Update of the STA1600 10560 x 10560 pixel high-resolution CCD

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Introduction

- Semiconductor Technology Associates provides imaging industry with custom charge-coupled device design, fabrication, characterization and operation.

- Update of our current work on a 10k x 10k (Wafer scale Imager).

- Description of recently developed deep depletion devices of interest for the astronomical community.
STA1600B 111Mega pixel imager

- Full 6” wafer imager
- 10560 x 10560 pixels
- 9 micron pixel
- 111,513,600 pixels per frame
- 16 dual stage high speed outputs
- Backside thinned available
- Acquisition speeds up to 1 frame/sec
- Designed for US Naval Observatory
STA1600 Themes and Variations

- **STA1600**
  - Standard device with dual stage high speed outputs
  - Full frame imager
- **STA1600 MPP**
  - Frontside illuminated low dark current
- **STA1600 LN**
  - 16 single stage low noise outputs.
- **STA1600 FT**
  - Frame transfer operation
- **STA1600 DD**
  - Deep depletion
STA1600 Schematic

STA1600 Full Frame Imager

Image Region 10560x5280

STA1600 Output Section

Image Region 1320x5280
STA1600A Epitaxial Material

- Material cross section measurement of the Epitaxial Doping
- Two materials: 30 µm/ >1000 Ohm-cm and 100 µm/ >4000 Ohm-cm
Backside QE

- Blue optimized coating
STA1600 Baseline Performance

- 7.0-9.0 electrons noise @ 1.0 MHz
- 5.0 electrons @ 100 kHz
- Full well > 80,000 electrons non-MPP
- 16 amplifiers
  - 8 & 16 channel full frame readout
- Capable of readout rates up to 40MHz
STA1600 Performance

- HCTE and VCTE > 0.999998
- Less than 1% non-linearity between 200 e- and 80ke-
STA1600A Performance

Uncorrected STA1600A Image. Each output section shown is 1320 pixels X 5280 pixels. PRNU = 9.2% over a 4k x 4k area located at the center of the device. Wavelength is 650nm.
These frontside images exhibit the on chip strapping necessary to reduce vertical gate time constant.

As a result the device can be driven at enhanced data rates without degradation of CTE or increased image smear.

All versions incorporate this feature.
STA1600MPP

• High speed performance
  – Serial registers readout as fast as 40 Mhz
  – Parallel clock rates > 100kHz
  – Full well 30k e-
  – Better than 1 FPS
STA1600 Single chip Package

- Substrate fabricated on invar for good thermal matching to silicon, which allows the device to be cooled to -120°C
- Can mount front or backside devices

STA1600 Frontside Package
STA1600 USNO Dewar Assembly

Dewar 61 Pin I/O and 18 Pin Temp Connectors

Demonstration Unit
USNO Robotic Astrometric Telescope
URAT

- 8 inch Refracting Telescope for Astrometry
- Upgrade initiated to a 2x2 array by Dr Norbert Zacharias for an all sky survey - URAT
- STA is providing complete system including
  - Dewar – Window – Bonn Shutter
  - Four BI STA1600 CCDs – Three STA 3000 Guiders
  - Five Aura cameras with software
  - Telescope robotic control software
Large Focal Plane Efficiency

- Four 10ks provide more active image area than nine 4k imagers
- 91% Active area for 4k imager
- 95% Active area for 10k imager
URAT 2x2 Focal Plane

- Next generation astrometry focal plane
  - 1 Frame = 1 Gigabyte of data
- Incorporates buttable package version of STA1600
- GL Scientific Dewar
Aura Camera

- One of five cameras for URAT system
- There is a FPGA programmable timing core
- 16 ADC channels each have low noise fully differential AC-coupled preamps with high and low gain
- CCD clock signals are generated from 60Mhz DACs
Antarctica Schmidt Telescopes (AST3)

- Location Dome: A Antarctica
- Clear aperture: 50cm
- FOV: 4.2°
- Wave Band: 400nm-900nm (g, r, i filters for 3 telescopes)
- Scale: 1 arcsec/pixel
- Image quality: 80% energy encircled in one pixel
- Type: STA1600FT
- Working mode: frame transfer
AST3 System STA1600FT

- Small 180 mm dewar system
- TE Cooling for operation at -80°C
  - Average outdoor temperature -50°C
- STA1600FT Split frame store operation
Reflex Camera

- Reflex Camera System
  - 11” x 9” x 5.5” (6-slot chassis)
- Flexible Modular Features
  - 8-ch 120 Mhz 16-bit A-D
  - 12-ch 500 Mhz 16-bit clock driver
    - +/- 12V (Programmable slew)
  - 16-ch 16 bit DC bias
    - Voltage and current monitoring
    - Programmable current limit
  - Full cameralink interface
    - Swappable for custom, gigabit ethernet, firewire.
  - Single 12 V DC power supply
STA1600 LN

- Low noise version of STA1600
- 16 dual stage outputs are replaced with single stage low noise outputs
- Noise < 3 electrons
- Sensitivity 4-5 µV/e-
- Identical pinout
- Available Fall 2010
STA1600 DD

- Deep depletion for optimum red response
- STA1600DD would have similar performance
- 93 µm thickness
- >50% QE @ 1 µm
- Available 2011
STA1920A LSST

- Study contract device
- 100 μm thick, high resistivity bulk silicon, capable of overdepletion
- 4K x 4K, 10 μm pixels, 16 outputs

Crab Nebula shows chip segmentation
1.2 m Calypso Telescope at Kitt Peak
Substrate bias control of charge diffusion

- $^{55}\text{Fe}$ x-rays generate compact charge clusters within $\sim 30$ $\mu$m of silicon surface.
- Fully depleting the silicon restores the PSF.
STA3200 Extreme Deep Depletion Imager

- Designed for direct X-Ray detection
- 4000 x 4000 24 micron pixels
- 20,000 ohm-cm p-type starting material
- Full depletion of 600 µm silicon at 120V
- Expect 90% QE at 1 µm
STA3200A CCD Layout

- Chip imaging dimensions 96 mm x 96 mm.

- 16 Separate outputs
  - Each output reads out a subsection of 500 x 2000 pixels when using all 16
  - Possible to readout complete array to top or bottom 8 outputs.
Summary

- The STA1600 variations are a result of the evolutionary growth of scientific imager requirements.

- The STA1600 greatly decreases the number of devices necessary for large focal plane arrays.

- The high resolution, along with high speed low noise capabilities, makes STA1600 appealing to a variety of large area imaging applications.

- Thank you for your attention.