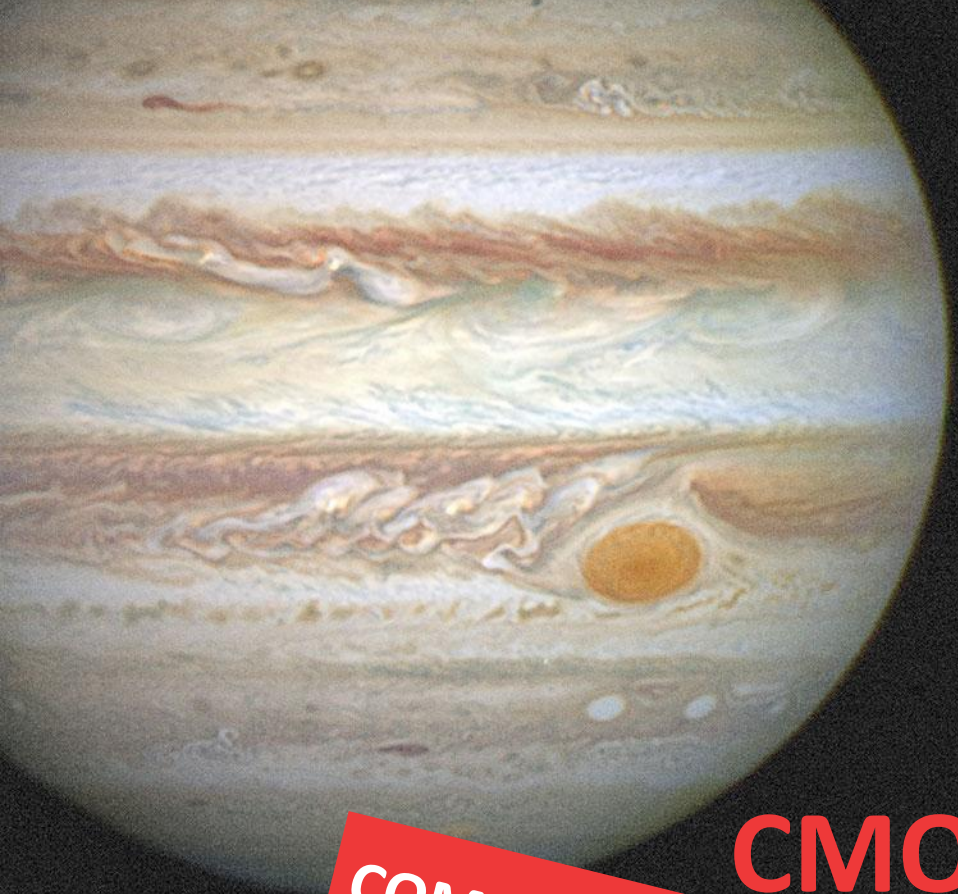


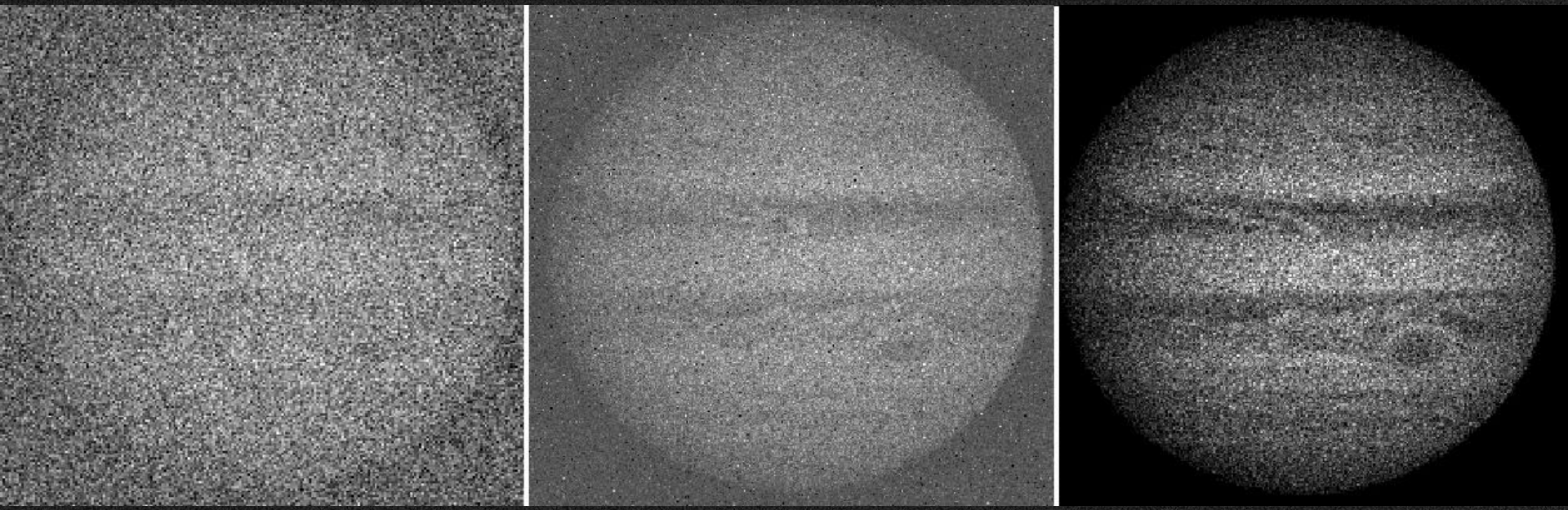
COMPLETELY CMOS technology changed the astronomy world

Matej Mihelčič, ZWO

Jupiter Image Credit: NASA, ESA, and A. Simon (Goddard Space Flight Center)

Why CMOS technology changed the astronomy world

CCD vs. CMOS vs. PERFECT CAMERA



Exposure time: 0.001sec (1ms)
Pixel size: 2.9µm
Read noise: 8e-
Quantum Efficiency: 60%

Exposure time: 0.001sec (1ms)
Pixel size: 2.9µm
Read noise: 1e-
Quantum Efficiency: 75%

Exposure time: 0.001sec (1ms)
Pixel size: 2.9µm
Read noise: 0e-
Quantum Efficiency: 100%

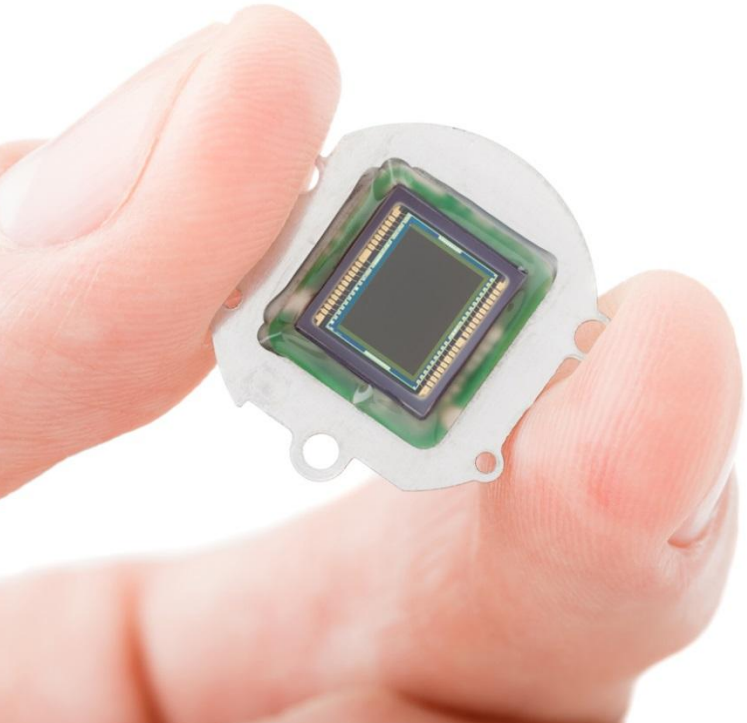
Simulations: Matej Mihelčič
Jupiter Image Credit: NASA, ESA, and A. Simon (Goddard Space Flight Center)

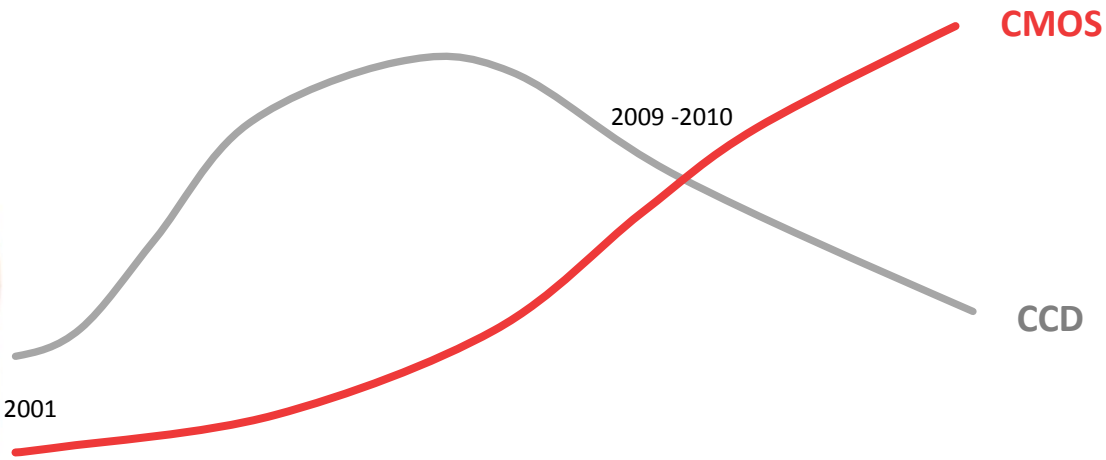
MAIN BENEFITS OF **CMOS** (vs. CCD)

- **Cheaper** production
- Today **main sensor**

High QE, around **70%-80%**

- **Low read noise**, also 1 electron (e-) or less
- **High-speed** capturing, 200 fps or more





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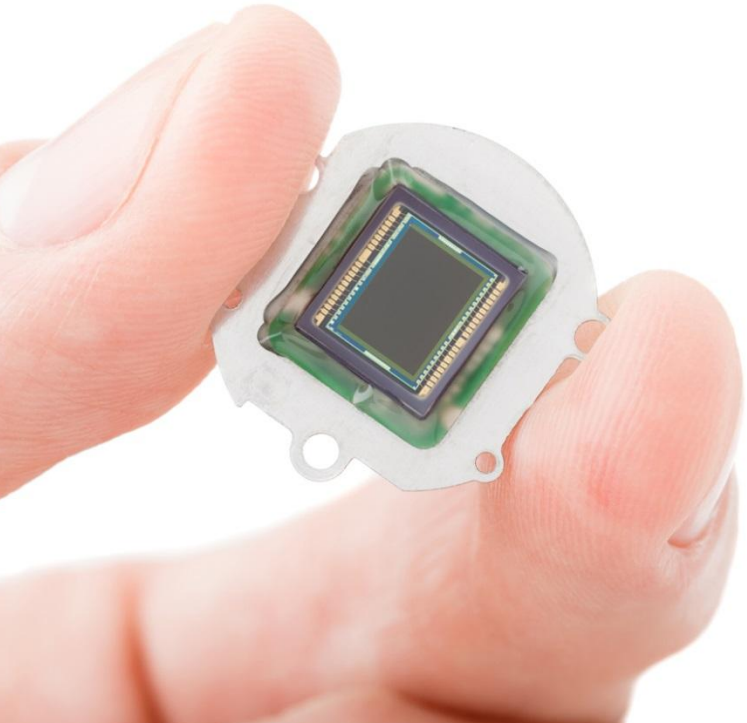
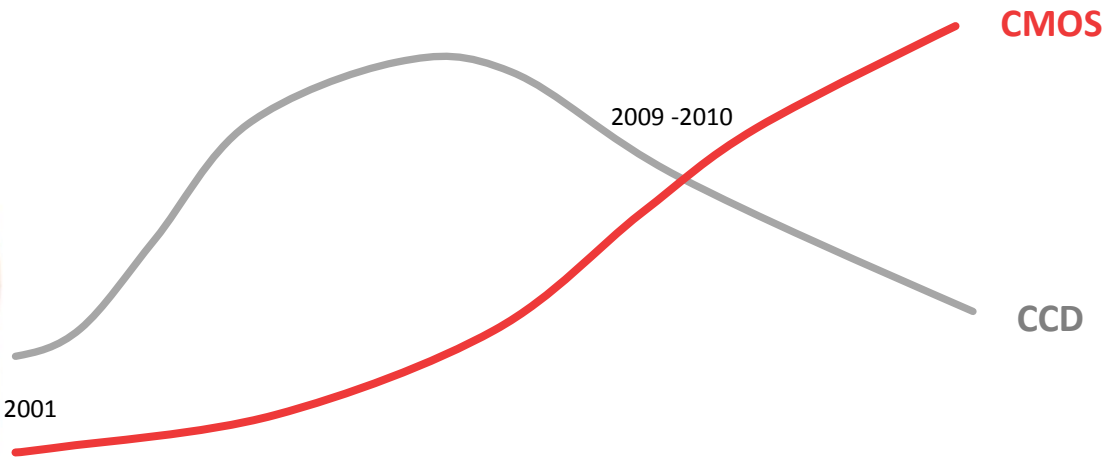


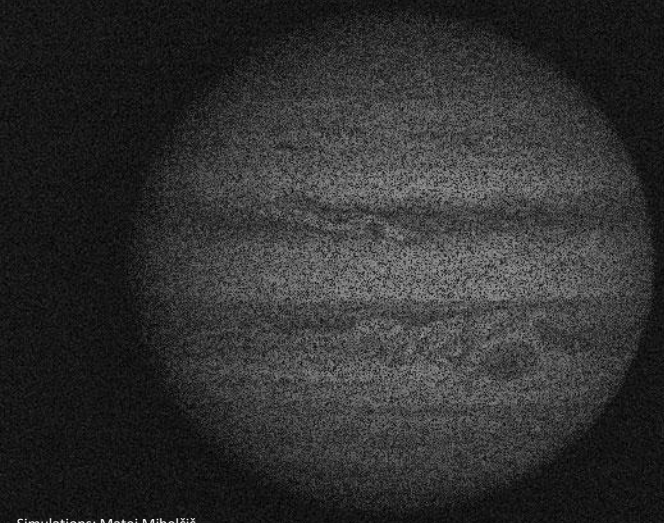


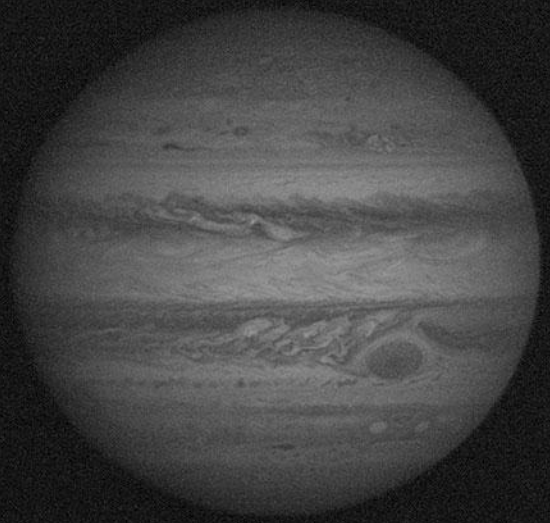
the lower, the better

HOW **READ NOISE** EFFECTS IMAGES?

also known as **temporal dark noise**

- Noise is **always present** in each camera signal
- Read noise is **added to every pixel** in **each frame** when it is read out from the sensor (even if the camera captures total darkness) and is **caused by electronics** and it is random
- **Lower read noise** means a **clearer image**
- Analog gain higher/read noise lower





Simulations: Matej Mihelčič
Jupiter Image Credit: NASA, ESA, and A. Simon (Goddard Space Flight Center)

the higher, the better

QE 50% or 80%?

- High **Quantum Efficiency** means that the sensor is more efficient at turning incoming light into an electrical signal = % of photons converted to light information
- **Higher QE** means a **greater sensitivity** for detecting light especially in **low-light conditions**
  - **Example:** higher QE in the near-IR range (850–950 nm) = very suitable for Jupiter observing in methane band (CH4) such like ASI224 or ASI290

Simulations: Matej Mihelčič
Jupiter Image Credit: NASA, ESA, and A. Simon (Goddard Space Flight Center)

- When the **readout speed** is **not fast enough** (below 30 fps) the **image quality will distort** due to bad seeing or wind or any other movements or rolling shutter
- Fast capturing speed **freezes seeing** and acquires **more good images**
- We recommend; USB3.0 and SSD disk

Simulations: Matej Mihelčič
Jupiter Image Credit: NASA, ESA, and A. Simon (Goddard Space Flight Center)

ZWO`s the best **CMOS** planetary (**JUPITER**) cameras

ASI224

ASI290

ASI224MC (color)

ASI224 color camera has **IMX224** SONY **Exmor** sensor and NIR Technology. It has **extremely low read noise** (0.75 e to 3 e) and high sensitivity especially in near-IR range (850 – 950 nm). It is very suitable for **planetary** astronomy and also for small DSO imaging. This color camera is also suitable for Jupiter **CH4 imaging**.

ASI224 general specifications:

Pixel Size: 3.75 µm

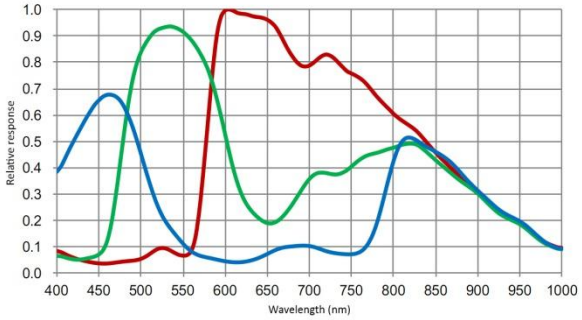
Resolution: 1.27 Mega Pixels 1304 px x 976 px

Diagonal: 6.09 mm

Read Noise: 0.75 e @ 30 db gain

Speed: max

- 1304 × 976: 150 fps
- 320 × 240: 577 fps



sample Jupiter images

ASI224MC

RGB

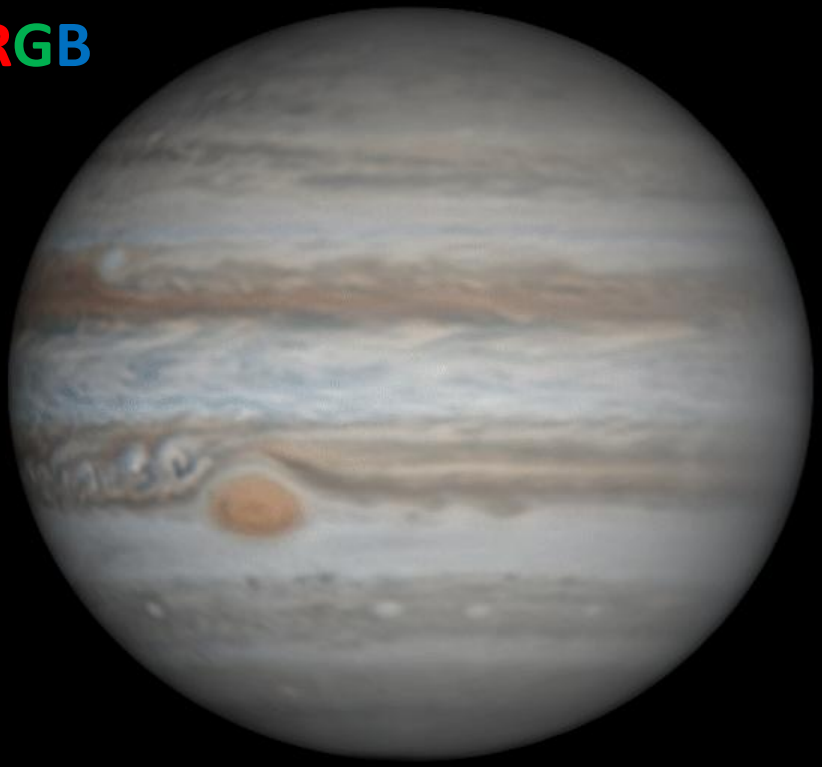


Image Credit: **Ethan Chappel**

CH4

Image Credit: **Martin Lewis**

ASI290MC/MM (color or mono)

ASI290 is the first ZWO camera with IMX290/IMX291 **Exmor R Back-Illuminated CMOS Sensor** with improved visible light and near-IR range (850 - 950nm). Very low read noise close to ASI224MC. The best **new** planetary imaging **mono** camera!?

BRAND NEW!

ASI290 general specifications:

Pixel Size: 2.9 µm

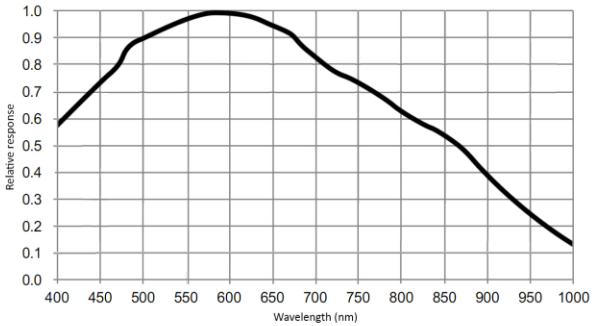
Resolution: 2.13 Mega Pixels 1936 px x 1096 px

Diagonal: 6.46 mm

Read Noise: 1.0 e @ 30 db gain

Speed: max

- 1936 × 1096: 170 fps
- 320 × 240: 737 fps



ASI290 will be released in May 2016!

sample image

ASI290MM

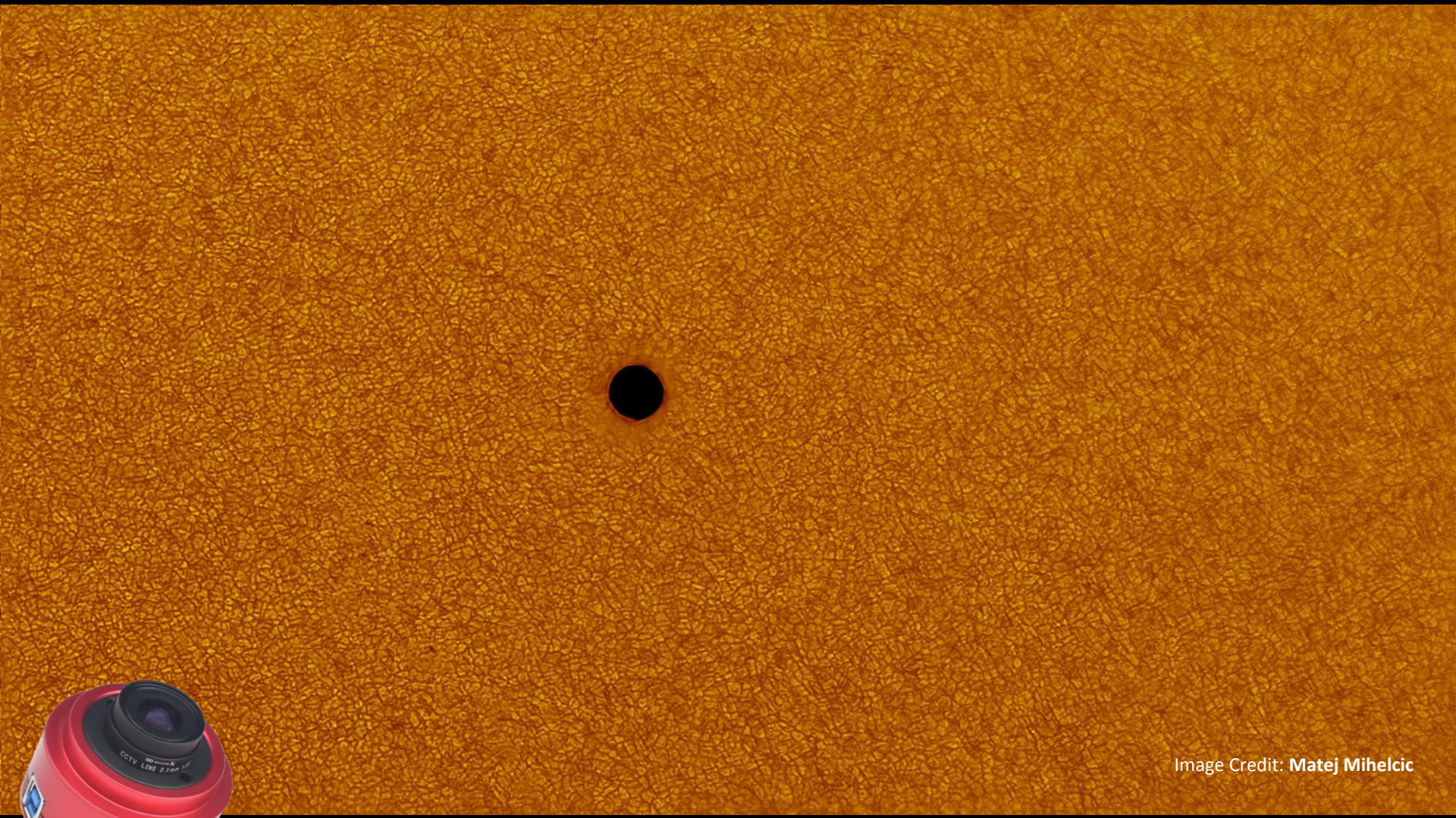


Image Credit: **Matej Mihelcic**

future?

Depends what the main sensor players Sony, Omnivision, Aptina and others will manufacture for other applications.

Astronomy does not play the main role in the sensor developing process!

COMPLETELY

CMOS technology

changed the astronomy world

w: astronomy-imaging-camera.com

f: facebook.com/ZwoDesignAstronomyCameras

m: info@zwoptical.com

Jupiter Image Credit: NASA, ESA, and A. Simon (Goddard Space Flight Center)