University of Arizona
Imaging Technology Laboratory

Detector Characterization Report

Customer	University of Arizona
Device	ITL SN3670 STA0500A Lot run 78093.1 Wafer 13 Die 1
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Prepared by	R. Tucker, M. Lesser

1. Introduction

The above detector is part of the University of Arizona Foundry Run. Most tests were performed at or close to -100 C, a typical operating temperature for most scientific CCDs.

This device will be provided to AIP as a two amp, low noise part with a broad band (or red) AR coating. There are actually three working outputs.

2. Description of the ITL Detector Characterization System

Uniform monochromatic illumination for the Device Under Test (DUT) is provided by a system consisting of an Oriel 6255 150-watt xenon arc lamp enclosed in an Oriel 66002 lamp housing, Oriel model 68805 Universal Power Supply, Oriel 68850 Photofeedback Controller, Oriel 76995 Electronic Shutter Controller, Oriel model 76994 Shutter, Oriel 77702 Monochromator, and an 20" diameter Labsphere Integrating Sphere with a UV-enhanced interior diffuse coating.

Diode mode DUT and calibrated diode photocurrents are measured during QE testing by a Keithley Model 6512 Electrometer.

The detector was operated in a liquid-nitrogen-cooled Kadel dewar equipped with a fused quartz window of 137 millimeter aperture. The temperature was regulated at -100C for temperature-critical tests.

The device was tested with a gen1 CCD controller from Astronomical Research Cameras, Inc. The software system used was the ITL AzCam data acquisition system.

3. Diode Mode Quantum Efficiency

The quantum efficiency (QE) of the imaging device was measured by comparison with a silicon photodiode with an NIST-traceable calibrated response. The photodiode is attached to the output of the optical system (where the CCD in its dewar will be placed) and the monochromatic output of the integrating sphere is sampled at each wavelength of interest by scanning the monochromator. This procedure is then repeated with DUT by connecting the electrometer to the CCD SUBSTRATE and RESET DRAIN. QE is computed based upon the ratio of the photocurrents, UV quantum yield, relative light collecting areas and geometric factors involving the particular dewar and window material. The QE is shown in Table 1 and Figure 1.

Wavelength (µm)	QE
300	67.7%
320	72.3%
340	66.6%
350	62.0%
360	58.6%
380	63.8%
400	69.8%
450	78.6%
500	83.5%
550	90.8%
600	92.1%
650	89.5%
700	85.3%
750	77.2%
800	62.5%
850	44.4%
900	30.2%
950	16.0%
1000	6.8%
1050	3.2%
1100	3.8%

Table 1. Measured QE at -100C

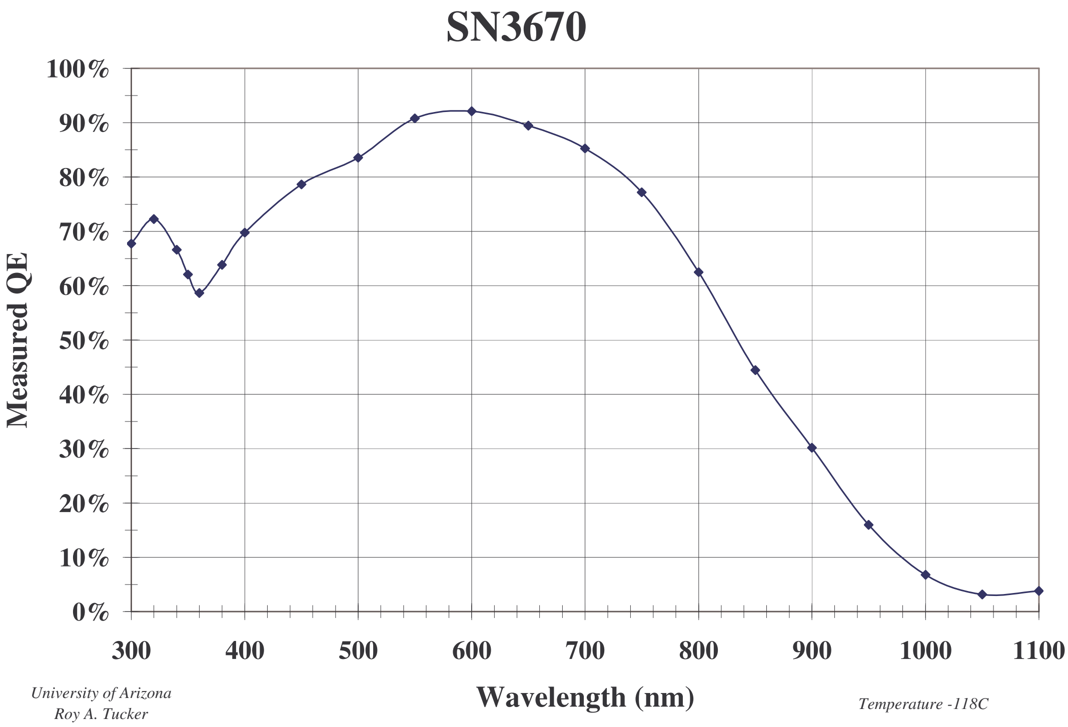

Figure 1. Measured QE at -118C

4. Detector Cosmetics

Flat field images were obtained with illumination wavelengths of 400, 600, and 900 nanometers. Light of 400 nanometers wavelength is detected very close to the surface of the device and critically reveals details of the surface charging. A scattering of large spots is visible. A gauzy-looking area of small spots occupies about one-tenth of the area of the device.

600 nanometer light penetrates more deeply into the device and the detected electrons are less influenced by surface charging. At this wavelength, the previously mentioned dark spots are still visible but the 'gauzy' area is less distinct.

900 nanometer light penetrates through the imager and the resulting optical interference fringes provides information about the thinning of the device. The 'topographic map' pattern of fringes appears to be modulated by an off-center, vaguely concentric ring feature, probably due to variations in how the silicon crystal grew, but inconsequential in the operation of the device. Many of the dark spots are not visible.

5. Dark Current Measurement

A thirty-minute dark image was acquired at -118C. The -118C bias-subtracted dark image was featureless except for cosmic ray events and indicated a dark current of 1.8 electrons per pixel per hour.

6. Fe-55 Noise, Gain, and CTE measurements

Characterizations of read noise, conversion gain, and charge transfer efficiency using Fe-55 X-ray images were conducted at approximately -100C. The readout speed was approximately 41.3 kpixel/sec. Based upon later characterizations, these bias and clock settings are suggested for operation:

Vod = 25 volts	**Vrd = 17 volts**	**Vog = -1.0 volt**
RG = +8/-2 volts	**SW = +4/-4 volts**	**TG = +3/-9 volts**
Sx = +4/-4 volts	**P1,2 = +3/-9 volts**	**P3 = +4.5/-7.5 volts**

Amp 0 of this device was characterized with these settings:

Vod = 21 volts	Vrd = 14 volts	Vog = +1.0 volt
RG = +8/-2 volts	SW = +4/-4 volts	TG = +3/-9 volts
Sx = +4/-4 volts	P1,2 = +3/-9 volts	P3 = +4.5/-7.5 volts

Performance at -118C	
Amp 0	
Parallel CTE – 1.000005	Serial CTE – 1.000034
Gain – 3.52 µV/e	Read noise – 5.26 e

Amp 1 was characterized with:

Vod = 23 volts	Vrd = 15 volts	Vog = -1.0 volt
RG = +8/-2 volts	SW = +4/-4 volts	TG = +3/-9 volts
Sx = +4/-4 volts	P1,2 = +3/-9 volts	P3 = +4.5/-7.5 volts

Performance at -118C	
Amp 1	
Parallel CTE – 1.000005	Serial CTE – 1.000000
Gain – 5.10 µV/e	Read noise – 3.68 e

Amp 3 was characterized with:

Vod = 23 volts	Vrd = 15 volts	Vog = -0.5 volt
RG = +8/-2 volts	SW = +4/-4 volts	TG = +3/-9 volts
Sx = +4.5/-4.5 volts	P1,2 = +3/-9 volts	P3 = +4.5/-7.5 volts

Performance at -118C	
Amp 3	
Parallel CTE – 0.999993	Serial CTE – 0.999999
Gain – 5.27 µV/e	Read noise – 3.24 e

7. Parallel register full well

A photon transfer series showed departure from linearity at about 88 kiloelectrons.

A ramp image was obtained by opening the shutter and exposing the device to 600 nm light during the readout process. This type of images shows a linear increase in signal level until CCD full well or video processor saturation is reached. The point at which this departure from linearity occurs is one measure of maximum charge capacity. With a system gain of about 1.6 e^-/ADU, saturation was seen at about 47,000 ADUs or 75 kiloelectrons.

8. Summary

Three amps worked well, the QE was excellent, the full well capacity was perhaps a bit shallow for the pixel size, and CTE at the typical operating temperature was very good. There are two partial bad columns and a scattering of spots. Read noise was measured in the vicinity of 5 electrons for amp 0 and less than 4 electrons for the others. It is believed these noise results are due to the less-than-optimum biases and clock voltages. Experience with later devices indicates that use of the suggested voltages will produce noise approaching 3 electrons.