

TEST RESULTS WITH 2KX2K MCT ARRAYS

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Abstract: The performance of both an LPE 2Kx2K engineering grade and a science grade array have been evaluated. Both arrays have a cut-off wavelength of $\lambda_c=2.6 \mu\text{m}$. At an operating temperature of 60 K, the dark current of the science grade array is 0.004 e/s. The peak quantum efficiency of the science grade array is 84.4%. The readout noise is 14 electrons rms for a single double correlated clamp and 5 electrons rms for a readout with 16 Fowler pairs.

Key words: infrared array, HgCdTe, noise, dark current, quantum efficiency

1. INTRODUCTION

In 1997 the University of Hawaii and ESO made a joint contribution to fund the Hawaii2 2048x2048 project. Within the framework of this contract two LPE 2Kx2K HgCdTe arrays grown on a sapphire substrate have been delivered and evaluated. Both arrays have a cut-off wavelength of $\lambda_c=2.6 \mu\text{m}$.

2. MEASUREMENT SETUP

A prototype continuous flow test cryostat was built to start the evaluation of the Hawaii2 arrays. The detector is cooled by a two stage pulse tube closed cycle cooler which has no moving cryogenic parts and is completely

free of vibrations. The second stage of the pulse tube can reach a temperature of 21K.

The arrays are read out by accessing the internal bus directly. All 32 analog outputs are used and fed into a symmetrical operational amplifier. It is located near the focal plane on the fan-out board which is at cryogenic temperatures. In this configuration the on-chip output source followers are bypassed and switched off [1]. Hence, they do not glow when multiple sampling is applied to reduce the readout noise. This is an important advantage of using off-chip cryogenic amplifiers.

3. QUANTUM EFFICIENCY

The cut-off wavelength of the first engineering grade array was measured to be $\lambda_c=2.58 \mu\text{m}$. The dark current of the engineering grade array was higher than expected and showed a temperature dependence yielding an effective temperature of one third of $T_{\text{eff}} = E_g/2Kb$, the typical temperature for a g-r conduction mechanism. Hence, the sensitivity of the array was investigated at wavelengths longer than λ_c . With a narrow band filter centered at $\lambda=3.22 \mu\text{m}$ the quantum efficiency was determined to be 10^{-5} . Photon response at $\lambda=3.22 \mu\text{m}$ was confirmed by measuring the transmission of the narrow band filter with a scanning grating monochromator. An extrinsic transition from impurity donors to the conduction band in either the multiplexer, the buffer layer, or the diode array could explain the excess dark current and the photon response at $\lambda=3.22 \mu\text{m}$.

The quantum efficiency of the science grade array is above 0.68 over the whole spectral range of the detector and peaks in K-band at 0.84. The accuracy of the measurement shown below is limited by the sensitivity of the pyroelectric detector used to calibrate the efficiency of the monochromator. The Hawaii2 science grade array has the highest QE of all LPE arrays ever evaluated at ESO.

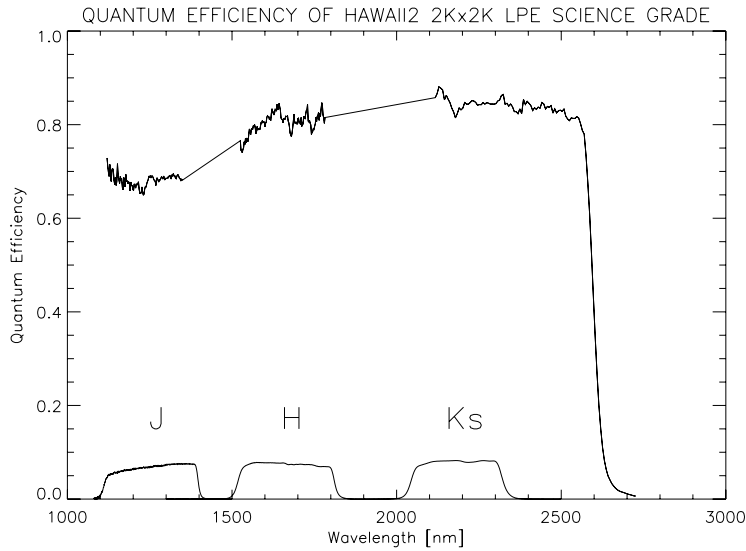


Figure 1. Quantum efficiency of LPE Hawaii2 2Kx2K HgCdTe science grade array.

4. DARK CURRENT

For the LPE science grade array the temperature dependence of the dark current yields the correct effective temperature $T_{\text{eff}} = 2360$ K. The dark current is 0.004 e/s at 60K and 0.20 e/s at 79.1K. The cosmetic quality degrades substantially by raising the temperature from 60K to 79 K.

Since the final arrays which will be installed in the multiobject spectrograph NIRMOS are MBE arrays grown on CdZnTe substrate with $\lambda_c = 1.9 \mu\text{m}$, a smaller format engineering array grown by using this technology was hybridized to a PICNIC 256x256 multiplexer. It has already been tested in order to validate the continuous flow concept for the NIRMOS cryostats. The MBE array shows excellent dark current performance. At a temperature of 100 K the dark current scaled to a pixel size of $18 \mu\text{m}$ is 0.008 e/s. The persistence is strongly reduced in comparison to LPE grown MCT material, which demonstrates the potential of MBE on CdZnTe.

The glow of the Hawaii2 multiplexer is substantially reduced in comparison to the Hawaii1 multiplexer. At the edges of the array the glow is 1.5 electrons/frame and peaks to 3 electrons/frame in the corners. The glow is negligible at a distance of 30 pixels from the edges.

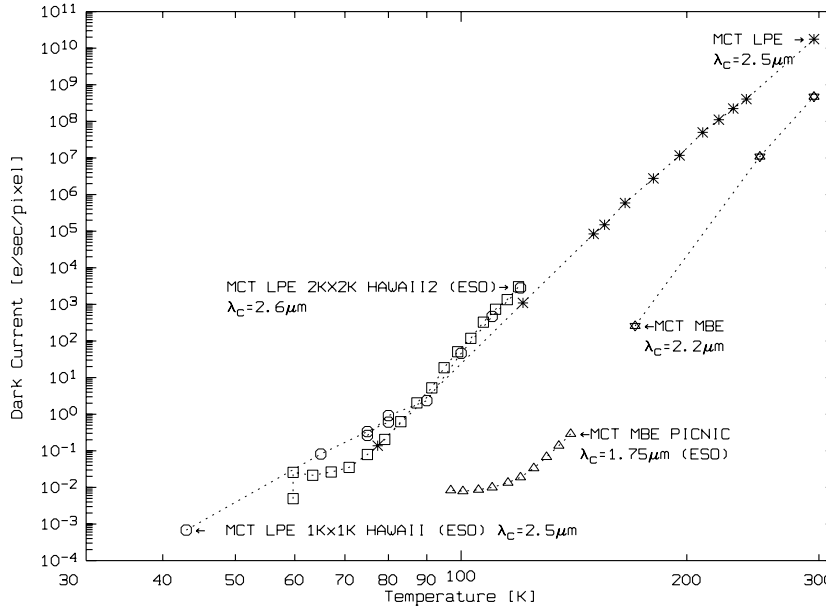


Figure 2. Dark current versus temperature for MCT LPE and MBE arrays and different λ_c .

5. READOUT NOISE

The readout noise has been measured with the unbuffered output reading out all 32 channels at a frame rate of 1.7 Hz. For a double correlated clamp it is 12 electrons rms. With multiple nondestructive sampling using 16 Fowler pairs the readout noise can be reduced to 5.2 electrons rms. In the best quadrant the readout noise is as low as 4.4 erms [2].

6. CONCLUSIONS

Although in most respects the Hawaii2 science grade array exhibits excellent performance, there are some problems associated with the Hawaii2 multiplexer such as rise times of < 50 ns for clocks of the fast shift register and the complexity of using the reference output. Consequently, Rockwell redesigned the Hawaii2 multiplexer resulting in the new Hawaii-2RG, which will be delivered with all MBE arrays presently on order by ESO.

REFERENCES

- [1] G. Finger et al., "Performance of large format HgCdTe and InSb arrays for low background applications", Proceedings SPIE vol. 4008, pp 1280-1297, 2000
- [2] G. Finger et al., "Readout Techniques for drift and low frequency noise rejection in infrared arrays", these proceedings.