CMOS Sensors: HDR and e2v

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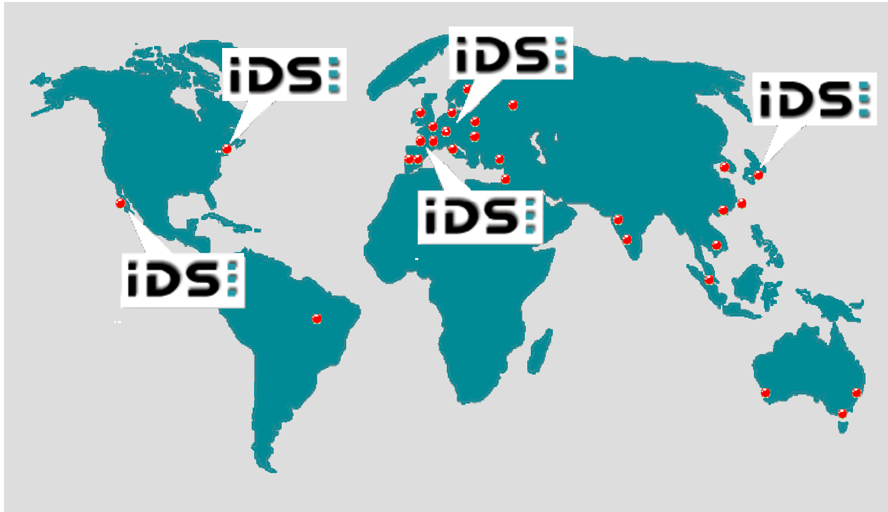
Product Manager

www.ids-imaging.com
www.ueye.com



HDR

New Sensor with Extremely
High Dynamic Range

A World Class Supplier of CMOS Sensors™

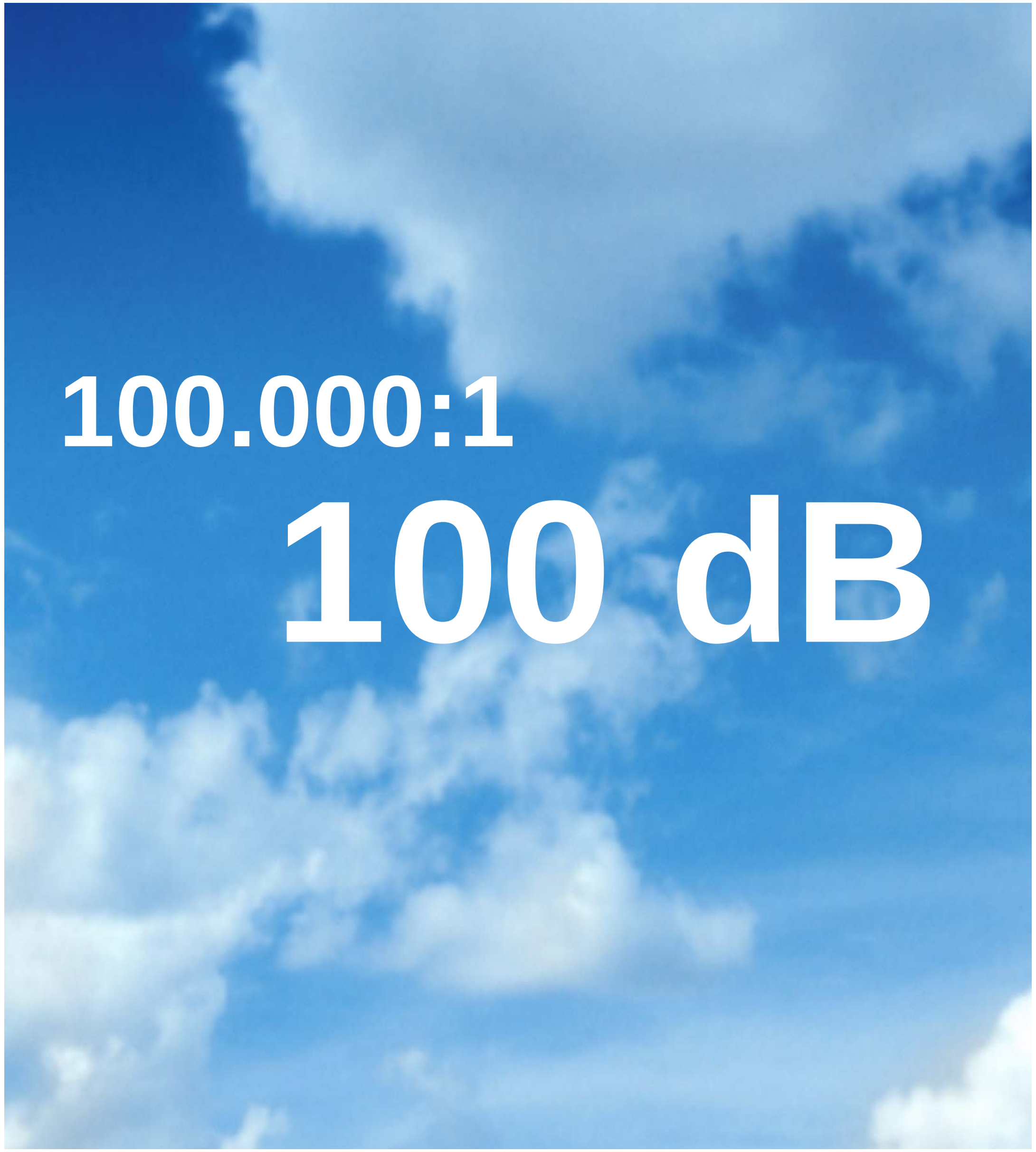
In scenes with a large dynamic range conventional image sensors are limited.

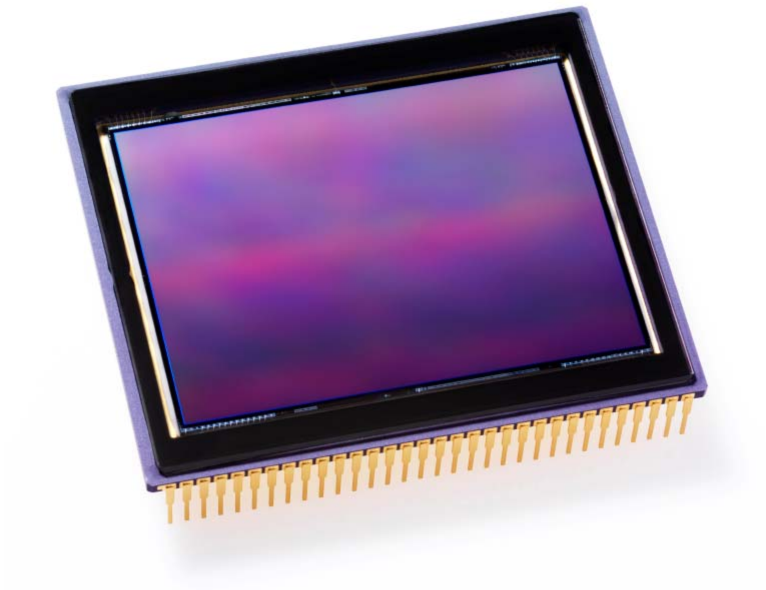
Ratio of the largest brightness value

to the smallest brightness value:

$$D = 20 \cdot \lg\left(\frac{l_1}{l_2}\right) dB$$

The dynamic range of a daylight scene exceeds the capabilities of conventional CCD sensors.

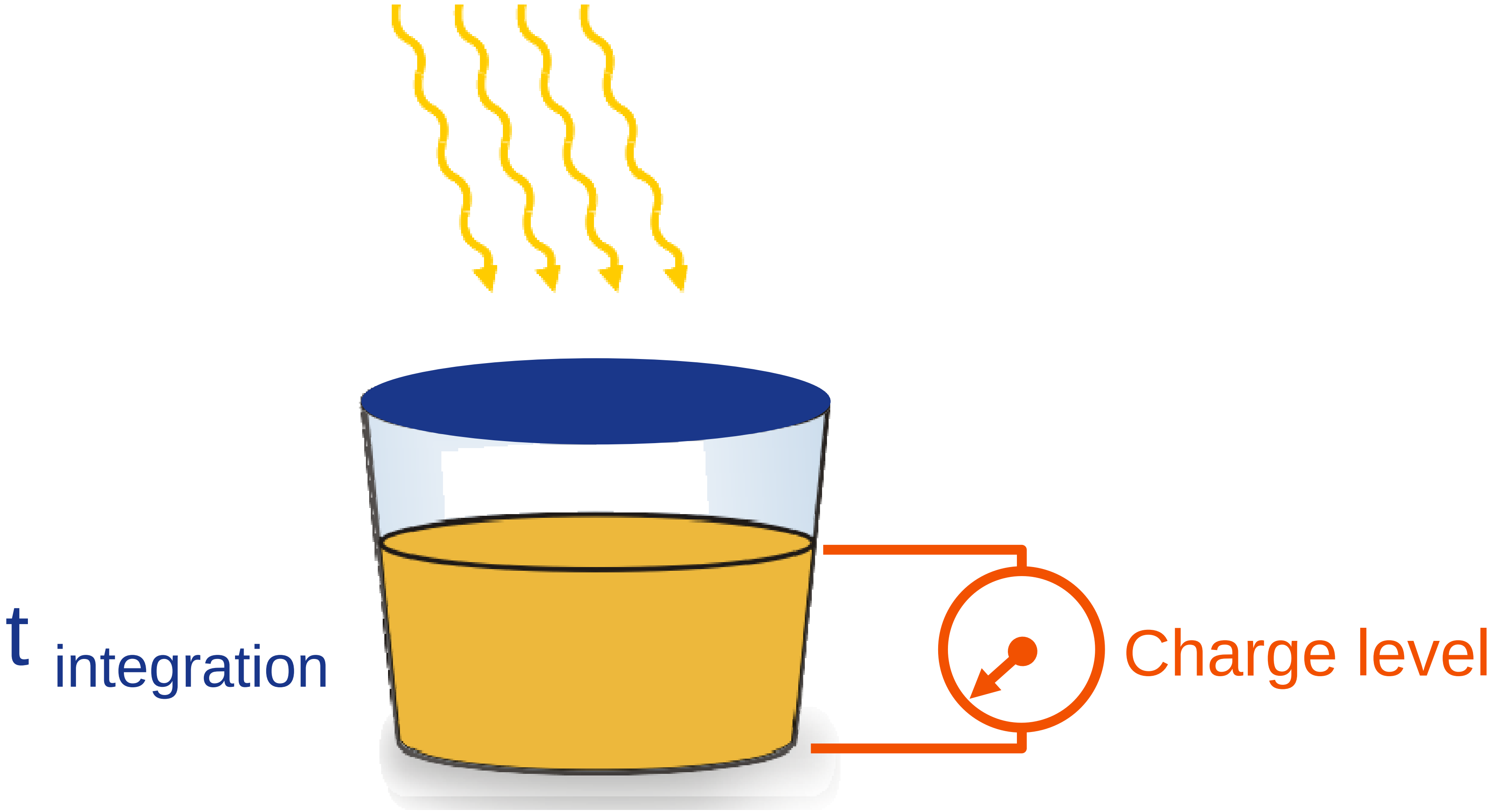




1.000:1

60 dB

Method of functioning:
Conventional sensor with integrating pixel



uEye UI-1120.

A dimmed light bulb with a CCD sensor…

uEye UI-1120.
A different situation…

4W

40W

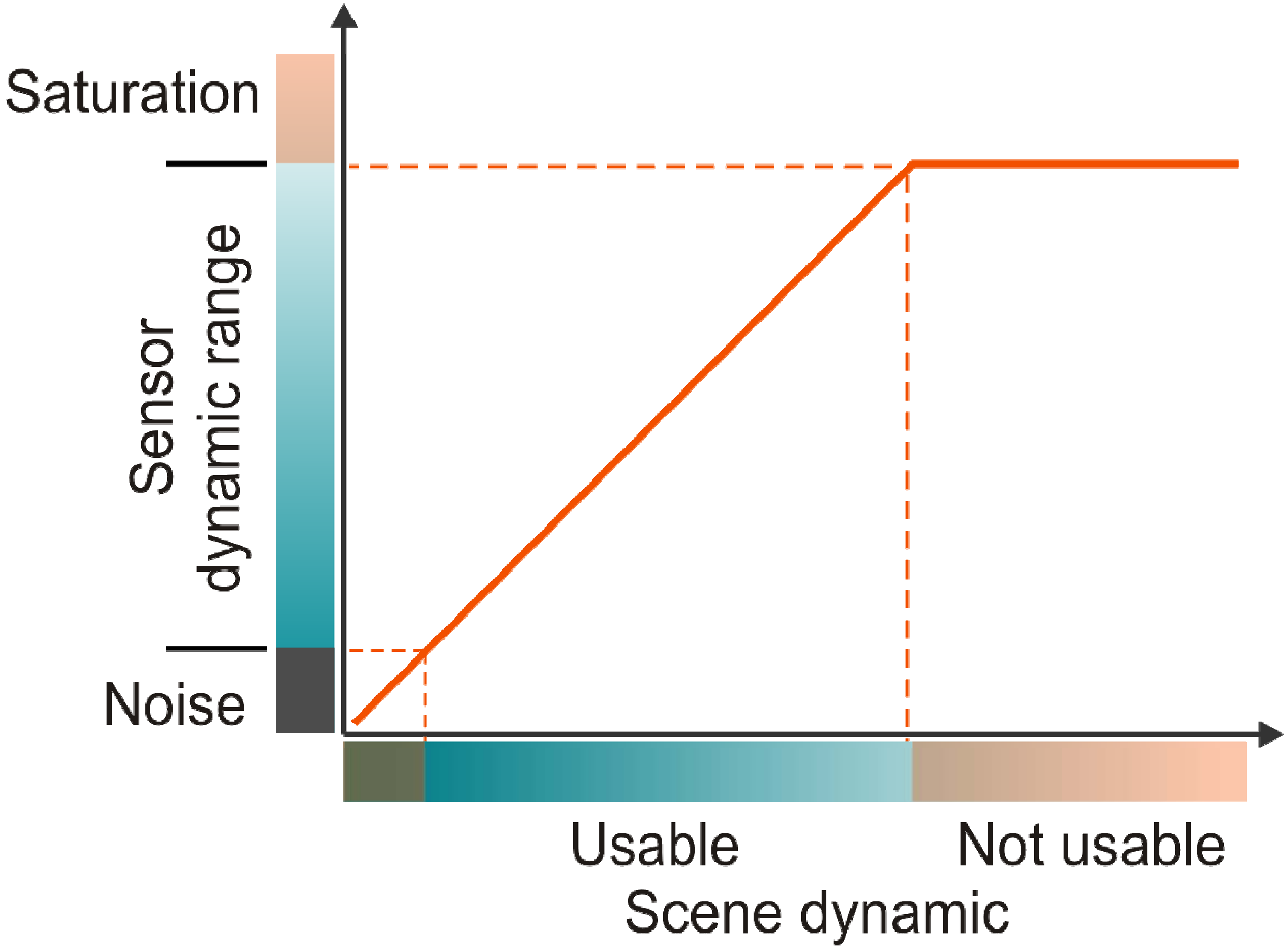
40W with short exposure

uEye UI-1120.
Effects of overexposure …

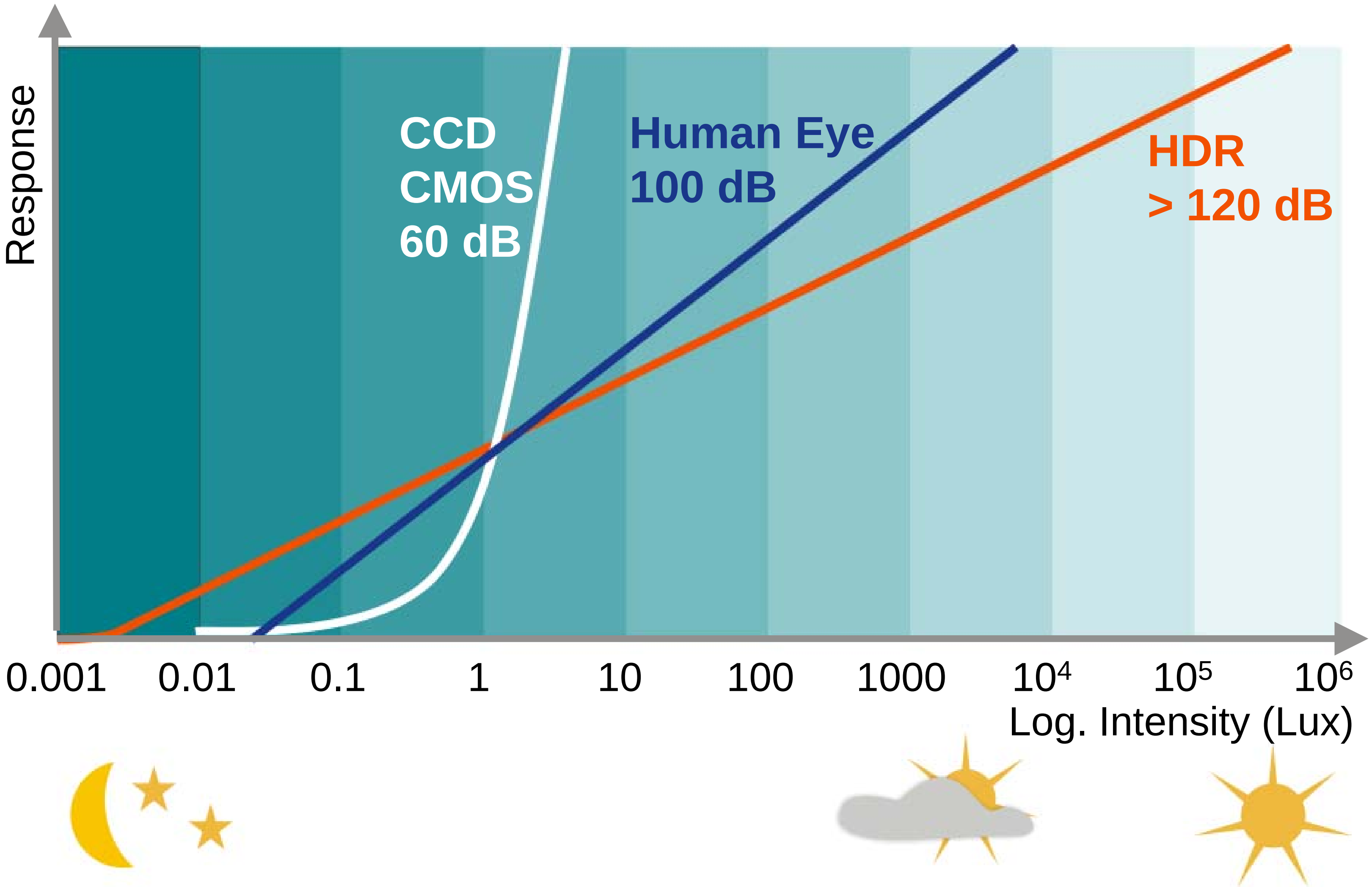
…CCD

…CMOS

The dynamic range of a linear sensor is limited by the saturation of the pixels.

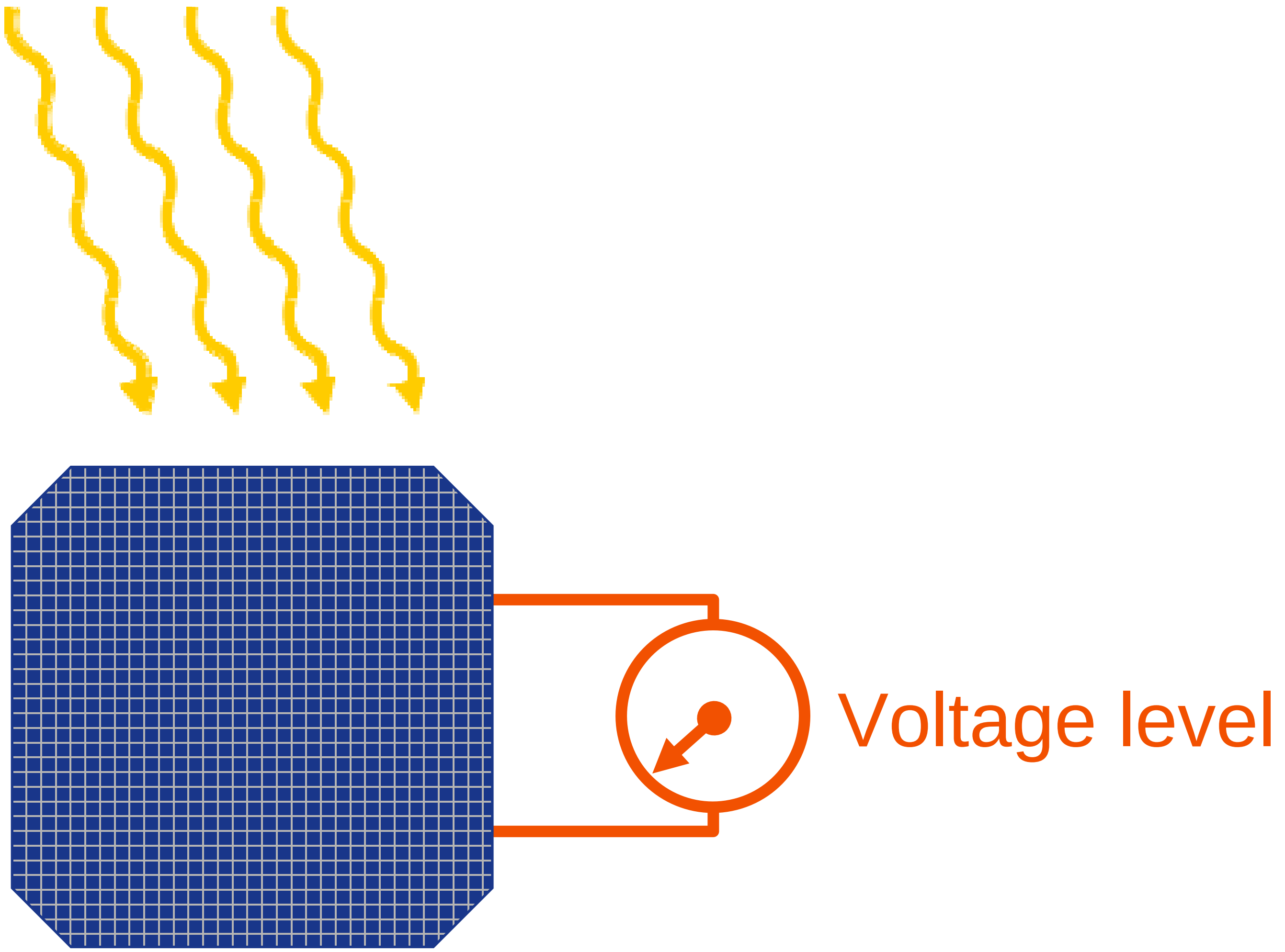


uEye UI-1120.
We need HDR (High Dynamic Range)!



The new HDR sensor is based on the principle of a solar cell and has a 1000x higher dynamic range than CCDs.

Method of functioning:
HDR sensor with photovoltaic pixel



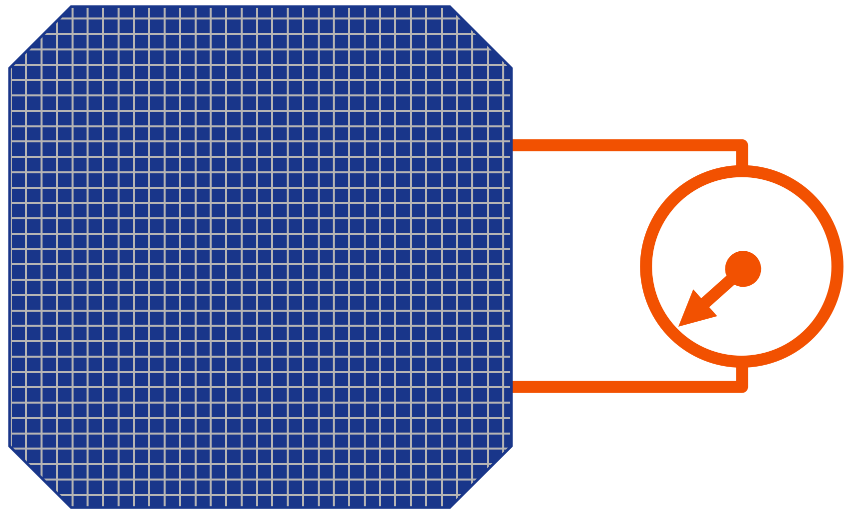
Method of functioning:
HDR sensor with photovoltaic pixel

✗ **No exposure time.**

No motion blur.

✗ **No overexposure.**

No information loss.



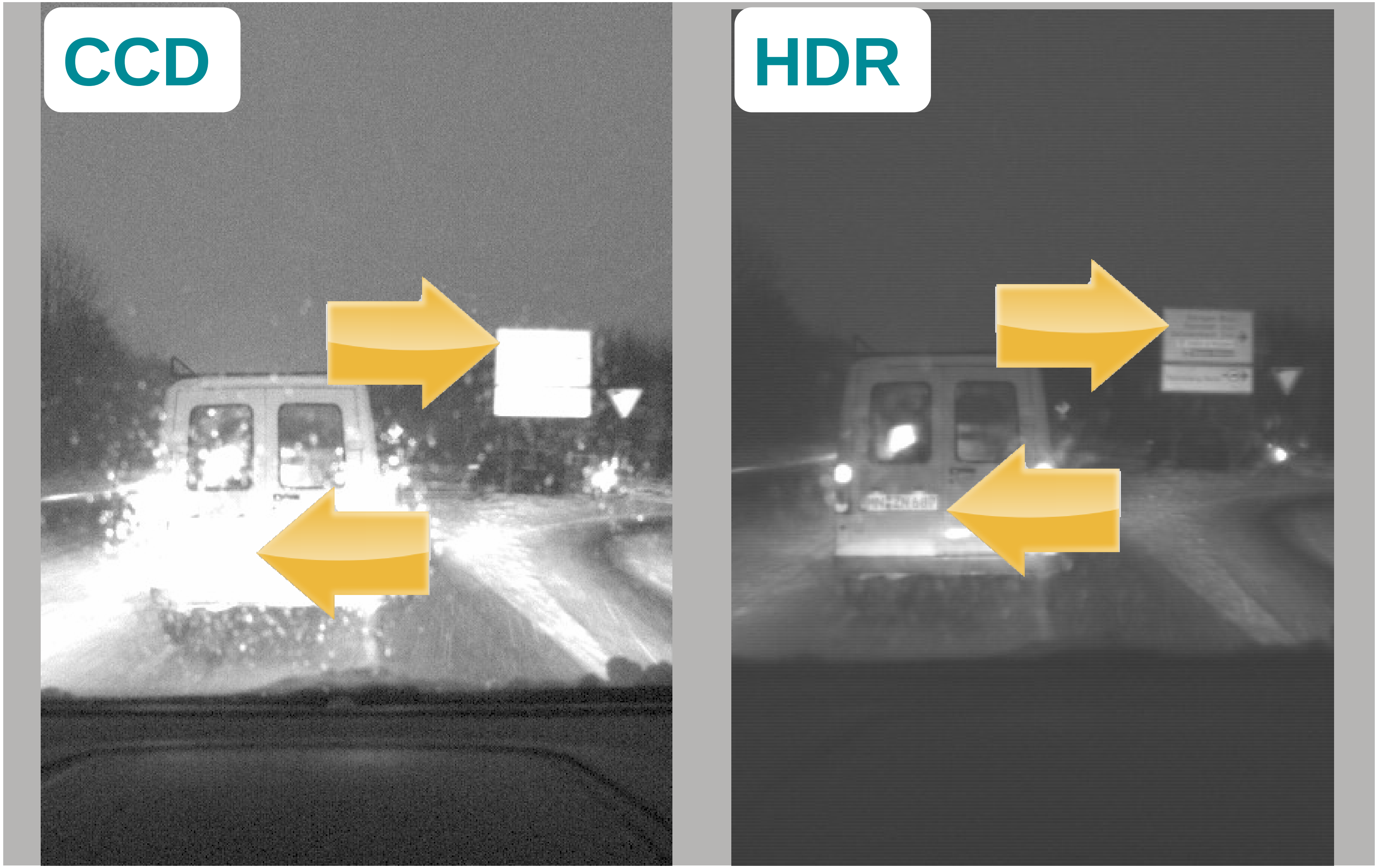
uEye HDR sensor example:
Light bulb

CCD

HDR

uEye HDR sensor example:
Traffic situation with back light

uEye HDR sensor example:
Traffic situation with brightness fluctuation



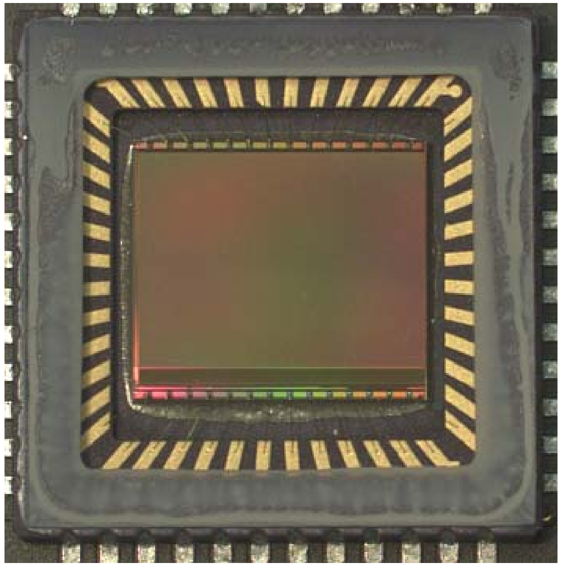
A sensor with a logarithmic curve does dynamic compression in the pixel.

uEye UI-1120.
Sensor technical data

Real logarithmic HDR images
CCIR / D1 resolution (768 x 576)
1/1.8" diagonal

Square pixels with 10µm
No microlenses
45% fillfactor

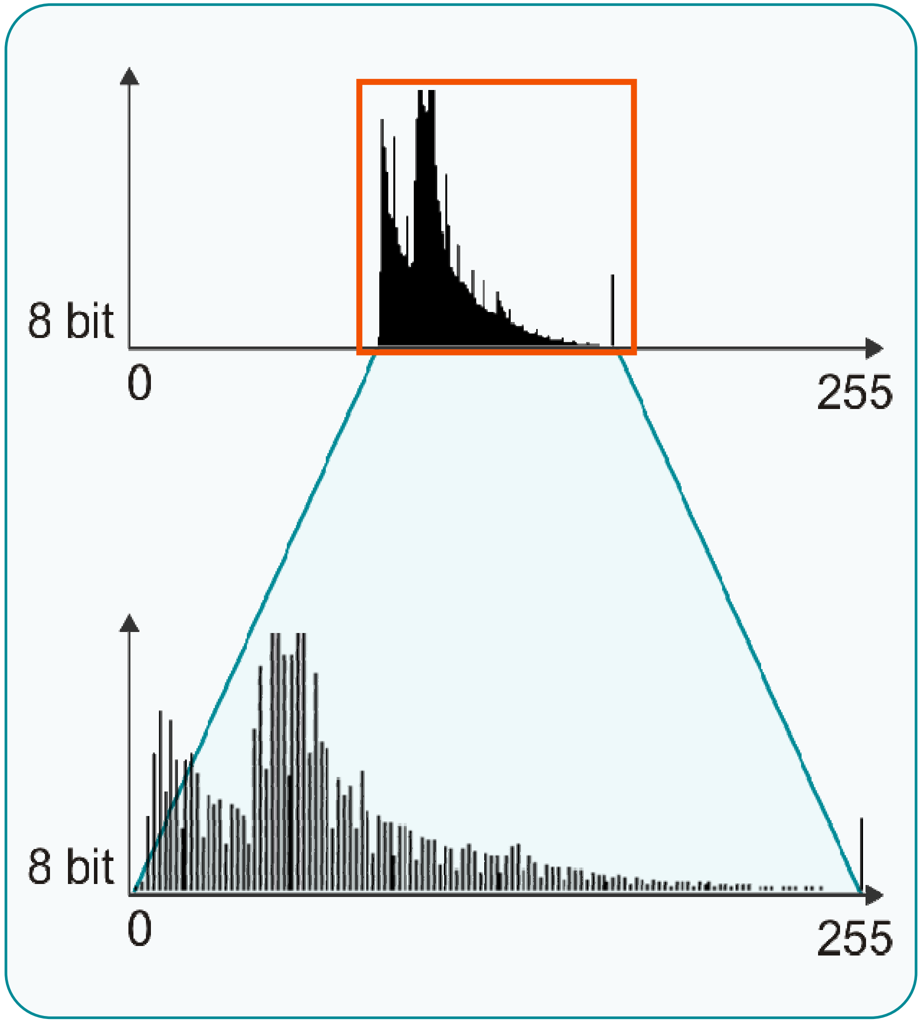
Visible and IR QE
Rolling readout
Max. 50 fps



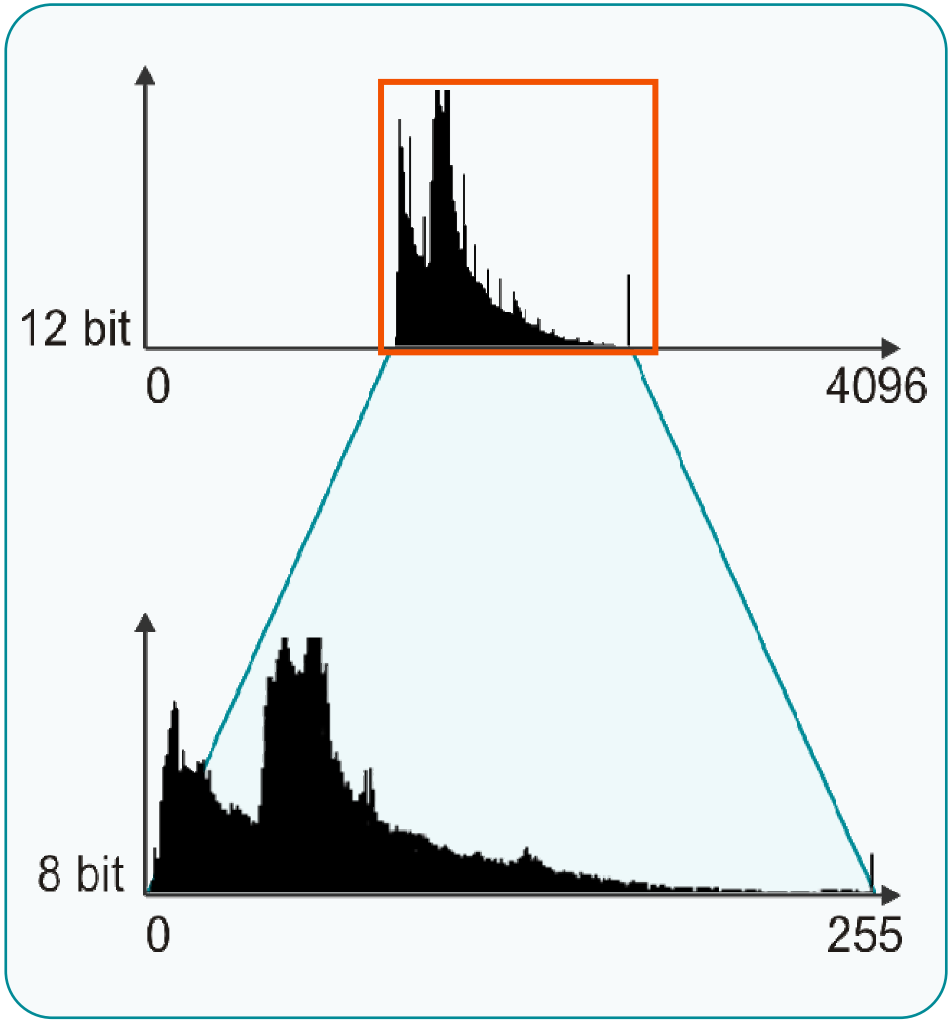
Type: NCS0806
http://www.new-imaging-technologies.com/media/doc/12_nsc0806-flyer-v2.pdf

For best results, use 12 bit raw data in image processing tasks.

8 bit raw data



12 bit raw data



Cameras with high bit depth are required using the full potential of the uEye HDR sensor.

12 bit raw image

Cameras with high bit depth are required using the full potential of the uEye HDR sensor.

After contrast adjustment

Cameras with high bit depth are required using the full potential of the uEye HDR sensor.

Detail 8 Bit

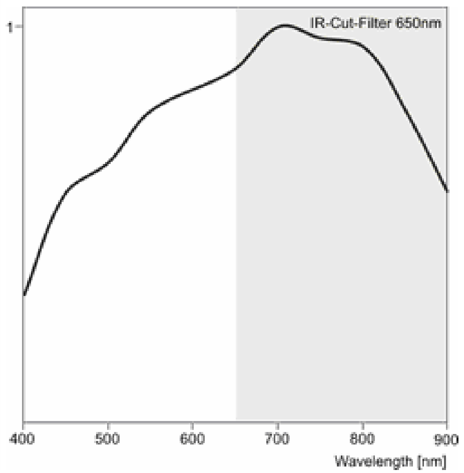
Detail 8 Bit

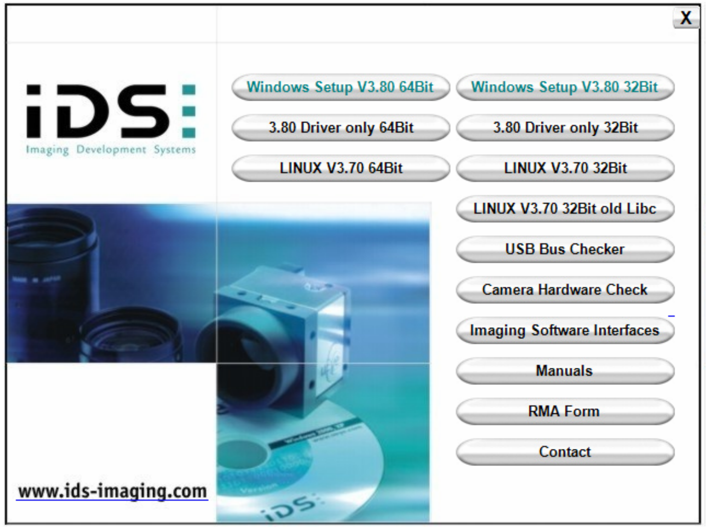
uEye UI-1120.
Support

A white paper will help to understand the new technology.
http://www.ids-imaging.com/whitepaper.php

Free SDK, Viewer, Sourcecode and online manual.
http://www.ids-imaging.de/frontend/files/uEyeManuals/Manual_eng/uEye_Manual/index.html

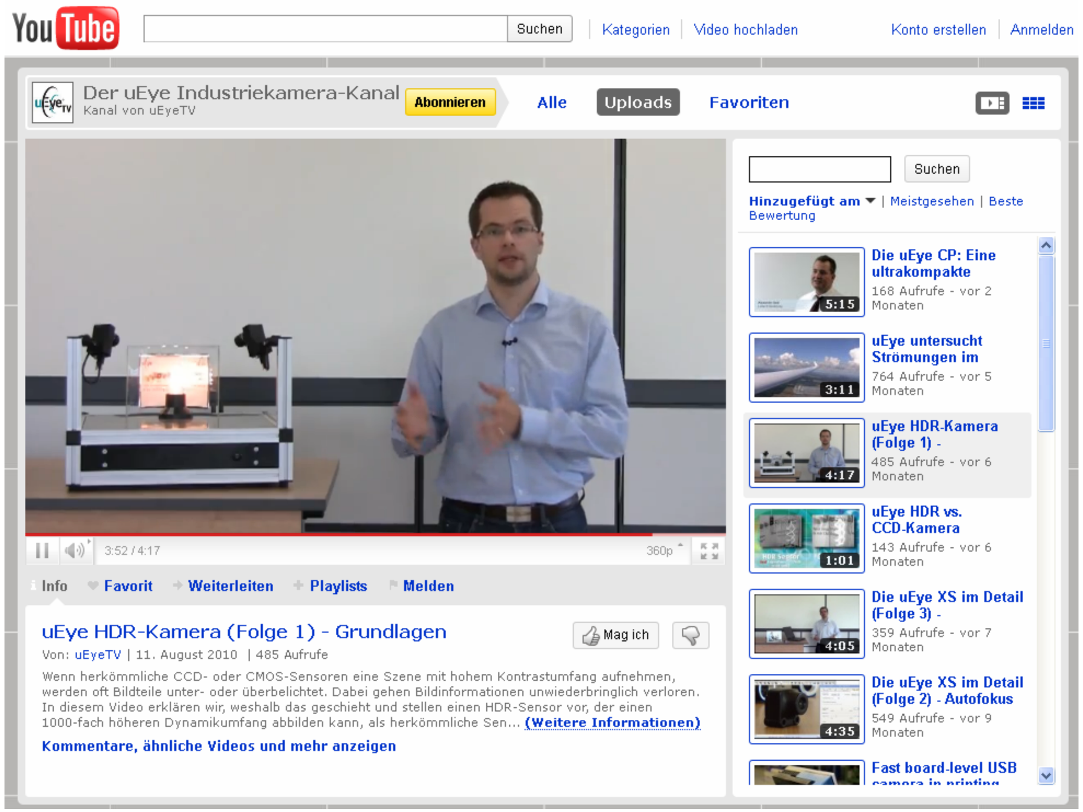
www.ueyesetup.com





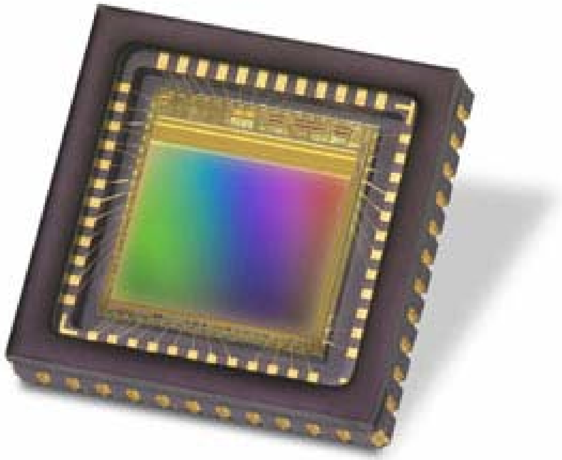
uEye UI-1120.
Announcements

German: http://www.youtube.com/user/uEyeTV
English: http://www.youtube.com/user/uEyeTVe



HDR sensors are mainly suitable for the following areas of use:

- ✔ Very high dynamic range
- ✔ Unpredictable brightness fluctuations
- ✘ Long time exposure



e2v

UI-1240

New: EV76C560

1.3 Megapixel CMOS sensor

1280 x 1024 pixel

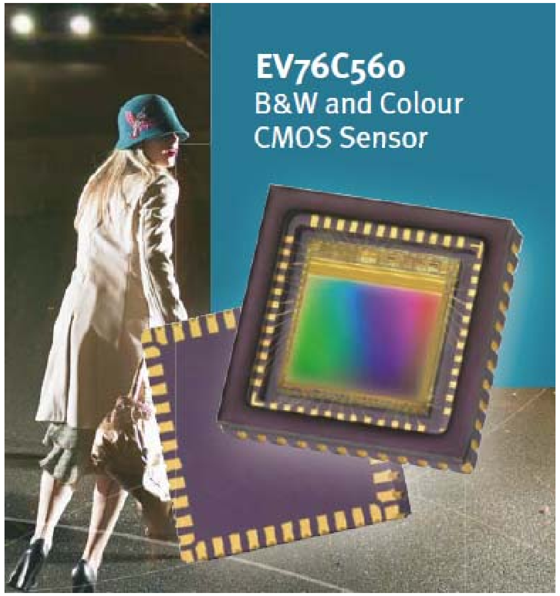
Global and rolling shutter

Mono and Color version

Optical 1/2“ class (exact: 8.7mm diagonal)

5,3µm pixel, square

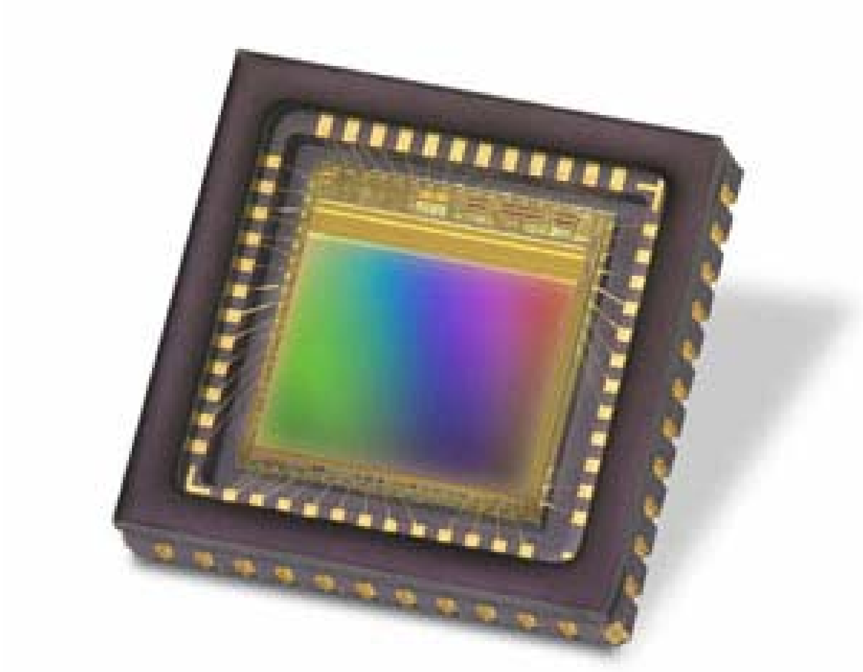
Max. 60 fps



e2v

UI-1240

CMOS pixel details



13.000 e- fullwell

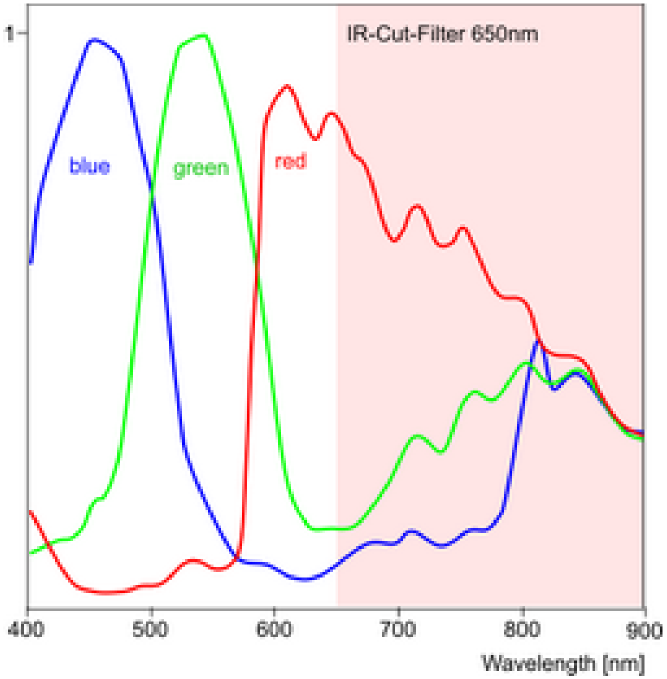
62 dB Dynamic range

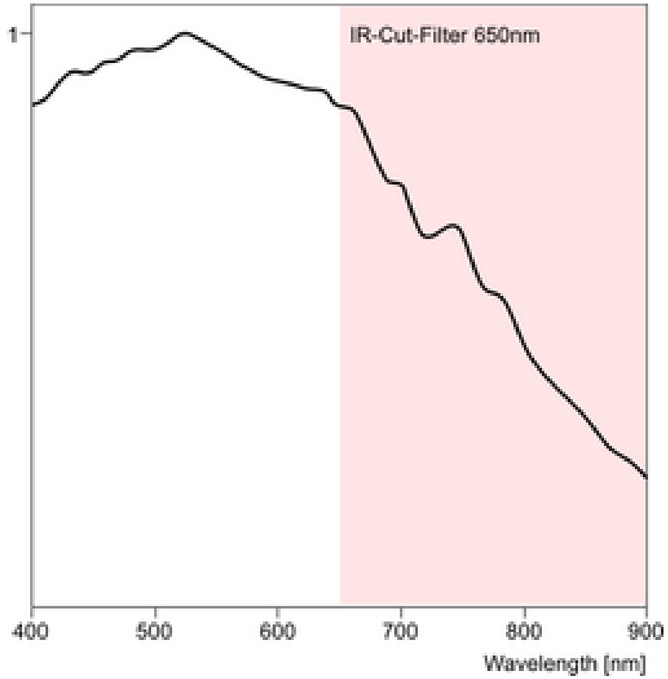
41 dB SNR

- Standard EPI 8e- RMS
- Double EPI (IR enhanced factor 2) 3e- RMS

* values for rolling shutter mode

Sensitive: QE up to 62%





e2v

UI-1240

Gamma Radiation Damage Study 1

http://oro.open.ac.uk/24041/1/2010_-_SPIE_Proc_Vol._7742_-_Gamma_Radiation_Damage_Study_of_0.18_%CE%BCm_Process_CMOS_Image_Sensors.pdf

The sensor is working up to 200 Krads.

Advantages compare to a CCD sensor by 10x thinner silicon

1. INTRODUCTION

Since CMOS imagers are just now approaching the performance of CCDs in several realms[1], the possibility of using them to replace CCDs for certain space observation and spectrography applications is appearing. In some characteristics CMOS imagers can outperform CCDs, especially in terms of power consumption, weight, and radiation hardness, which makes them very appealing candidates for space imaging applications, especially where a radiation-hard sensor is important and power budgets are low. This work is aimed at understanding and improving the radiation hardness of the CMOS design and process used by e2v technologies plc. by characterizing the effect of ionization damage arising from a Co^{60} gamma radiation. The device irradiated was originally designed for use in machine vision applications, meaning that no specific design steps were taken to make the device radiation hard.

The solar system comprises of two different classes of radiation environment, these are the transient and non transient environments. The non-transient class comprises of trapped particles, e.g. protons and electons, held within planetary magnetic fields, for example those of the Earth and Jupiter. The transient class consists of cosmic and galactic rays and the products of solar events such as solar flares[2]. During solar events the incident particle flux can increase greatly, and planning for these events is integral to any mission with regards to radiation damage[3]. Gamma rays fall within the transient class, and thus can affect space missions at any point in time, not just during transfer within the belts, so the sensor often has to be operated whilst under continuous gamma flux and so the effects are important to investigate.

Gamma radiation causes damage to semiconductor devices primarily by creating electron-hole pairs in the gate oxide of the MOSFETs. The holes become trapped, changing the voltage required to activate the gate(increases for p-channel, and decreases for n-channel[4]), and forming traps that contribute to surface-generated leakage current. As this damage is cumulative, the total ionising dose (TID) is the important metric to compare doses in devices. This is measured depending on the absorbing material, as absorption depths are dependent on material, and for these monolithic detectors are thus measured in krad(Si). More detail on how ionising dose affects MOS devices can be found in [5], and how the dose affects individual components of the image readout process in [6]. High energy radiation such as gamma-rays can also cause single effect events, such as latch-up, which can lead to pixel failure[7].

2. SETUP

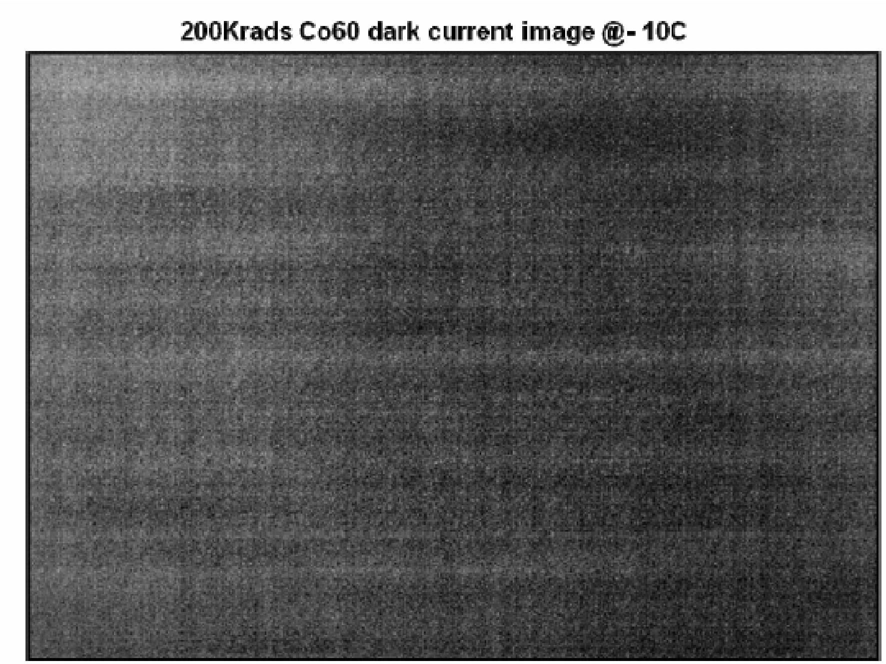
Figure 1. Photographs showing the CMOS chip on demonstration board (left), and close-up of the chip (right)

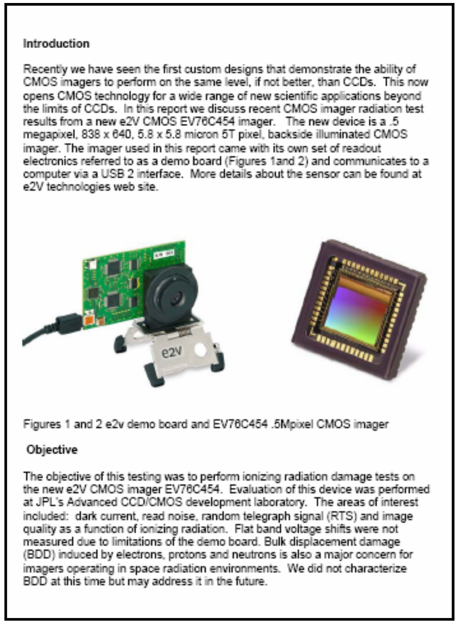
The imagers used for this study are 0.5 Mpixel arrays of 5T 6 × 6 μm pixels, manufactured using a 0.18 μm process, and were provided by e2v technologies plc. based in Chelmsford, UK. Examples of the chip and readout boards are shown in Figure 1. The pixels have no advanced structures designed to mitigate radiation damage, so the results of this study will show a baseline of radiation hardness for the design and process used.

Tom Elliott

(Jet Propulsion Laboratory, California Institute of Technology)

Study 2: 200 Krads test shows an increased black level caused by Temperature and Radiation





Introduction

Recently we have seen the first custom designs that demonstrate the ability of CMOS imagers to perform on the same level, if not better, than CCDs. This now opens CMOS technology for a wide range of new scientific applications beyond the limits of CCDs. In this report we discuss recent CMOS imager radiation test results from a new e2V CMOS EV76C454 imager. The new device is a .5 megapixel, 838 x 640, 5.8 x 5.8 micron 5T pixel, backside illuminated CMOS imager. The imager used in this report came with its own set of readout electronics referred to as a demo board (Figures 1and 2) and communicates to a computer via a USB 2 interface. More details about the sensor can be found at e2V technologies web site.

Figures 1 and 2 e2v demo board and EV76C454 .5Mpixel CMOS imager

Objective

The objective of this testing was to perform ionizing radiation damage tests on the new e2V CMOS imager EV76C454. Evaluation of this device was performed at JPL's Advanced CCD/CMOS development laboratory. The areas of interest included: dark current, read noise, random telegraph signal (RTS) and image quality as a function of ionizing radiation. Flat band voltage shifts were not measured due to limitations of the demo board. Bulk displacement damage (BDD) induced by electrons, protons and neutrons is also a major concern for imagers operating in space radiation environments. We did not characterize BDD at this time but may address it in the future.

Impact:

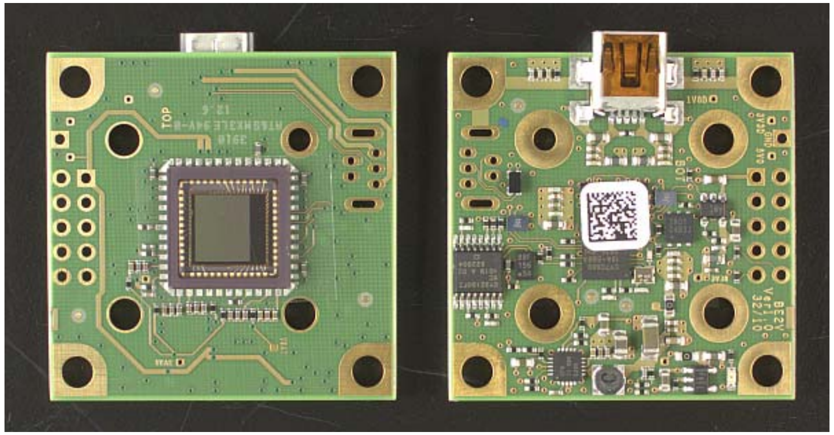
The results of this work demonstrate that **e2V** has a commercial CMOS imager process that has **potential** for flight applications in **extreme radiation environments** and could lead to a scientific CMOS imager that satisfies JPL’s near term future flight camera requirements.

Future testing could focus on displacement damage from protons, electrons and neutrons and how their damage affects device performance.

e2v
UI-1240

We offer more than 1200 different variations of a camera

Also OEM versions with sensor and interface on one pcb or separated sensor pcb.



Thank you!

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