Technical Report
RAL-TR-2004-015

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InGaAs Infra-red Detector Project

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Addendum to:-

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InGaAs Infra-red detector project.

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Introduction

This work was funded by the CCLRC Centre for Instrumentation. The proposal was to connect a commercial InGaAs linear photo diode array to existing CCLRC Xstrip readout chip and perform linear imaging over the InGaAs IR spectral range from 800 nm out to 1.7um. The XDAS-10 electronics containing the Xstrip readout IC is a flexible and fast, charge measuring system that can be connected to any photo-diode array. Previously it has shown an advantage in the X-ray spectrum over other multiplexed readout ICs such as the Reticon devices. We have now demonstrate this advantage in the IR region with this quick trial. The array produced will provide unique capabilities for ultrafast spectroscopy for the CLF user community.

Phase 1

We initially purchased one XDAS-10 system from ETL containing the Xstrip chip, and one 16channel Hamamatsu G7150-15 InGaAs detector. We constructed a simple interface card to connect the two together as seen in Fig 1.

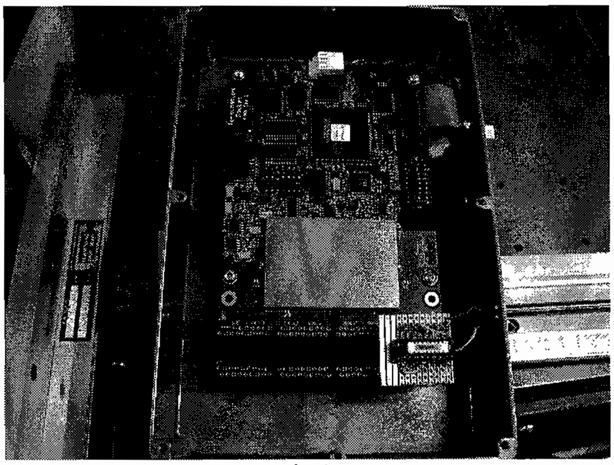


Fig 1.

We up rated a Bentham Monochromator to work from below 800nm through to 2.5microns shown in Figure 2. This now has two selectable gratings and two output ports. The gratings, ports and emitted photon wavelengths can be selected and scanned under computer control.

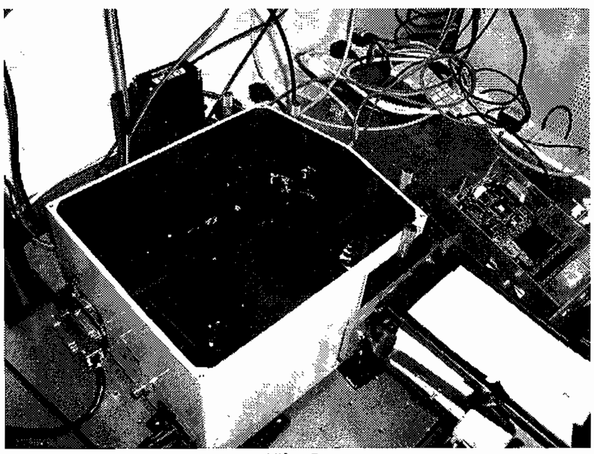


Fig 2.

We then tested the 16 channel device over the spectrum produced by the monochromator. Fig 3 shows the spectrum obtained from the unbiased Hamamatsu device.

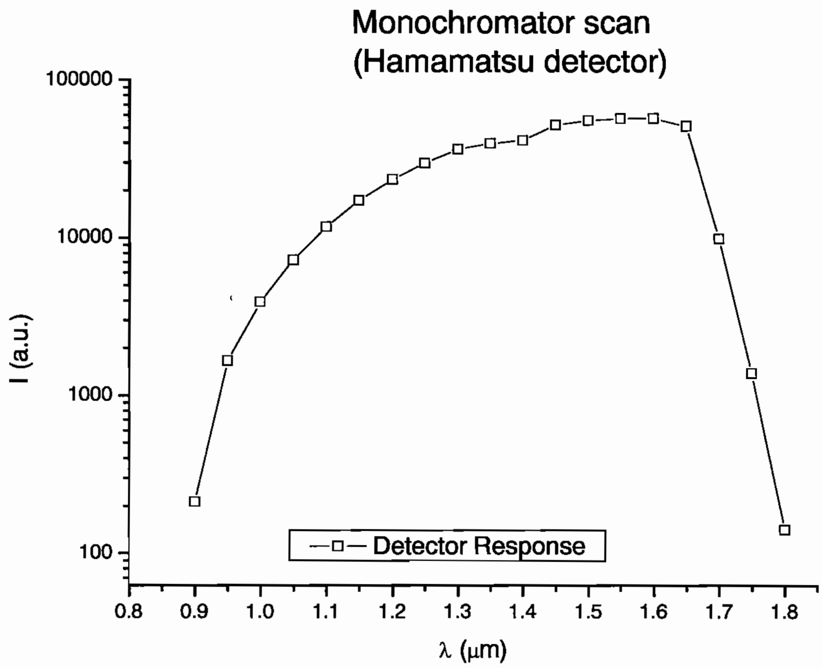


Fig 3.

The Hamamatsu device was then taken to the CLF laser where 800nm light is converted to a white light spectrum using non-linear photon addition in a water sample. The resulting spectrum measured by the InGaAs detector shown in Fig 4 demonstrates that the laser light has a cut-off at 1.4um which is below the 1.7um range of the detector.

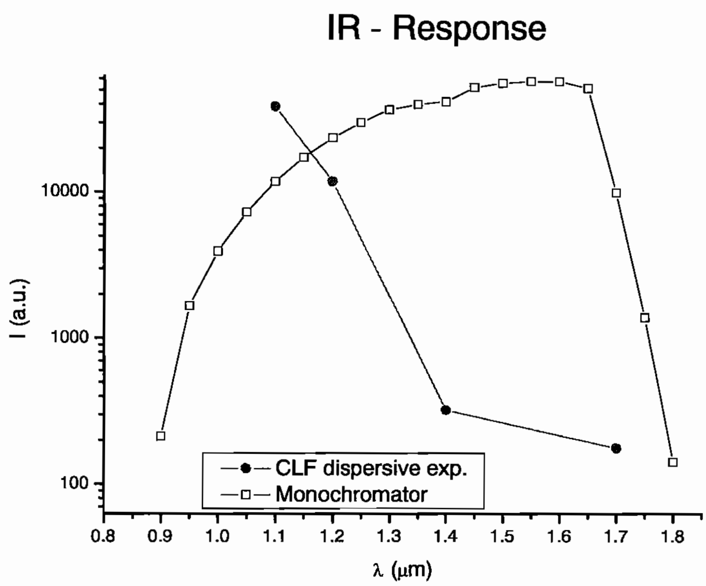
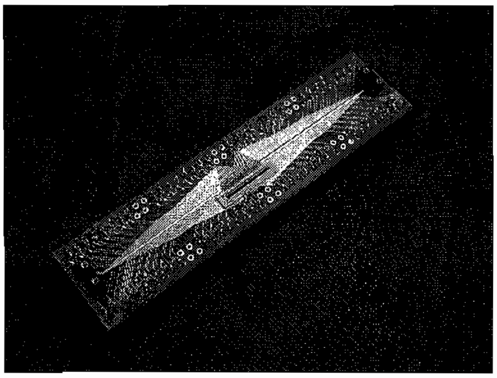


Fig 4.

Phase 2

It proved very difficult to purchase InGaAs detectors which were not connected to multiplexing electronics. All the US and far–east companies we approached eventually refused to sell us bare detectors. A Belgium company turned out to be our only option. We thus have purchased 5 linear InGaAs detectors from Xenix. One was a test device and 4 were full 256 channel devices. Each detector elements are 500um tall by 50um pitch. They are especially designed so that even and odd channels have the same efficiency, which has been an issue for other similar detectors. We connected two strips together into each of the 128 channels of the XDAS-10 to give a 128 channel detector with a 100um pitch. This gives a 500um by 12.8mm coverage. The 5 devices were connected to the XDAS-10 card with an interface card made to our design by Ability Designs. The first version of the interface card did not work as the pitch of the XDAS-10 connector was wrongly assumed to be a uniform 0.1inch pitch. Blocks of 34 were actually on a 0.1 pitch but these blocks were separated by a different pitch. A second version worked perfectly. The Xenix InGaAs detectors were glued to a ceramic substrate and then bonded to the interface cards. The back of the InGaAs detectors were glued with conductive epoxy to the gold surface of the substrate and this was biased to the input voltage of the XDAS-10 channels. Fig 5 shows the interface card and Fig 6 show a detector on the ceramic substrate, Aluminium wire-bonded at RAL to the interface cards.



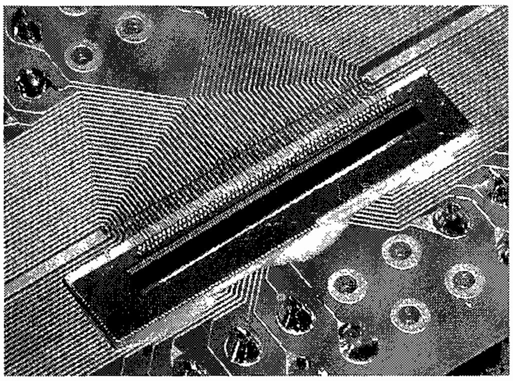


Fig 5, 6.

These detectors showed very similar spectral response to the Hamamatsu device as shown in Fig 7

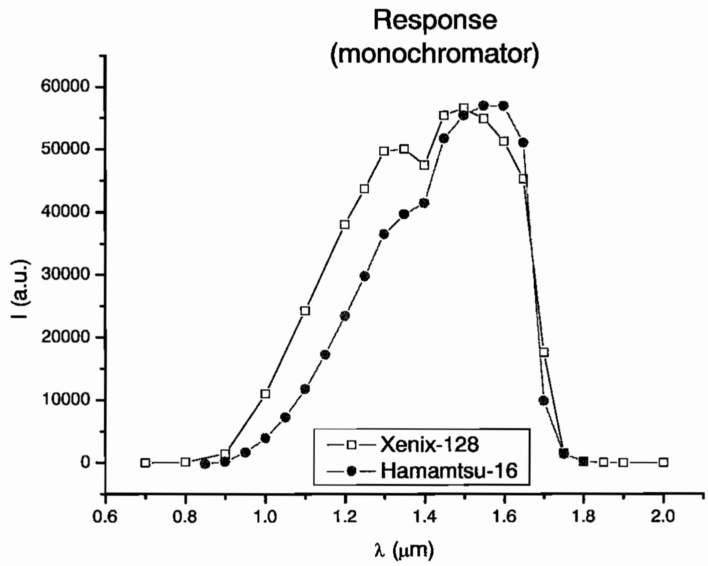


Fig 7.

The initial trials with single detectors on a single XDAS showed very good yield with only one channel missing from any of the detectors, shown in Figure 8 and Figure 9.

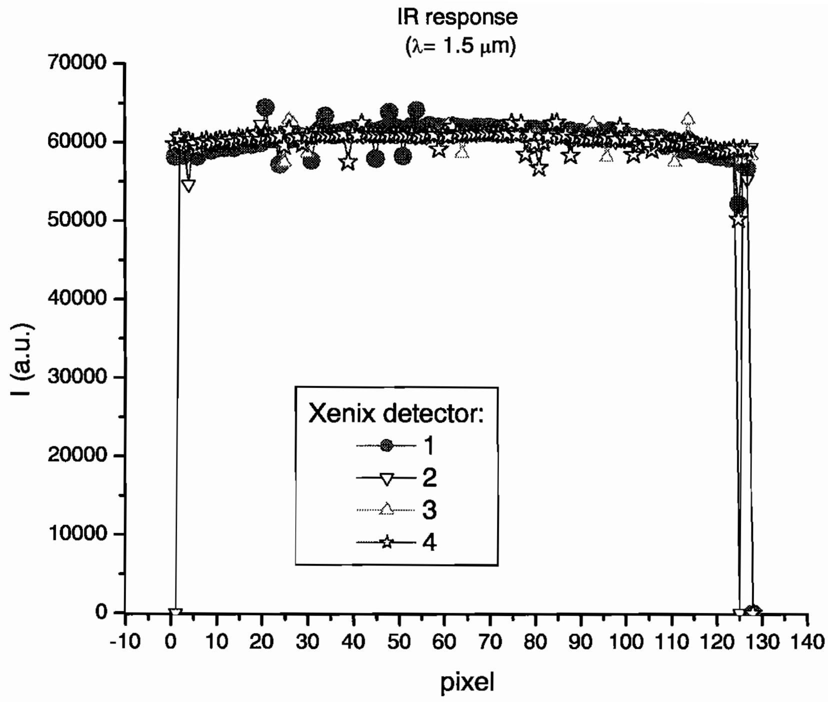


Fig 8.

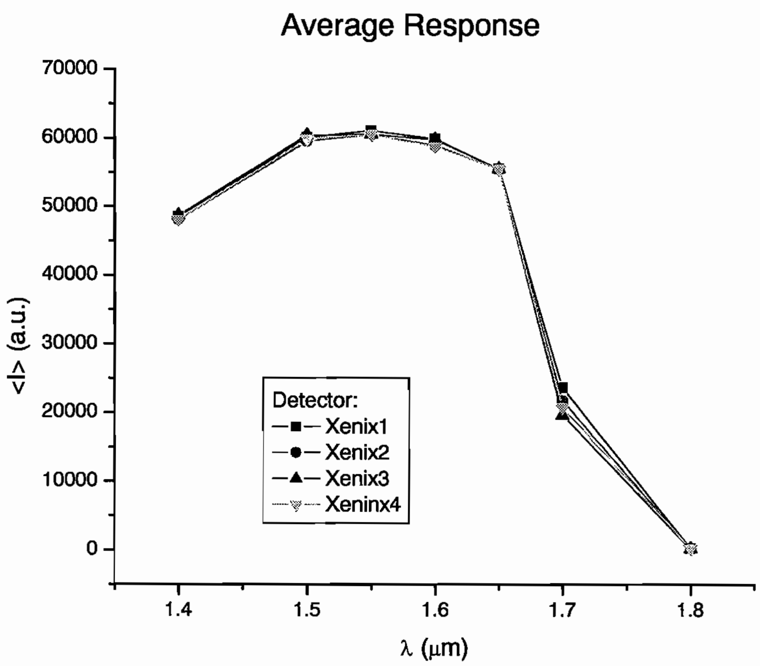


Fig 9.

This unit can be triggered from an external signal to capture data at up to 1kHz repetition rate. Two more XDAS-10 units were obtained from ETL and these were mounted to each other and were operated together as shown in Fig 10. and Fig 11.

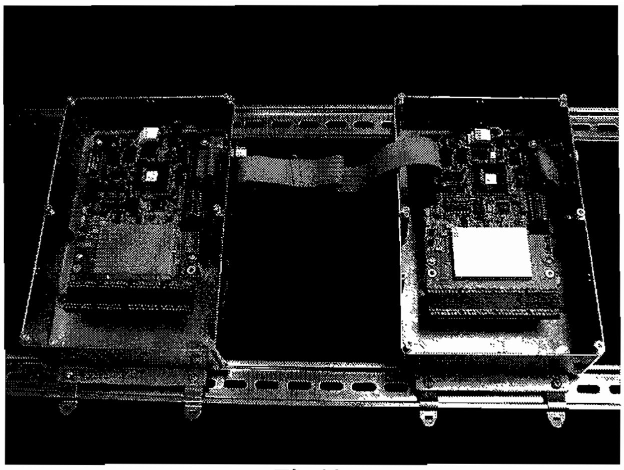


Fig 10.

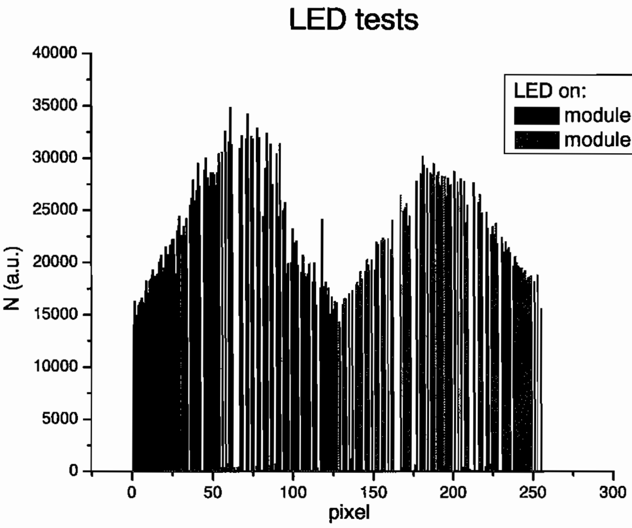


Fig 11.

The dual-detector unit did work, however we noticed that some channels were no longer working on some of the detectors. We then went back to the single XDAS system and a similar result was obtained. This proved to be because the wire bonds had lifted off of the interface card tracks. This could be due to contamination of the gold or inadequate cleaning. We selected two of the five detectors which give a total of 6 bad channels in total which does not present a problem in this project.
The dual detector system is installed in the Central Laser System Lab awaiting use in an absorption experiment.
At present we have a problem in operating the system at full speed as the ETL evaluation software does not allow 1kHz operation. This can be solved in future by programmng the control signals and readout signals in Labview.

Conclusion
We have demonstrated that a linear IR detector can be made of essentially any length with 50um or 100um pitch and with 500um high pixels. This is active over the 800nm to 1.7micron range. Xenix also sell two other InGaAs detectors with different compositions that can extend the range to 2.5um. There is every reason to believe these would work equally effectively in our system with some cooling. CCLRC now has the capability to build custom instruments with this technology to measure photons from 500nm to 2.5microns for applications in Space, Synchrotrons and Laser applications.