e2v

e2v technologies

Ground Imaging using CCDs

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Introduction

Who is e2v, what do we do, and how are we involved in ground imaging?

I shall give a brief overview of :

- The e2v company structure since the purchase of Atmel (Grenoble)
- Some ground scanning instruments for which we have supplied CCDs.
- How we plan to develop our capability

e2v Company Structure

e2v currently includes two product divisions:

- RF and Sensors
- Advanced Imaging & Semiconductors

RF and Sensors Division

Travelling Wave Tubes :

Radar and countermeasures

Magnetrons :

Radar and medical (radiotherapy, lithotripsy, µwave endometrial ablation)

Klystrons :

High Energy Physics, Broadcast (world's largest supplier of broadcast tubes)

Thyratrons :

Fast high current switching

Gridded tubes :

Industrial heat treatment and welding

Thermal Imaging cameras, Gas sensors, X-ray sensors,

Gunn diodes for Automotive Radar (reactive cruise control)

Defence, Aerospace & Scientific Imaging : DASI

The DASI business has a turnover of >£25M pa.

~£15M is in Space & Astronomy
rising at >10% pa.

We differentiate ourselves in the market by concentrating on engineering solutions, rather than volume manufacturing.

Design & Manufacture

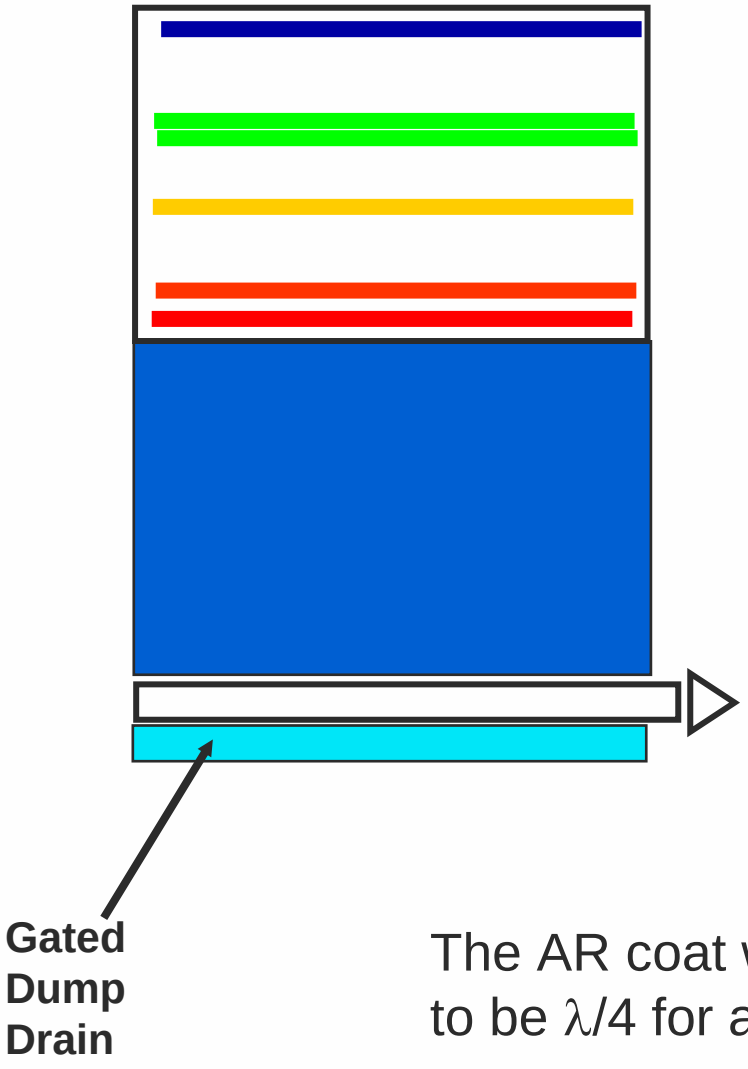
Nick Waltham's talk described push-broom imaging of the ground using linear CCDs and TDI CCDs, the relative merits of each device type, and how they are used in ground scanning instruments.

I shall concentrate on the design, manufacture and supply of such devices, fully qualified for space application.

It is of interest to us to understand what the instrument is seeking to achieve, so we can design the CCD to best meet those goals.

In many cases, the cost of device customisation is far out-weighed by the benefits from having a device which is optimised for the application.

Device design for purpose



The gated dump drain, adjacent to the serial register, was first introduced in support of the MERIS hyperspectral imager.

This allows rows of charge to be dumped without needing to be transferred through the output.

Data reduction is then possible in the charge domain by dumping unwanted spectral data into a gated dump drain. Spectral bands can be broadened by line binning.

The AR coat was made with graded thickness, to be $\lambda/4$ for all wavelengths

Linear CCDs

The linear CCD has some advantages:

- The photodiode has no surface absorbing layers, so QE is good.
- It is relatively simple to make very small pixels
- Signal charge is integrated adjacent to the pixel, so the link between pixel size and charge storage capacity is less severe.
- In push-broom operation, it is not critical that scan direction is orthogonal to the array……

Thales (UK) recon pod on Jaguar utilising e2v linear CCD sensors

Images courtesy of Thales Optronics UK

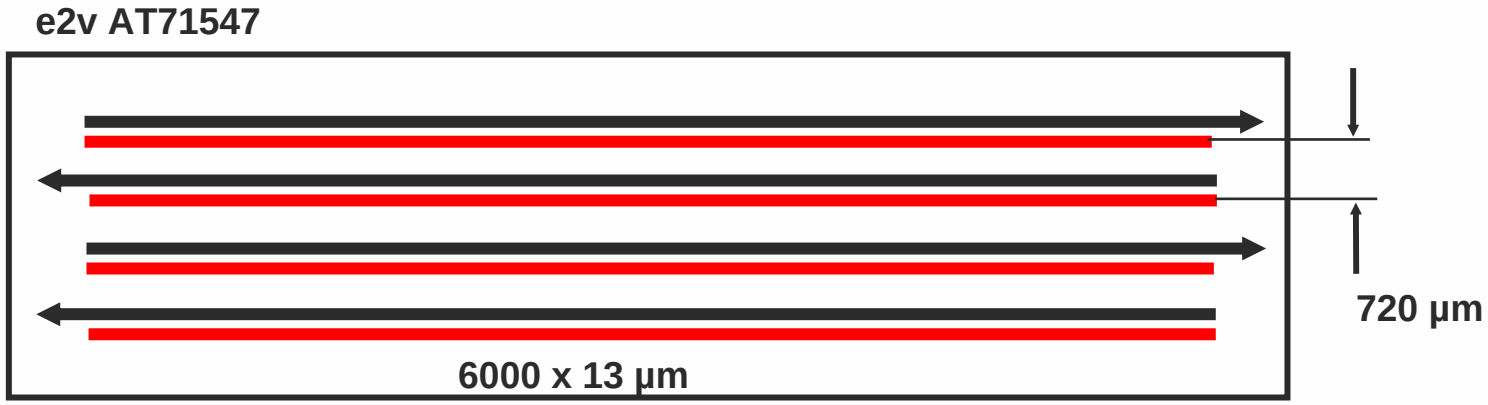
Thales (UK) recon pod on Jaguar utilising e2v linear CCD sensors

Images courtesy of Thales Optronics UK

e2v Grenoble Linear devices

e2v Grenoble supplies high performance CCDs for earth imaging from space

SPOT II, III, IV, V	Linears
Vegetation	Linears
Helios	Linears
CBERS 3 & 4	Quad-Linear AT71547



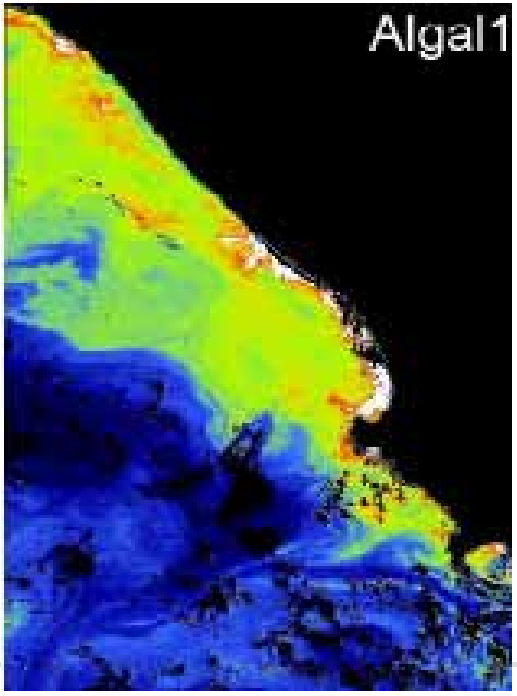
Hyperspectral imagers

e2v Chelmsford developed CCDs for

MERIS	Hyperspectral
CHRIS	Hyperspectral

In both cases, a graded AR coat gives $\lambda/4$ at all wavelengths

True colour image



Spectral signature for chlorophyll

TDI imagers

The TDI device increases the signal integration time, so is able to operate with smaller input signals.

We have also made such devices witha number of remotely selectable TDI lengths, which enables optimum performance over a range of signal conditions.

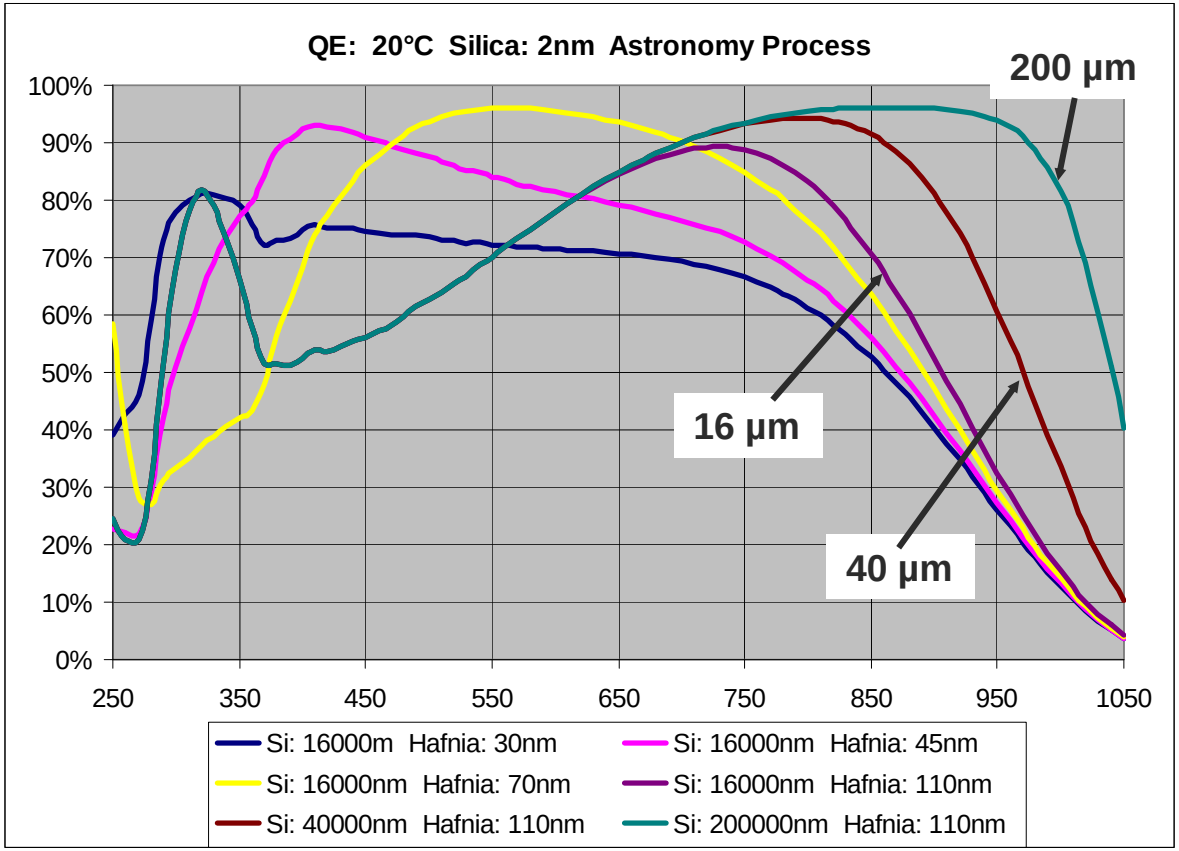
As an area imager, the basic TDI device suffers some loss of QE due to optical absorption in the electrode structures.

Kodak has significantly reduced this effect by the use of transparent Indium-tin oxide electrodes.

The e2v approach is to use our well established back-illumination process, which can achieve very high QE over a wide spectral range.

Quantum Efficiency for Back Illuminated CCDs

Most of this variability is by selection of the best anti-reflection coating



In the NIR region, QE is dominated by the thickness of the silicon.

Recent work with Hi-Rho silicon enables depletion of >200 µm silicon.

TDI devices from e2v Chelmsford

HiRISE

Variable length, back illuminated, high speed.

New Horizons

Monolithic 6 x TDI + frame transfer CCD

Pleiades

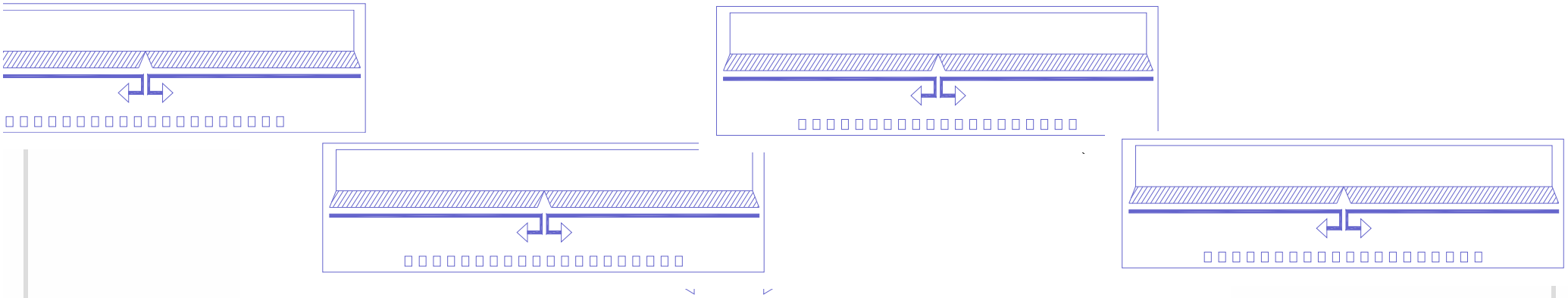
High performance, variable length, back illuminated

HiRISE Format

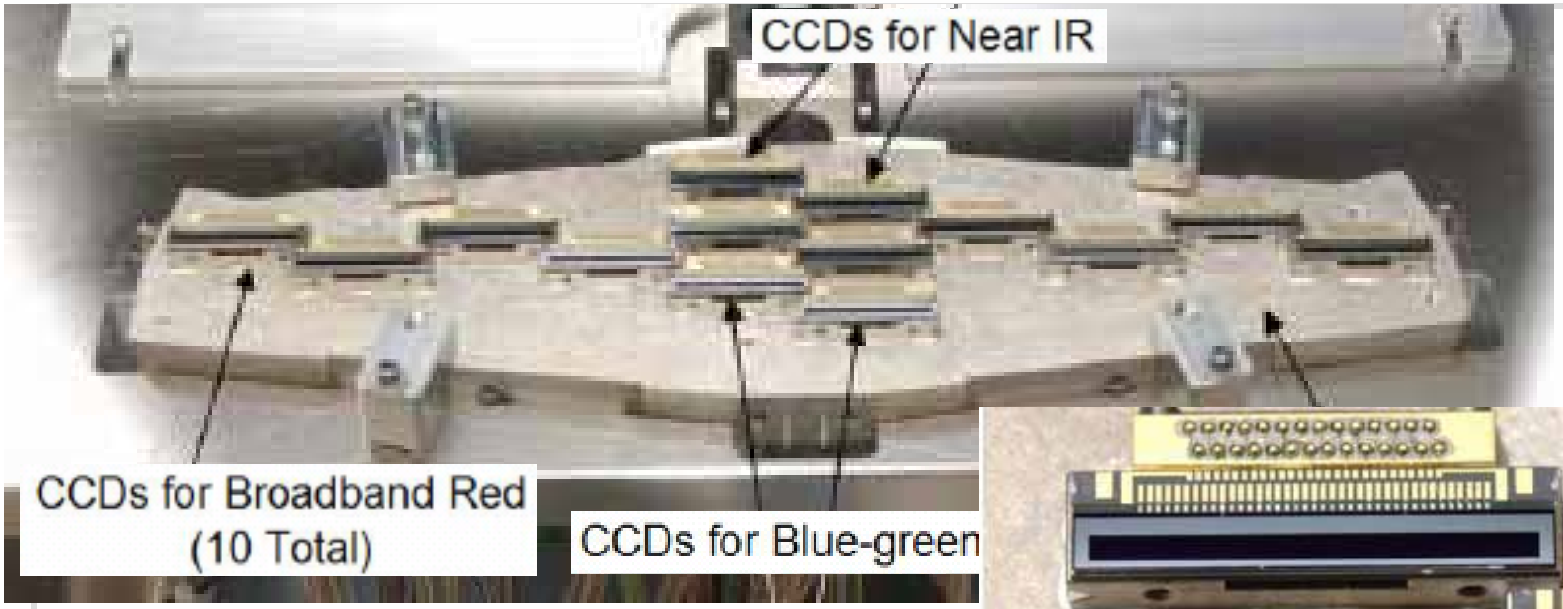
TDI sensor : 2048 x 128, 64, 32, 8
Un-wanted lines are reverse clocked to a drain.

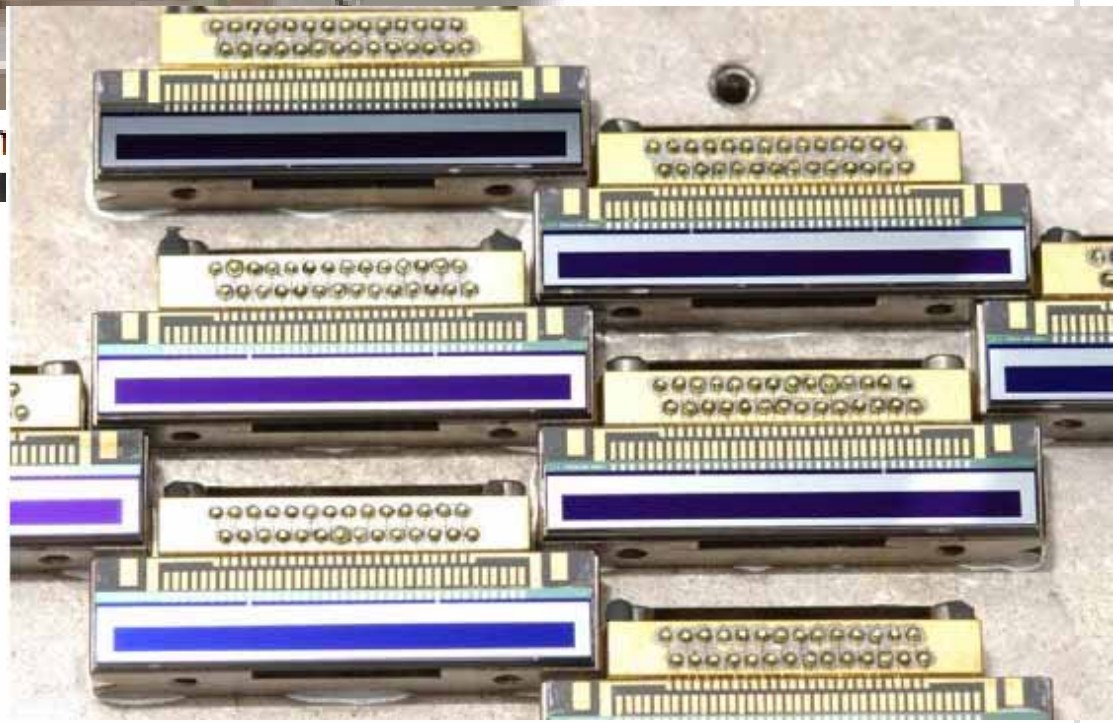
For 30cm imaging on Mars, this chip needs to run fast, so it has two outputs/chip, each operating at 15MHz

Central position of outputs facilitates chip overlapping

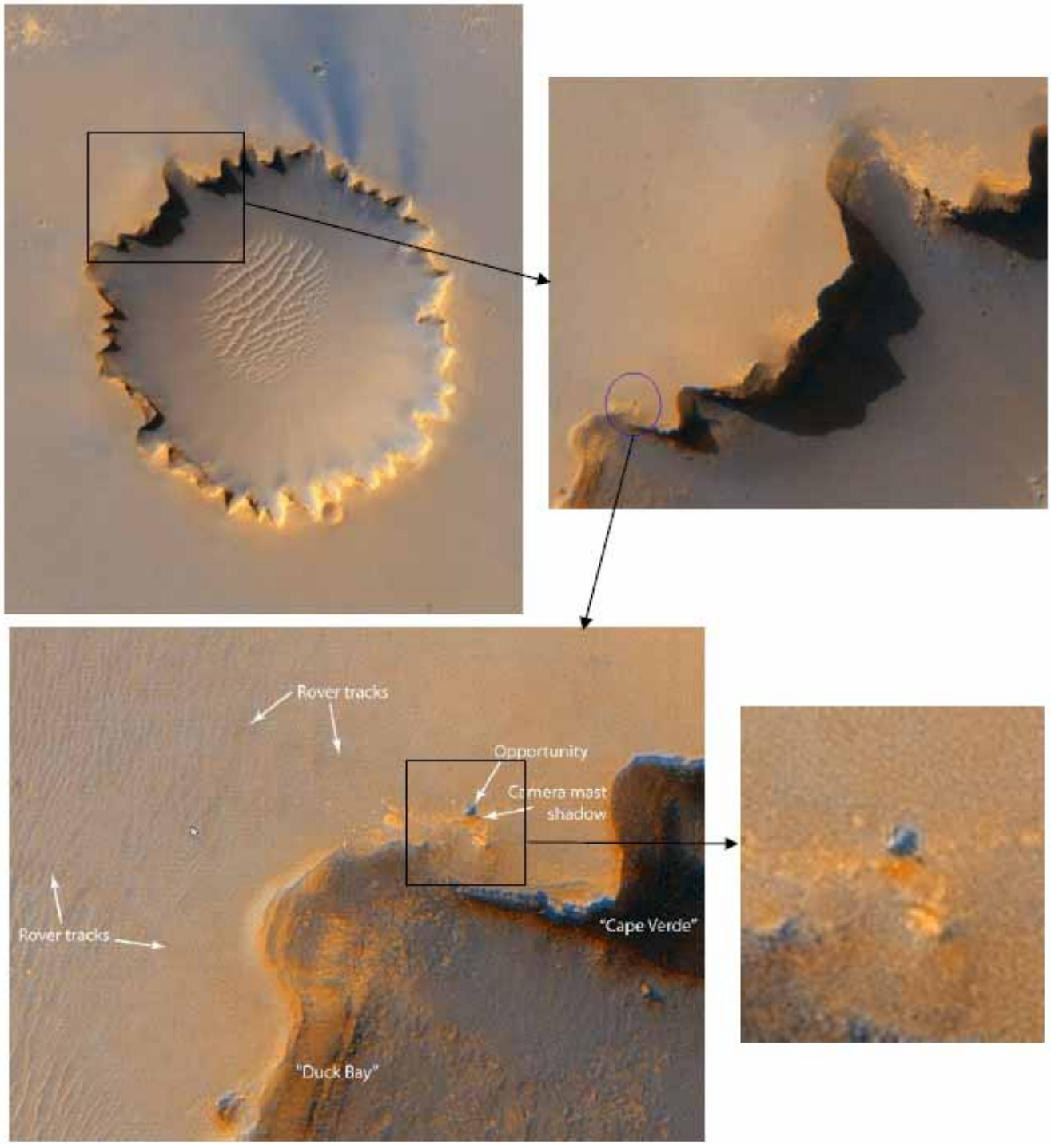


HiRISE Focal Plane Assembly





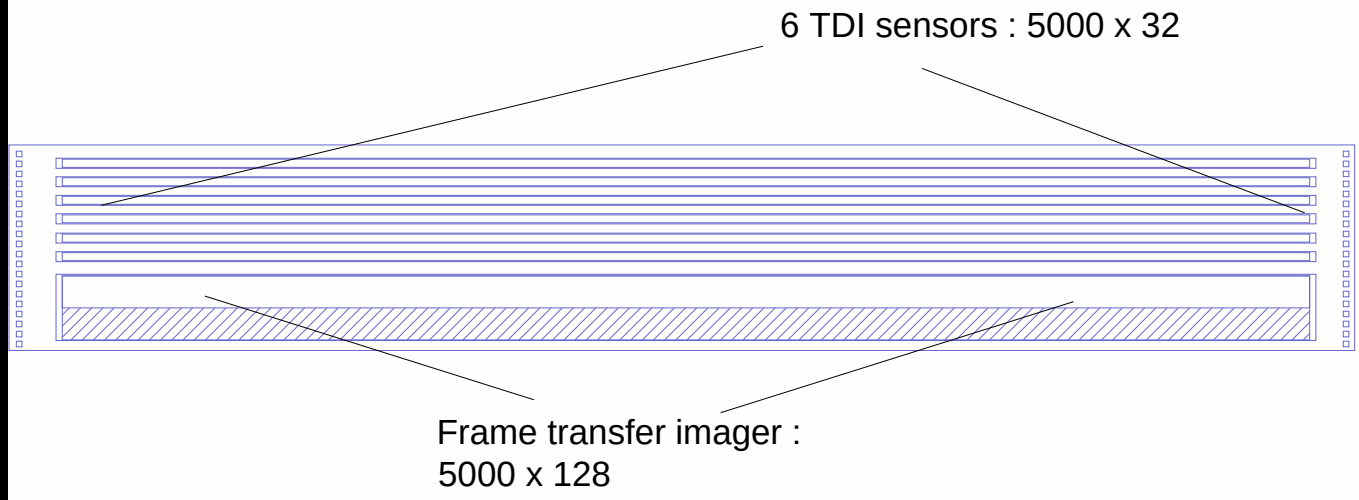
Images courtesy of Ball Aerospace



HiRISE

The images created by this instrument, on MRO, are very well known.

New Horizons



New Horizons will cruise to a Pluto-Charon encounter in 2015 and Kuiper belt encounters in 2016 to 2020

This image was produced during a Jupiter gravity assist, February 2007.

Pleiades

13 µm pixels, 6000 columns, 16, 13, 10 or 7 TDI lines.

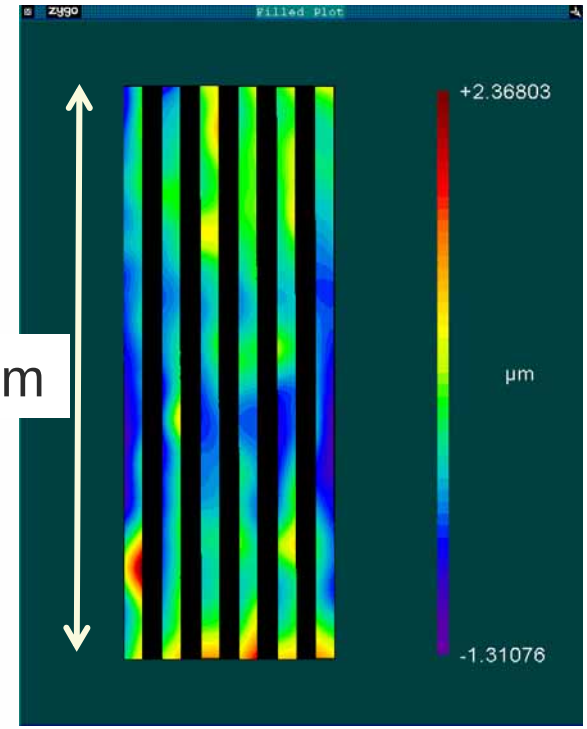
When one parallel electrode is held “off” charge cannot pass, so spills to an anti-blooming structure

10 outputs each operating at 7.5MHz

This device was commissioned by CNES to be the basis of the next generation, high performance instruments for ground scanning of the earth

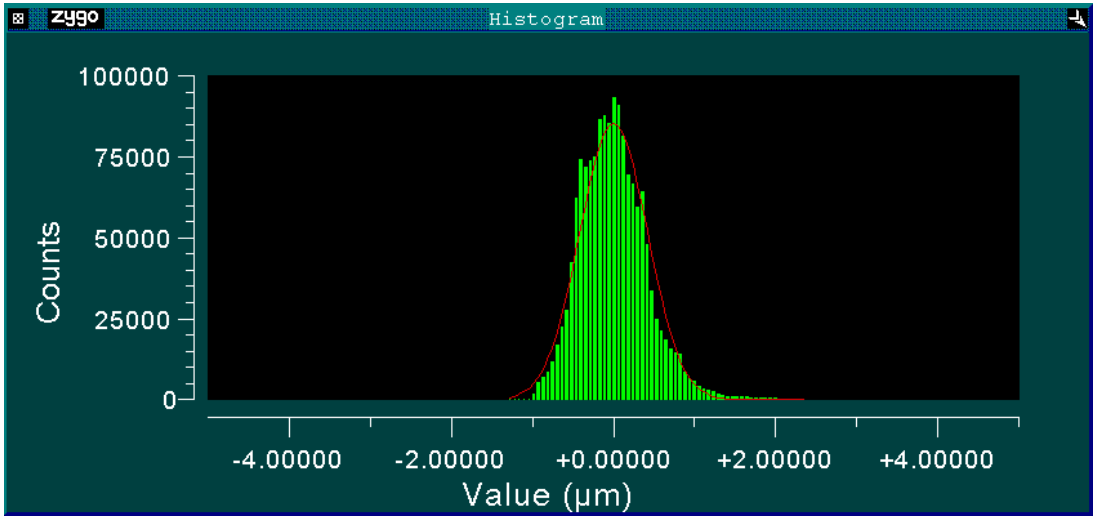
Developments : Array flatness

e2v is developing focal plane construction strategies which place the chips with precision, keeping all devices very flat and co-planar



96 mm

A verification array has been constructed from a plain silicon wafer cut to the same size as a CCD linear.



The topographic image and histogram of that data show that the construction of an array with peak to valley flatness of approximately 3 microns is possible.

Process Development

In addition to precise focal plane construction, we are pushing process development, aimed at:

- Reduced pixel size for increased ground resolution in a small instrument
- Low noise output circuits with increased speed.
- Addition of close-support ASICs, with the CCD, in multi-chip modules

Complete Focal Plane Package

We are just beginning to offer to supply the flight electronics required to support our CCDs. This is being done in collaboration with RAL, and we would initially use RAL design, but with e2v increasing its design contribution with time.

As this develops, we expect to incorporate some of the close-support components in the CCD package, so the boundary between imaging device and support electronics will become more blurred.

Supply of a complete flight FP package simplifies management of the instrument procurement and the performance seen at despatch test is the performance that is flown.

We look forward to the opportunity to work with our colleagues in Brazil on future instruments for ground imaging or space science.

Thank you