda_c = 2.5 \mu m$. It will be the only array available for NIRMOS until September 2001 when the first NIRMOS MBE arrays will be delivered. For this reason, if the present schedule is kept, only one camera can be equipped with the first 2Kx2K LPE grown HgCdTe array during the assembly, test and integration phase in Europe and for the commissioning at UT4.

5.2 MBE grown HgCdTe on CdZnTe

More advanced detector technologies are available. The LPE process can be replaced by molecular beam epitaxy (MBE). The HgCdTe diode array consists of double layer planar heterostructures (DLPH) grown on a CdZnTe substrate. The crystal lattice of the substrate is better matched to HgCdTe resulting in much lower defect densities. Contrary to the PACE material the DLPH MBE diodes are produced by a p-on-n heterostructure process. The surface or capping layer of HgCdTe is wider band gap material than the IR absorbing layer. The p-type side of the diode is produced by As implantation through the capping layer into the n-type base material. A cross section of the diode structure is shown in Figure 3. The outcome of this fabrication process are HgCdTe arrays with near-theoretical performance.

![Figure 2 Structure of PACE1 hybrid focal plane array grown by liquid phase epitaxy (LPE)](image)
The performance improvements are best shown by the darkcurrent density in Figure 4. For $\lambda_c = 2.5 \mu m$ the detector darkcurrent of MBE relative to LPE is reduced by more than 3 orders of magnitude at a specific operating temperature.

Due to the low defect densities of MBE material an additional benefit may be that MBE detectors will have negligible persistence.

Figure 3 Detector cross section of p-on-n Double Layer Planar Heterostructure photodiode arrays grown by molecular beam epitaxy (MBE).
K-band spectroscopy is not possible with NIRMOS, since the cold optical bench is only cooled to -55 C. Because NIRMOS does not have a cold field mask, K-band imaging will suffer from reflected thermal radiation as has been experienced with the IRAC cameras and has also been demonstrated with SOFI using the small field objective with the focal elongator and the mask for the large field objective. The ring structure is prominent in Figure 5. It is due to reflection of room temperature blackbody radiation by optical surfaces.
For H-band spectroscopy the instrument performance will be completely limited by the thermal emission of the warm slitmask. In Figure 6 the photon flux seen by a detector pixel is plotted versus the temperature of the cold optical box (COB). The curves are calculated for different temperatures of the slit mask. The temperatures indicated are relative to the ambient temperature of 14°C. The cumulative probability of the corresponding dew points in Paranal are indicated as well. Cooling the slit mask will improve the performance of H-band spectroscopy. To reduce the background to the level of the OH continuum the mask has to be cooled to 50°C below ambient temperature. For J-Band spectroscopy it is not necessary to cool the optical bench.

Figure 5 K-band image taken with SOFI using small field objective and focal elongator (field 1.2 x 1.2 arcminutes) and cryogenic field mask of large field objective (4.9x 4.9 arcminutes) to demonstrate ring effects without cold field mask.
To simplify the cryogenic design of the cryostat, the optical baffling and the straylight suppression, the detector cutoff wavelength is set to 1.9 \( \mu \text{m} \). MBE on CdZnTe is chosen for the detector material to reduce the cooling requirements necessary to meet the darkcurrent specification of <0.01 e/s/pixel. A simple continuous flow cryostat cooling the detector to an operating temperature of 80 K is sufficient for MBE material.

6 Status of 2048x2048 HgCdTe detector development:

6.1 Si CMOS Read-out multiplexer

The pixel design is identical to the 1Kx1K layout, but on an 18 \( \mu \text{m} \) pixel pitch. The silicon readout multiplexer of the 2Kx2K array (HAWAII-2) consists of 4 electrically independent quadrants. 12 multiplexers are fabricated on a single 8 inch Si wafer. Each multiplexer is stitched together by photocomposition of four 1Kx1K quadrants.

The number of video outputs provided by the readout chip is programmable between 4 and 32. Since the analog signal bandwidth can be reduced by using all video outputs, we use all 32 outputs. The multiplexer clock-
The first lot of 25 multiplexer wafers has been fabricated at Conexant. On each wafer there are 12 multiplexers. Six of the wafers have been thinned and probed. The yield of science grade multiplexers is ~20%.

The readout topology of the Hawaii-2 multiplexer is shown in Figure 7. It is organized in four identical, electrically independent quadrants. Each quadrant has a readout direction that is orthogonal to the other adjacent quadrants. The intersection of the fast and slow arrows in Figure 7 indicates the corner, where pixel 0,0 of the quadrant is located.

ESO has received the first multiplexer. In Figure 8 the 2Kx2K multiplexer is mounted in the NIRMOS detector board. In the lower part of this board the 32 cryogenic off-chip preamplifiers are located. Each preamplifier has two symmetrical outputs and two inputs, one for the video channel and one for the additional on chip reference to enable monitoring of electrical and thermal detector drifts and to minimize noise pickup in the long cables transporting the signal to the ADC board.

The array is mounted on a ceramic pin grid array (CPGA) which is plugged into a zero insertion force (ZIF) socket. The central pins are used for heatsinking the detector. This method of cooling the detector has been successfully tested in the NIRMOS test camera with an empty CPGA. A detector temperature of 83 K has been achieved [5].
Figure 7 Readout topology of Hawaii 2 array. Four identical, electrically independent quadrants. Readout direction of quadrants are orthogonal. The intersection of the fast and slow arrows indicate the corner of pixel 0,0.
The first arrays have been produced using the PACE 1 process. The cutoff wavelength of all 2Kx2K LPE arrays is 2.5 µm.

6.2 LPE grown HgCdTe on Al₂O₃ (PACE 1)

The first arrays have been produced using the PACE 1 process. The cutoff wavelength of all 2Kx2K LPE arrays is 2.5 µm.
The infrared diode array on the sapphire substrate and the silicon readout multiplexer having indium interconnects deposited on each pixel have to be aligned on a mating machine and pressed together to form a cold metal weld. The large size of the FPA requires very high loads to bond the hybrid. The first focal plane arrays (FPAs) were hybridized with a low mating force to make sure the FPA did not incur interconnection failure due to slippage. Future arrays will be hybridized with a new mating machine allowing larger mating forces. However, as can be seen in Figure 10a to Figure 10d, Rockwell is on a steep learning curve. Hybrids number 1 and 2 have nonfunctional quadrants. Hybrid number 3 has all four quadrants functional with >90% interconnect yield and the latest hybrid is already science grade with 99.98% operable pixels.

The thermal expansion mismatch between the infrared detector on the sapphire substrate and the silicon multiplexer imposes challenges on thermal cycling reliability. To minimize the stress introduced by repetitive thermal cycling a balanced composite structure (BCS) design is used. A laminate structure is placed under the
multiplexer to compress the multiplexer to better match the thermal contraction of the detector. Using the BCS
design has proven reliable for the 1Kx1K arrays and similar performance is expected for the 2Kx2K arrays.

The NIRMOS tests in Europe and the commissioning at UT4 have to be carried out with one single LPE array,
which will be the only 2Kx2K array available in time.

6.3 MBE grown HgCdTe on CdZnTe

As discussed in the previous chapter on the selection of the detector technology, NIRMOS does not include
the K-band. The cutoff wavelength of the detector is set to 1.9 \( \mu \text{m} \). It will be cooled by a simple continuous flow
cryostat and operate at a temperature of 80 K.

The best technology for achieving extremely low darkcurrents at relatively high operating temperatures is mo-
lecular beam epitaxy grown HgCdTe on Cd ZnTe substrate. Dark currents are reduced due to lower defect den-
sities of the lattice matched material system. The cutoff wavelength can easily be tuned and superior pixel
performance is expected.

The NIRMOS detectors will be based on this technology. A contract for the procurement of four 2Kx2K MBE
grown HgCdTe arrays has been prepared and is finalized with Rockwell Science Center. The specifications of
the NIRMOS arrays are summarized in Table 1 and discussed in more detail in reference [1].

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<td>Detector Material</td>
<td>MBE HgCdTe double layer planar heterostructure (DLPH) grown on CdZnTe substrate</td>
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<tr>
<td>Format</td>
<td>2048x2048</td>
</tr>
<tr>
<td>Cutoff wavelength</td>
<td>( \lambda_c = 1.9 +/- 0.05 \mu \text{m} )</td>
</tr>
<tr>
<td>Pixel size</td>
<td>18 ( \mu \text{m} )</td>
</tr>
<tr>
<td>Package</td>
<td>128 pin in 19x19 pin grid array ceramic carrier for pin grid array zero insertion force socket</td>
</tr>
<tr>
<td>Number of outputs</td>
<td>Switchable between 32 outputs, single output an shuffled output Both source follower and internal bus outputs selectable on same output pins</td>
</tr>
<tr>
<td>Reference Outputs</td>
<td>4 outputs, 1 output / quadrant</td>
</tr>
<tr>
<td>Frame rate</td>
<td>&gt; 5 Hz using 32 parallel outputs</td>
</tr>
<tr>
<td>Reset by row</td>
<td>Nondestructive readout possible</td>
</tr>
<tr>
<td>Readout noise</td>
<td>Double correlated: &lt; 15 erms Multiple sampling: &lt; 7 erms &lt; 9 erms &lt; 4 erms</td>
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Table 1 Specifications for the NIRMOS detector arrays

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<th>Specification Goal</th>
<th>Specification</th>
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<tr>
<td>Storage capacity @ 0.5 V</td>
<td>$6 \times 10^4$ electrons</td>
</tr>
<tr>
<td>Integration capacitance</td>
<td>&lt; 35 fF</td>
</tr>
<tr>
<td>Fillfactor</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>Quantum efficiency (+/- 5%) at 80 K</td>
<td></td>
</tr>
<tr>
<td>$\lambda = 1.2 , \mu m$</td>
<td>&gt; 60%</td>
</tr>
<tr>
<td>$\lambda = 1.75 , \mu m$</td>
<td>&gt; 70%</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>$\lambda = 0.9 , \mu m - 1.9 , \mu m$</td>
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<tr>
<td>Darkcurrent (80 K, $V_{\text{bias}} = 0.5$ V)</td>
<td>&lt; 30 e/hour</td>
</tr>
<tr>
<td>Uniformity in H ($\lambda = 1.5 , \mu m - 1.8 , \mu m$)</td>
<td>STDEV/MEAN &lt; 0.07</td>
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<tr>
<td>Yield (working pixels)</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>80 K</td>
</tr>
<tr>
<td>Cooldown cycles without degradation of cosmetics</td>
<td>&gt; 150</td>
</tr>
<tr>
<td>Multiplexer glow</td>
<td>&lt; 0.1 e/frame in the center of the array</td>
</tr>
<tr>
<td>Persistence</td>
<td>&lt; 100 electrons in second consecutive one minute dark exposure after being exposed to point source generating photocurrent of $2 \times 10^5$ e/s</td>
</tr>
<tr>
<td>Crosstalk</td>
<td>$\alpha &lt; 5 \times 10^{-6}$ (see reference [1])</td>
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7 Data Acquisition System

The data acquisition system of NIRMOS must be capable of reading four 2Kx2K detectors simultaneously. The IRACE architecture is flexible and well suited for this task.

The concept and design for the data acquisition system is identical to the IRACE systems used for ISAAC, CONICA, CRIRES, VISIR and the LaSilla instrument SOFI. It consists of standard IRACE modules as defined in [2] or http://www.eso.org/projects/irid/irace/documents.html. The IRACE system for NIRMOS has to read out four 2K x 2K Rockwell detectors. All detectors are read out at the same time. Since each detector has 32 video channels, in total 128 parallel channels have to be read simultaneously.

The detector electronics inside the cryostat consists of filters and protection circuits for the array and 32 cryogenic preamplifiers with symmetrical output which are next to the detector at cryogenic temperatures. The
space required for the 64 cryogenic operational amplifiers (2 per channel) is 230 am². The detector board is shown in Figure 8.

The only upgrade made to the IRACE system is the implementation of a newly developed ADC board with 16 channels. Instead of using ADC boards equipped with 4 ADC’s (AQ4) the new ADC boards (AQ16) is equipped with 16 ADC’s. The expensive and large hybrid ADC from Analogic (ADC 4322 / 16 Bit / 2MHz, cost 2000DM) is replaced by the cheaper ADC from Linear Technology (ADC LTC1604CG /16 Bit /333 KHz, cost 70 DM). This reduces dramatically both the size of the front end electronics rack and the system cost. Even though the ADC speed is slower and the maximum readspeed per pixel will be 4µs, the readout time for the full frames of all four 2Kx2K arrays will be 400ms due to the multiplex advantage of the 128 parallel video channels. The ADC boards have been produced and tested. In Figure 13 a comparison between a four channel ADC board on the left side and the NIRMOS 32 channel ADC board on the right side is shown.

The front end electronics for all four detectors are contained in a single rack which has the size and weight of the ISAAC front end electronics (19 inch VME rack 10HE / 84TE / 300mm). The detector front-end is connected to the detector back-end and number cruncher interface by two fiberoptic links. One link is designated to system administration (10Mbit) the other link to data transfer (1Gbit/s). The number cruncher is a commercial SUN Ultra Spark as in the standard IRACE system. In Figure 11 the layout of the IRACE system for NIRMOS is shown.

A prototype version of the 128 channel IRACE system was built and tested. Both the front and back-end IRACE system is shown in Figure 12.
Figure 11 Data Acquisition system IRACE for reading out all 128 video channels of four 2Kx2K HgCdTe arrays simultaneously. Frame rate 2.5 Hz.
Figure 12 IRACE 128 channel data acquisition system for readout of 4 2Kx2K MCT arrays each having 32 parallel video channels. Left rack: Interface to Sun ultrasparc. Right rack: Front end electronics with 128 ADC channels, sequencer and clock drivers. Data transport (gigalink) and communication (TIF) to front end by fiber optic links.
8 Cryogenic Requirements

The cut-off wavelength of the final NIRMOS detectors is $\lambda_c = 1.9 \, \mu m$, and the detector material is MBE grown on CdZnTe. The instrumental darkcurrent has to be small in comparison with the photon generated current caused by the continuum emission. To achieve a photon flux smaller than $10^{-2}$ photons/s/pixel the instrument temperature must be lower than 180 K. This temperature can be easily achieved by a continuous flow cryostat.

The only 2Kx2K detector available for testing and commissioning NIRMOS will be based on PACE1 LPE material. Exceptionally good LPE arrays like the Hawaii 1Kx1K array mounted in SOFI have darkcurrents as low as 0.1 electrons/second. This was the lowest darkcurrent we have measured at 80 K. But there is no guarantee to achieve this outstanding performance with the first 2Kx2K LPE array which will be produced for ESO.
For the final MBE grown NIRMOS arrays an operating temperature of 80 K is expected to achieve darkcurrents well below $10^{-1}$ e/s/pixel as extrapolated by darkcurrent curve for MBE arrays shown in Figure 14.

Detector Cryostat

The detector cryostat houses the detector, the cold detector electronics including cryogenic preamplifiers for 32 channels and one cold filter wheel driven by a backlash-free pinion gear system as used in IRATEC. The filter wheel has 10 positions for square filters each having a size of 47x47mm. The cryostat window is the last lens of the 6 lens f/2 objective. It will not be actively cooled.

The cryogenic system is based on a continuous flow cryostat similar to the standard ESO system used to cool the CCD detectors. An instrument temperature of <140 K can be easily maintained by this system. During first cryogenic tests the filter wheel was cooled to temperature of 100 K and the dummy detector reached a final temperature of 84 K. [5]

The cryostat window lens has to be positioned with a lateral accuracy of +/-250 µm with respect to the optical axis. The tolerance for the tilt is +/- 5 arcminutes and the tolerance in direction of the optical axis is +/- 200 µm. The complete detector cryostat will be rotated around the optical axis to align the dispersion direction parallel to the rows of the detector array. Since the lens window will be passively cooled, test setups of the interface to the cold optical box have to be prepared and tests have to carried out with special attention to avoid window condensation and vacuum leakage of the window seal, which is a potential risk for the detector array in case of sealing problems at low temperatures [7].

Figure 14 Detector darkcurrent as function of temperature. Stars and circles: LPE material having cutoff wavelength of $\lambda_c=2.5$ µm. Hexagons: MBE material having cutoff wavelength of $\lambda_c=2.2$ µm. The detector darkcurrent of LPE grown HgCdTe is < $10^{-2}$ e/s/pixel for a detector temperature < 53 K.
The detector movement in the rotating test camera was measured to be 16 µm and 4 µm in the two directions of the detector plane and has to be further improved [5].

The control electronics for the filter wheel drive and the wheel initialization are similar to the ISAAC system. The requirements for the control system of the cryogenic and vacuum system are defined in reference [3]. The design is presented in reference [4]. The hardware prototype shown in Figure 16, has been successfully tested during operation of the test camera.

Figure 15 NIRMOS test camera with plane entrance window and continuous flow system.
Figure 16 NIRMOS cryo-mechanical camera control electronics
10 Schedule

The milestones for the fabrication of the detectors are shown in Figure 17. The schedule may be delayed due to unforeseen problems encountered during the development of the 2Kx2K HgCdTe arrays. If so, the solution of these problems may take longer than anticipated at first sight, as we have experienced with other development programs. The four NIRMOS detectors will not be available for assembly, test and integration in Europe and for first light in Paranal. Only one single LPE grown 2Kx2K detector resulting from an ESO development program can be provided in time for performing tests in Europe and commissioning at UT4.

11 Conclusions

The development of the 2Kx2K HgCdTe focal plane arrays has made considerable progress. First LPE grown hybrids have been fabricated achieving pixel yields of 99.98%. The schedule of the NIRMOS detector system is critically depending on the progress of this development. If the consortium sticks to the present schedule, the test and integration in Europe and the commissioning at UT4 can only be conducted with one camera being equipped with an LPE array.

The technology selected for the four NIRMOS detectors is MBE grown HgCdTe on CdZnTe having a cut off wavelength of 1.9 µm. The contract with Rockwell for the manufacture of four NIRMOS detectors is prepared and some administrative issues are being finalized.

A bare multiplexer has been delivered and mounted in a 32 channel detector board. An IRACE prototype version of the 128 channel NIRMOS data acquisition system has been built and tested. Size and cost have been minimized by replacing by placing 16 integrated ADC’s on a single video port.

A continuous flow cryostat is adequate for the chosen MBE detector technology. First cryo-mechanical tests with the NIRMOS test camera, a prototype of the NIRMOS cameras, have been carried out. The cryogenic performance is adequate, but the flexure is still to be improved. The camera control electronics works reliably. Tests for interfacing the detector cryostat to the cold optical bench must be defined and performed.

The highest performance gain for H-band spectroscopy can be achieved by cooling the slit mask to the dew point temperature.
Figure 17 NIRMOS schedule and detector milestones.