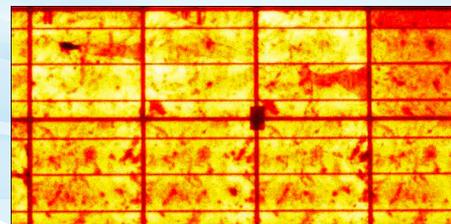
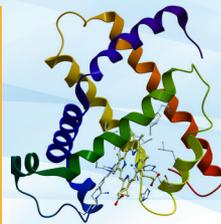
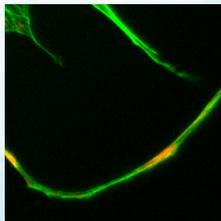
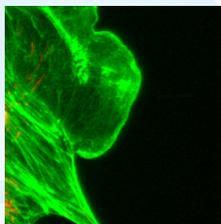
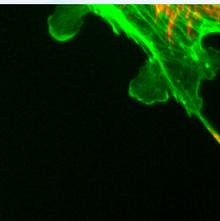
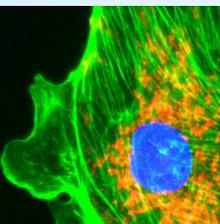
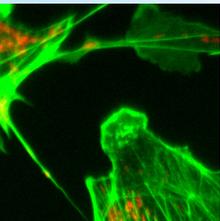


Lightning-Cam™ Camera

High Performance Scientific CMOS Camera



The sensitivity of EMCCDs with the resolution of CCDs

The new Lightning-Cam camera is a breakthrough in scientific imaging cameras. It offers a distinctive ability to simultaneously deliver extremely low noise, fast frame rates, wide dynamic range, high quantum efficiency, high resolution and a large field of view—all in one image.

high resolution

2048 x 2048 pixels

low noise

1.4 electrons



high dynamic range

36,000:1

high speed

100 fps

high quantum efficiency

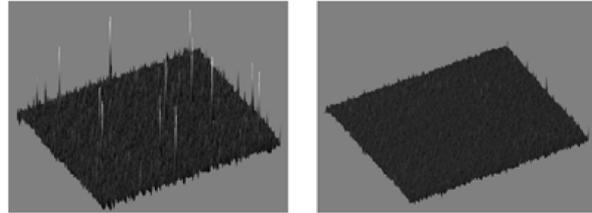
>70%

Features

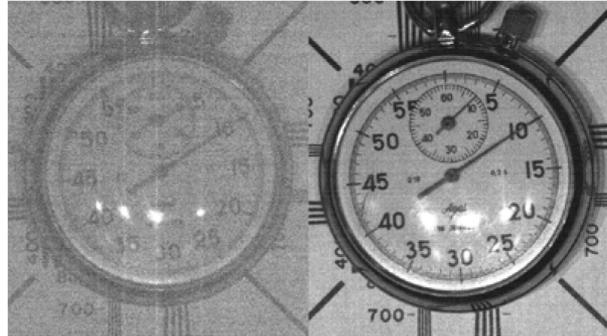
Supreme Image Quality

The new Lightning-Cam camera (with scientific CMOS image sensor) features outstanding low readout noise. Even at maximum speed of 100 frames/s at full resolution of 2048 x 2048 pixels, the noise is 1.0 e⁻ med. Moreover, the Lightning-Cam provides an excellent homogeneous pixel response to light (PRNU, photo response non-uniformity) and an excellent homogeneous dark signal pixel behavior (DSNU, dark signal non-uniformity), which is achieved by a sophisticated electronic circuit technology and firmware algorithms.

The figure to the right shows a comparison of a scientific grade CCD and the new Lightning-Cam sCMOS image sensor under similar weak illumination conditions. This demonstrates the superiority of sCMOS over a CCD with regard to readout noise and dynamic range, without any smear (the vertical lines in the CCD image).



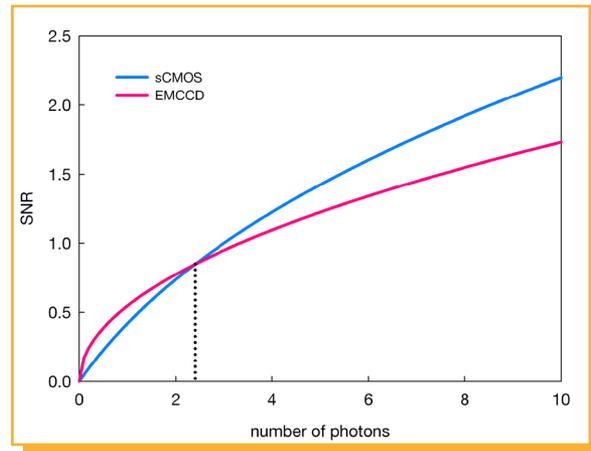
Dark image comparison with the measured distribution of "hot blinking" pixels at 5°C of the image sensor. The left image gives a 3D view with the sophisticated "blinker filter" algorithm off and the right image shows the result with the filter switched on.



The left image was recorded by a scientific CCD camera while the right image was recorded by a Lightning-Cam camera under identical conditions.

Reaching EMCCD Sensitivity

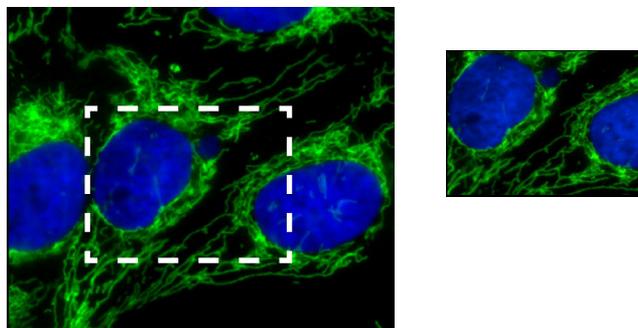
In the past, EMCCD image sensors featuring on-chip amplification were developed to detect the lowest level of light. However, amplification, while reducing readout noise, comes at the expense of dynamic range. Both features are not possible simultaneously in EMCCD sensors. In addition, the amplification process generates excess noise, which reduces the effective quantum efficiency (QE_{eff}) of the EMCCD sensor by a factor of two (e.g., the 90% QE of a back-illuminated EMCCD sensor has an QE_{eff} of 45%). The excess noise present in EMCCDs makes the Lightning-Cam camera the sensor of choice at light conditions above 2 photons per pixel (at 60% QE, assuming a cooled sensor with dark current = 0). Furthermore, available EMCCD sensors are limited in resolution and frame rate.



The graph shows the signal-to-noise (SNR) curves of a typical emCCD camera (gain = 1000) and a sCMOS camera vs. number of photons.

High Resolution

A 4.2 Mpixel resolution in combination with a moderate chip size (18.8 mm diagonal, 6.5 μm pixel pitch) benefits microscopy applications with a low magnification factor and large field of view, thereby reducing processing times and increasing throughput. The figure compares the potential of the new field of view of the Lightning-Cam camera to the 1.3 Mpixel image resolution which is widely used in microscopy applications for scientific cameras.

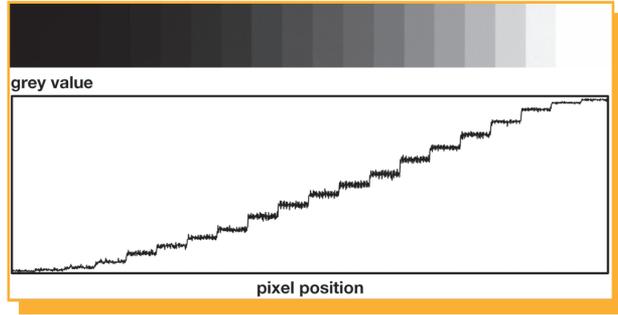


The two images show in comparison the field of view with sCMOS resolution vs. a 1.3 Mpixel resolution, courtesy of Dr. Stefan Jakobs, Dept. of NanoBiophotonics, MPI for Biophysical Chemistry.

Features

36,000:1 Dynamic Range

Due to the excellent low noise and the high fullwell capacity of the sCMOS image sensor, an intra-scene dynamic range of better than 36,000:1 is achieved. A unique architecture of dual column level amplifiers and dual 11 bit ADCs is designed to maximize dynamic range and to minimize readout noise simultaneously. Both ADC values are analyzed and merged into one high dynamic 16 bit value.



The top image shows an extract of a typical Lightning-Cam recording of a gray scale with a 1 : 10 000 dynamic in 20 steps. The bottom image is a plot of the gray values profile along the centered line through the top image (with gamma 2.2).

High Speed Recording and Data Streaming

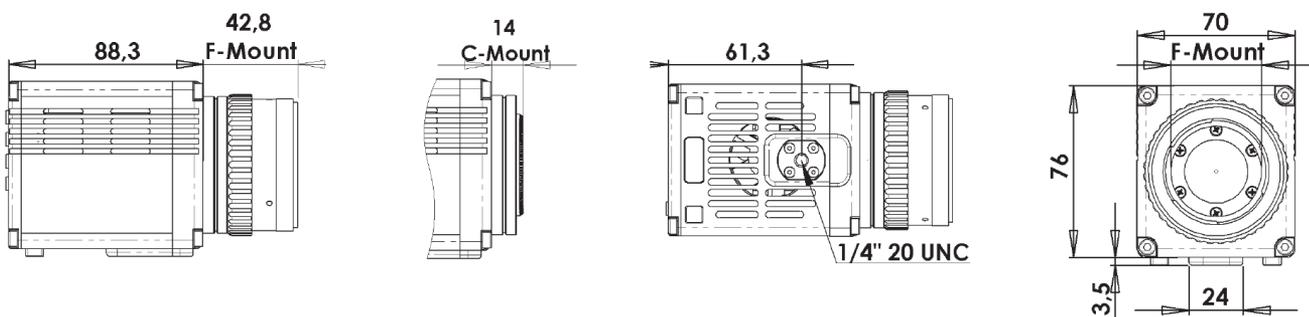
The new Lightning-Cam camera offers in fast mode a frame rate of 100 frames/s (fps) at full resolution of 2048 x 2048 pixels as a full download stream to the PC. Therefore, the recording time is just limited by either the amount of RAM in the PC, or in the case of a RAID system, by the capacity and number of hard disks. As in many CMOS-based cameras, the frame rate increases significantly if smaller regions of interest (ROI) are used. The reduction of the image area works as well in favor of the frame rate of CCD sensors, but here, unwanted regions still need to be read out at the expense of the total readout speed. The typical frame rate for a 1.3 Mpixel scientific CCD camera ($6 e^-$ readout noise), is 10 fps. The Lightning-Cam camera provides at 1.3 Mpixel resolution ($< 1.0 e^-$ readout noise) a frame rate of 200 fps in comparison.

Camera Views



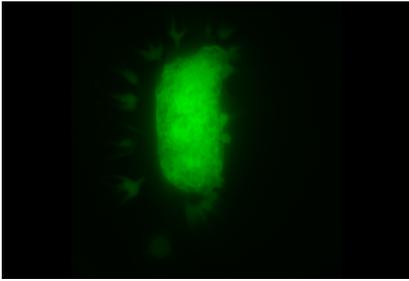
Dimensions

F-mount and c-mount lens changeable adapter.



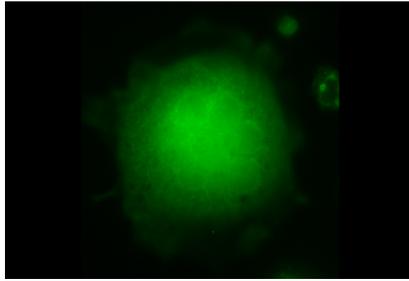
Applications

Life Science



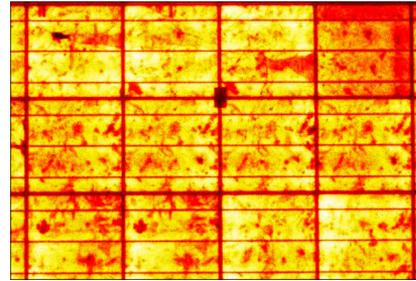
Osteoclast, loaded with Fluo4 taken on Lightning-Cam camera. Courtesy of Tom Chrones, Univ. of Western Ontario, London, ON, Canada

Life Science



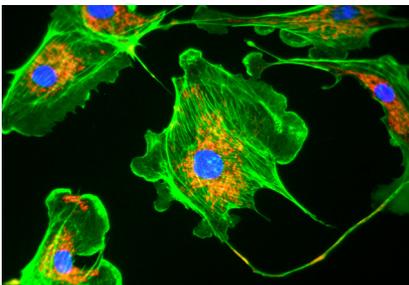
Multi Nuclei Osteoclast, loaded with Fluo4, taken on Lightning-Cam camera. Courtesy of Tom Chrones, Univ. of Western Ontario, London, ON, Canada

Physical Science



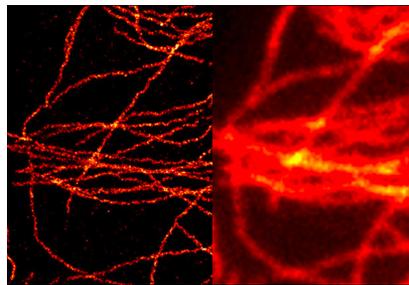
Electroluminescence of a solar cell panel to measure and visualize defects of the cells, recorded with the Lightning-Cam camera, Germany

Life Science



BPAE cells prepared with Mitotracker Red, Alexa488, DAPI. Taken on Lightning-Cam camera.

Life Science



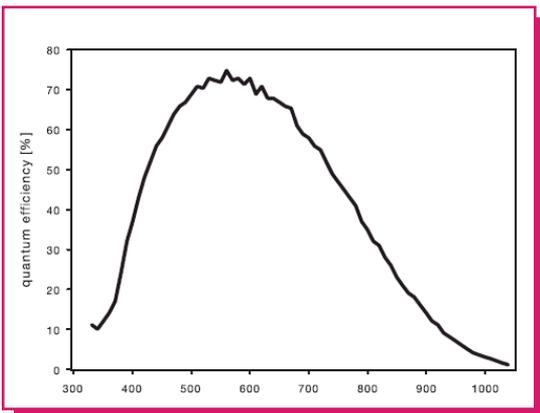
A widefield (right) and a GSDIM super-resolution (left) microscopy image of tubulin fibers, courtesy of Leica Microsystems, Wetzlar, Germany

Application Areas

- Live cell microscopy
- Single molecule detection
- Super resolution microscopy
- TIRF microscopy/waveguides
- Spinning disk confocal microscopy
- Genome sequencing (2nd and 3rd gen)
- FRET
- FRAP
- Lucky astronomy/imaging
- Adaptive optics
- Solar astronomy
- Fluorescence spectroscopy
- Bio & Chemi-luminescence
- High content screening
- Photovoltaic inspection
- X-ray tomography
- Ophthalmology
- Flow cytometry
- Biochip reading
- Spectral (hyperspectral) imaging
- Laser Induced Breakdown Spectroscopy (LIBS)

Quantum Efficiency

Monochrome CIS 2051



Specifications

Image Sensor

Type of Sensor	Scientific CMOS (sCMOS)
Resolution (h x v)	2048 x 2048 active pixels
Pixel Size (h x v)	6.5 μm x 6.5 μm
Sensor Format/Diagonal	13.3 mm x 13.3 mm / 18.8 mm
Shutter Modes	Rolling shutter (RS) with free selectable readouts, lightsheet option
MTF	76.9 lp/mm (theoretical)
Fullwell Capacity	30,000 e ⁻
Readout Noise ¹	0.9 _{med} / 1.4 _{rms} e ⁻ @ slow scan 1.0 _{med} / 1.5 _{rms} e ⁻ @ fast scan
Dynamic Range (typ.)	33,000 : 1 (90.4 dB) slow scan
Quantum Efficiency	> 70 %
Spectral Range	370 nm – 1100 nm
Dark Current (typ.)	< 0.5 e ⁻ /pixel/s (rs1) at 5 °C
DSNU	< 1.0 e ⁻ rms
PRNU	< 0.5%
Anti Blooming Factor	1:10,000

Frame Rate Table²

Typical Examples	Fast Scan	Slow Scan
2048 x 2048	100 fps	35 fps
2048 x 1024	200 fps	70 fps
2048 x 512	400 fps	140 fps
2048 x 256	800 fps	281 fps
2048 x 128	1600 fps	562 fps
1920 x 1080	189 fps	66 fps
1600 x 1200	170 fps	60 fps
1280 x 1024	200 fps	70 fps
640 x 480	426 fps	150 fps
320 x 240	853 fps	300 fps

Frame Rate Table Extended Readout Mode³

Typical Examples	Fast Scan	Slow Scan
2048 + 12 x 2048	100 fps	35 fps
2048 + 12 x 1024	200 fps	70 fps

1. The readout noise values are given as median (med) and root mean square (rms) values, due to the different noise models, which can be used for evaluation. All values are raw data without any filtering.

2. Max. fps with centered ROI.

3. Extended readout mode with 12 columns of black reference pixels.

Specifications

Camera

Frame Rate	100 fps @ 2048 x 2048 pixels, fast scan
Exposure/Shutter Time	100 μ s–10 s
Dynamic Range A/D ⁴	16 bit
A/D Conversion Factor	0.46 e ⁻ /count
Pixel Scan Time	9272.3 MHz fast scan 95.3 MHz slow scan
Pixel Data Rate	544.6 Mpixel/s 190.7 Mpixel/s
Region of Interest	Horizontal: steps of 1 pixel Vertical: steps of 1 pixels
Non Linearity	< 1%
Cooling Method	+ 5 °C stabilized, peltier with forced air (fan) / water cooling (up to 30°C ambient)
Trigger Input Signals	Frame trigger, sequence trigger, programmable input (SMA connectors)
Trigger Output Signals	Exposure, busy, line, programmable output (SMA connectors)
Data Interface	Camera Link Full (10 taps, 85 MHz)
Time Stamp	In image (1 μ s resolution)

General

Power Supply	12 – 24 VDC (+/- 10%)
Power Consumption	20 W
Weight	700 g
Ambient Temperature	+ 10 °C to + 40 °C
Operating Humidity Range	10% – 80% (non-condensing)
Storage Temperature Range	-10 °C to + 60 °C
Optical Interface	C-mount (F-mount opt.)
CE/FCC Certified	Yes

4. The high dynamic signal is simultaneously converted at high and low gain by two 11 bit A/D converters and the two 11 bit values are sophistically merged into one 16 bit value.

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