ANDOR
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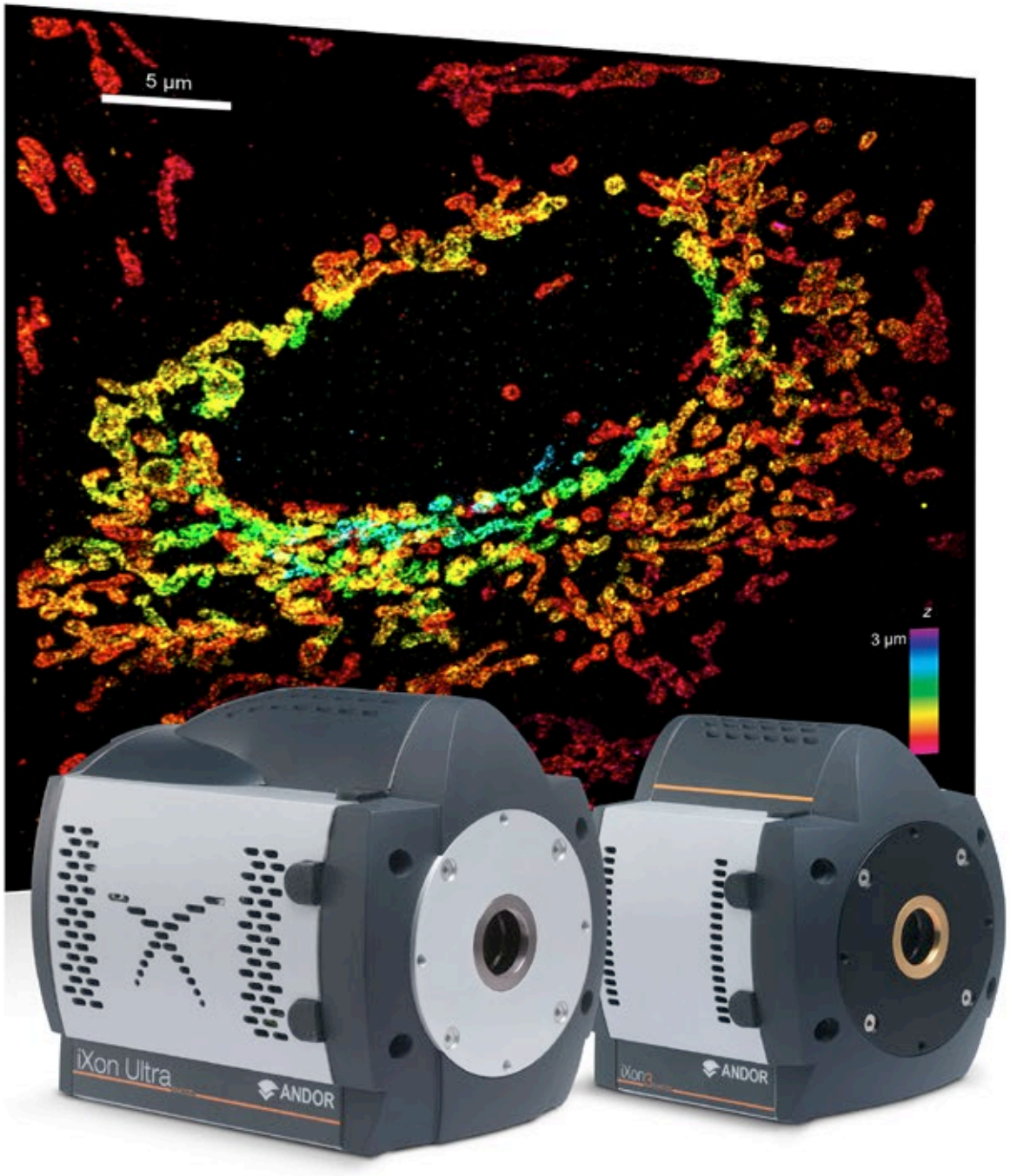
iXon EMCCD

Driving the absolute best from EMCCD technology



iXon

The Industry's Highest Performance Scientific EMCCD Cameras

Andor Technology pioneered the world's first scientific Electron Multiplying CCD (EMCCD) cameras, shipping the initial cameras back in 2000 and winning the Photonics Circle of Excellence award. At that time, Andor coined the name 'Electron Multiplying CCD (EMCCD)', which has been adopted right across this burgeoning industry.

Since then, Andor has consistently set progressively higher EMCCD performance standards with our successive iXon series of deep-cooled, vacuum sealed, quantitative EMCCD cameras. For example, Andor introduced the first back-illuminated EMCCDs in January 2002, alongside our unique 'Baseline Clamp' solution for enhanced quantitative performance. Andor's method for achieving industry-lowest Clock Induced Charge (CIC) was introduced in early 2003 and our benchmark quantitative and linearized EM gain control (RealGain™) and patented EM gain recalibration technology (EMCAL™) was innovated in January 2006.

In 2010, Andor introduced the iXon3 series that brought a number of customer requested features, such as one-click application optimization (OptAcquire) and the ability to calibrate data in either photoelectrons or photons (Count Convert).

The iXon Ultra has built upon this rich performance and feature set, raising the bar markedly higher still by driving frame rates up to 3x more than our already industry leading speed performance. This opens new possibilities for the majority of EMCCD-enabled applications that benefit from single photon sensitivity at fast frame rates.

2000 — Andor shipped first EMCCD cameras
- Pioneering EMCCD cameras
- Photonics Circle of Excellence Award

2001 — iXon
- Flagship high-end EMCCD camera platform
- First to introduce back-illuminated sensors
- Deepest cooling and lowest noise
- Fastest frame rates

2006 — iXon+
- New innovations and greater sensitivity
- Patented EMCAL™ and RealGain™
- World's first Megapixel back-illuminated EMCCD (888 model)
- Maintaining market leader status

2010 — iXon3
- New customer requested functionality
- Superior ease of optimization
- Quantify data in electrons or photons
- Enhancements in noise, speed and quantitative stability

2012 — iXon Ultra
- >60% faster - 512 x 512 @ 56 fps
- USB – universal Plug and Play
- Lower noise 'conventional' CCD mode
- 'On the fly' processing - direct output of raw data
- New EX2 Technology - extended EMCCD sensitivity

2014 — iXon Ultra 888
- Largest Field of View, 3x faster!
- 26 fps from 1024 x 1024; 93 fps from 512 x 512
- First USB 3.0 enabled EMCCD

> "The fast readout, low noise, and large areas of the iXon cameras allow us to beat the turbulence in the Earth's atmosphere in order to capture the details of the magnetic structuring in the solar chromosphere."

Image courtesy of Mr Kevin Reardon, INAF - Osservatorio Astrofisico di Arcetri, Italy

The EMCCD Advantage

Ultimate sensitivity with super fast speeds

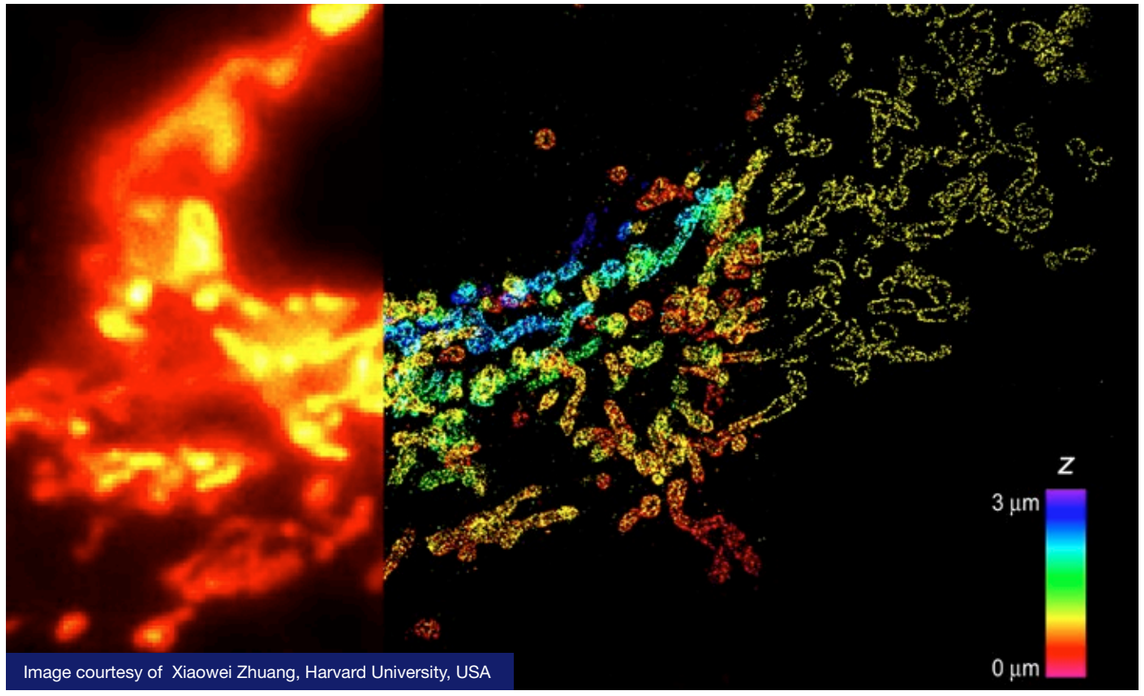


Image courtesy of Xiaowei Zhuang, Harvard University, USA

Current trends in photon measurement are placing unprecedented demands on detector technology to perform at significantly higher levels of sensitivity and speed. Electron Multiplying CCD (EMCCD) technology has been designed to respond to this growing need, unlocking new and innovative experimental prospects.

EMCCDs operate by amplification of weak signal events (down to single photons) to a signal level that is well clear of the read noise floor of the camera at any readout speed. Importantly, this 'on-chip' amplification process is realized without sacrificing the photon collection capability of the sensor, with back-illuminated sensors offering up to 95% Quantum Efficiency (QE).

iXon - The Microscopist's Choice

In applications such as single molecule microscopy, super-resolution, live cell microscopy (including confocal), calcium signaling, transport/motile imaging and intracellular bioluminescence, weak, rapidly changing fluorescent signals from cells must be dynamically imaged. Andor's iXon technology offers an ideal detection solution. Ultra-sensitive detection capability in fluorescence microscopy facilitates use of lower excitation powers (thereby reducing photobleaching and phototoxicity) and lower dye concentrations.

Since its pioneering introduction in 2000, Andor's EMCCD technology has been widely and highly successfully employed by microscopists throughout the world, resulting in an outstanding level of representation in high-profile publications.

iXon - The Physicist's Choice

The unique high-performance specifications of the optimized iXon range have been serving the physical scientist and astronomer in scenarios that demand more than simply an EM sensor in a camera. Andor has worked with numerous scientists to deliver solutions that work for their particular application requirements, such as providing effective charge purging immediately prior to acquisition, specific coatings, coupling to fiber optic scintillators and also specific interface requirements.

As such the Andor iXon brand has been prevalent across a variety of demanding applications, such as photon counting, lucky astronomy, adaptive optics, Bose Einstein condensation (BEC) / ion trapping, single molecule detection / nanotechnology, neutron tomography, X-Ray/Gamma tomography, plasma diagnostics, Raman detection and thermo-luminescence detection.

Why choose iXon?

Unparalleled flexibility and functionality

The principal reason for making use of Andor's iXon EMCCD technology is to ensure the absolute highest sensitivity from a quantitative scientific digital camera, particularly under fast frame rate conditions. In particular, truly exceptional speed performance is now available through the new iXon Ultra model. Andor's proven UltraVac™ vacuum technology, carrying a seven year warranty, is critical to ensure both -100ºC deep cooling and complete protection of the sensor.

The iXon series of cameras are designed to be the most flexible yet easy to use EMCCDs on the market, optimizable for a wide variety of application requirements in a single click via the new OptAcquire™ feature.

Furthermore, signal can be quantitatively calibrated in units of electrons or photons, either in real time or post-processing. Patented, pioneering technology offers automated recalibration of EM gain, alongside anti-ageing protection.

Crucially, the iXon brand carries an outstanding reputation within the industry for quality and reliability, brandishing an unparalleled track record of minimal field failures.

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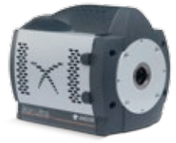
Andor's **UltraVac™** vacuum technology, carrying is critical to ensure both **-100ºC deep cooling** and **complete protection of the sensor**.

The iXon Range

The iXon portfolio encompasses a number of model variations, offering solutions for a wide range of application requirements.

Whether your needs are guided more by speed, resolution, field of view, wavelength dependence or simply budget, the iXon series of market leading EMCCD cameras will provide a match.



Model	iXon Ultra 888	iXon Ultra 897	iXon3 860
Core Attributes	Field of view, sensitivity and speed	Speed and sensitivity	Dedicated to speed; large pixel
Sensor Format	1024 x 1024	512 x 512	128 x 128
QE Options	BV, EX2, UVB	BV, EX2, UVB	BV, UVB
Pixel Size	13 µm	16 µm	24 µm
Frame Rate	26 fps (670 fps with 128 x 128 Crop Mode)	56 fps (595 fps with 128 x 128 Crop Mode)	515 fps
Interface	USB 3.0	USB 2.0	PCI-Express

iXon Ultra 888

Field of View and Sensitivity... now 3x faster!

Image courtesy of Jan Liphardt, Stanford University, USA

The highly innovative iXon Ultra 888 Megapixel, back-illuminated EMCCD camera, offers single photon sensitivity across a large field of view, at 25 fps.

Building on a rich history of first to market innovation, the 'supercharged' iXon Ultra 888, represents a massive performance boost for the largest available EMCCD sensor, as well as the first USB 3.0 enabled EMCCD camera.

The iXon Ultra 888 has been fundamentally re-engineered to facilitate 3x overclocking of the pixel readout speed to an unprecedented 30 MHz, whilst maintaining quantitative stability, thrusting the full frame rate performance to video rate. Furthermore, Andor's unique 'Crop Mode' can be employed to further boost frame rates from a user defined sub-region, for example pushing a 512 x 512 sub-array to 93 fps and a 128 x 128 area to 670 fps.

With a 1024 x 1024 sensor format and 13 µm pixel size, the resolving power, field of view and unparalleled speed of the iXon Ultra 888 render it the most attractive and versatile EMCCD option for demanding applications. These include single molecule detection, super-resolution microscopy, live cell imaging and high time resolution astronomy.

Specification sheets available at andor.com/ixon888

Key Specifications

Active pixels	1024 x 1024
Pixel size (w x h; µm)	13 x 13
Image area (mm)	13.3 x 13.3
Active area pixel well depth (e)	80,000
Max readout rate (MHz)	30
Frame rates (fps)	26 (full frame) - 9,610
Read noise (e^-)	< 1 with EM gain
QE max	> 90% (EX2 available)

Features and Benefits

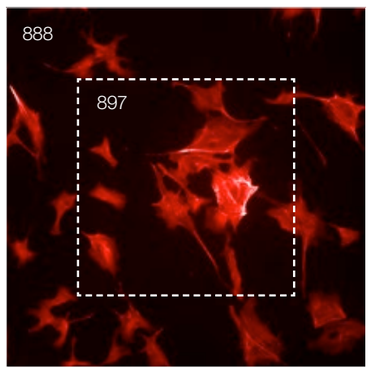
Overclocked to 30 MHz readout	Pushes frames to 26 fps (full frame); 93 fps with 512 x 512 Crop Sensor Mode.
13.3 x 13.3 mm sensor	Largest field of view EMCCD available.
Optically Centred Crop Mode (live cell super-resolution)	Continuous imaging with fastest possible frame rate from centrally positioned ROIs. Highly enabling for live cell super-resolution and much more (e.g. 251 fps with 256 x 256 ROI).
First USB 3.0 enabled EMCCD	Enhanced bandwidth and simple connectivity.
EX2 Technology (optional)	Extended QE response, beyond standard back-illuminated.
TE cooling to -90°C	Elimination of dark current detection limit.
RealGain™	Absolute EMCCD gain selectable directly from a linear and quantitative scale.
Fringe Suppression (optional)	Reduced etaloning in NIR.
OptAcquire	Optimize the highly flexible iXon for different application requirements at the click of a button.
Count Convert	Quantitatively capture and view data in electrons or incident photons. Applied either in real time or postprocessing, Count Convert does this important conversion for you.
EMCAL™	Patented user-initiated self-recalibration of EM gain.
iCam	Exposure time fast switching provides market leading acquisition efficiency.
Minimal Clock-Induced Charge	Unique pixel clocking parameters, yielding minimized spurious noise floor.
UltraVac™	Critical for sustained vacuum integrity and to maintain unequalled cooling and QE performance, year after year. Seven year vacuum warranty.
Spurious Noise Filter	Intelligent algorithms to filter clock induced charge events from the background. Real time or post-processing.
Direct Data Access	Camera Link output port to facilitate direct access to data for 'on the fly' processing.
Enhanced photon counting Modes	Intuitive single photon counting modes to overcome multiplicative noise. Real time or post-processing.
Superior Baseline Clamp and EM Stability	Essential for quantitative accuracy of dynamic measurements.
Lower Noise CCD Mode	'2 in 1' flexibility. EMCCD for ultra-sensitivity at speed, conventional CCD for longer acquisitions.
FPGA Timestamp	Hardware generated timestamp with 10 ns accuracy.

Key Applications

Single Molecule Detection
Cell Motility
Super Resolution (PALM, STORM)
TIRF Microscopy
FRET / FRAP
Single Plane Illumination Microscopy (SPIM)
Fluorescence Correlation Microscopy
Vesicle Trafficking
Microspectroscopy / Hyperspectral imaging
Spinning Disk Confocal Microscopy
Lucky Astronomy
Ion Signaling (Calcium Flux)
Adaptive Optics
Single photon counting

Additional features of the iXon Ultra 888 include high bandwidth USB 3.0 connectivity, a lower noise CCD mode and an additional Camera Link output. This offers a unique ability to directly intercept data for 'on the fly' processing, ideally suited to applications such as adaptive optics. Simultaneously, the iXon Ultra maintains all the advanced performance attributes and a rich customer requested feature set that have defined the iXon range to date, such as deep vacuum cooling to -95ºC, extremely low spurious noise and EM Gain calibration.

Count Convert functionality allows real time data acquisition in units of electrons or incident photons and OptAcquire facilitates one-click optimization of this versatile camera to a variety of application conditions.



Field of View Comparison between iXon Ultra models. The 888 model has a x2.6 greater sensitive area than the 897 model.

iXon Ultra 897

Ultimate sensitivity ... supercharged!

Image courtesy of Salvatore Sauro, King's College London, UK

Facilitated by a fundamental redesign, the iXon Ultra 897 takes the popular back-illuminated 512 x 512 frame transfer sensor and overclocks readout to 17 MHz, pushing speed performance to an outstanding 56 fps (full frame), whilst maintaining quantitative stability throughout. Ultimate sensitivity is also attained through deep thermoelectric cooling down to -100°C and industry-lowest clock induced charge noise. New EX2 Technology offers extended QE performance.

Additional unique features of the iXon Ultra include 'Optically Centered Crop Mode' for superb speed from ROIs and direct raw data access for on the fly processing. EMCCD and conventional CCD readout modes provide heightened application flexibility, with a new 'low and slow' noise performance in CCD mode.

The significant speed boost offered in the iXon Ultra 897 facilitates a new level of temporal resolution to be attained. This is ideal for speed challenged low-light applications such as super-resolution microscopy, single molecule tracking, ion signaling, cell motility, single photon counting, lucky astronomy and adaptive optics. The extremely low noise of the iXon 897 coupled with the new overclocked speed performance will place this model at the forefront of consideration when it comes to upgrading the high end imaging performance of your laboratory.

Specification sheets available at andor.com/ixonultra

Features and Benefits	
Overclocked to 17 MHz readout	Pushes frames to 56 fps (full frame); 595 fps with 128 x 128 cropped sensor mode.
Optically Centred Crop Mode (live cell super-resolution)	Continuous imaging with fastest possible frame rate from centrally positioned ROIs; 569 fps with 128 x 128 ROI. Highly enabling for live cell super-resolution and much, much more.
EX2 Technology	Extended QE response.
TE cooling to -100°C	Critical for elimination of dark current detection limit.
Fringe Suppression	Reduced etaloning in NIR.
RealGain™	Absolute EMCCD gain selectable directly from a linear and quantitative scale.
OptAcquire	Optimize the highly flexible iXon for different application requirements at the click of a button
Count Convert	Quantitatively capture and view data in electrons or incident photons. Applied either in real time or post-processing, Count Convert does this important conversion for you.
EMCAL™	Patented user-initiated self-recalibration of EM gain.
iCam	Exposure time fast switching provides market leading acquisition efficiency.
Minimal Clock-Induced Charge	Unique pixel clocking parameters, yielding minimized spurious noise floor.
USB 2.0	True universal 'plug and play'. No internal card required for compatibility. Operates readily on laptop at top speed.
UltraVac™	Critical for sustained vacuum integrity and to maintain unequalled cooling and QE performance, year after year. 7 year vacuum warranty.
Spurious Noise Filter	Intelligent algorithms to filter clock induced charge events from the background. Real time or post-processing.
Direct Data Access	Camera Link output port to facilitate direct access to data for 'on the fly' processing.
Enhanced photon counting Modes	Intuitive single photon counting modes to overcome multiplicative noise. Real time or post-processing
Superior Baseline Clamp and EM Stability	Essential for quantitative accuracy of dynamic measurements.
Lower Noise CCD Mode	'2 in 1' flexibility. EMCCD for ultra-sensitivity at speed, conventional CCD for longer acquisitions
FPGA Timestamp	Hardware generated timestamp with 10 ns accuracy.

Key Specifications	
Active pixels	512 x 512
Pixel size (w x h; µm)	16 x 16
Image area (mm)	8.2 x 8.2
Active area pixel well depth (e)	180,000
Max readout rate (MHz)	17
Frame rates (fps)	56 - 11,074
Read noise (e^-)	< 1 with EM gain
QE max	> 90% (EX2 available)

Key Applications	
Single Molecule Detection	Vesicle Trafficking
Cell Motility	Microspectroscopy / Hyperspectral imaging
Super Resolution (PALM, STORM)	Spinning Disk Confocal Microscopy
TIRF Microscopy	Lucky Astronomy
FRET / FRAP	Ion Signaling (Calcium Flux)
Single Plane Illumination Microscopy (SPIM)	Adaptive Optics
Fluorescence Correlation Microscopy	Single photon counting

iXon3 860

Lightning speed and sensitivity

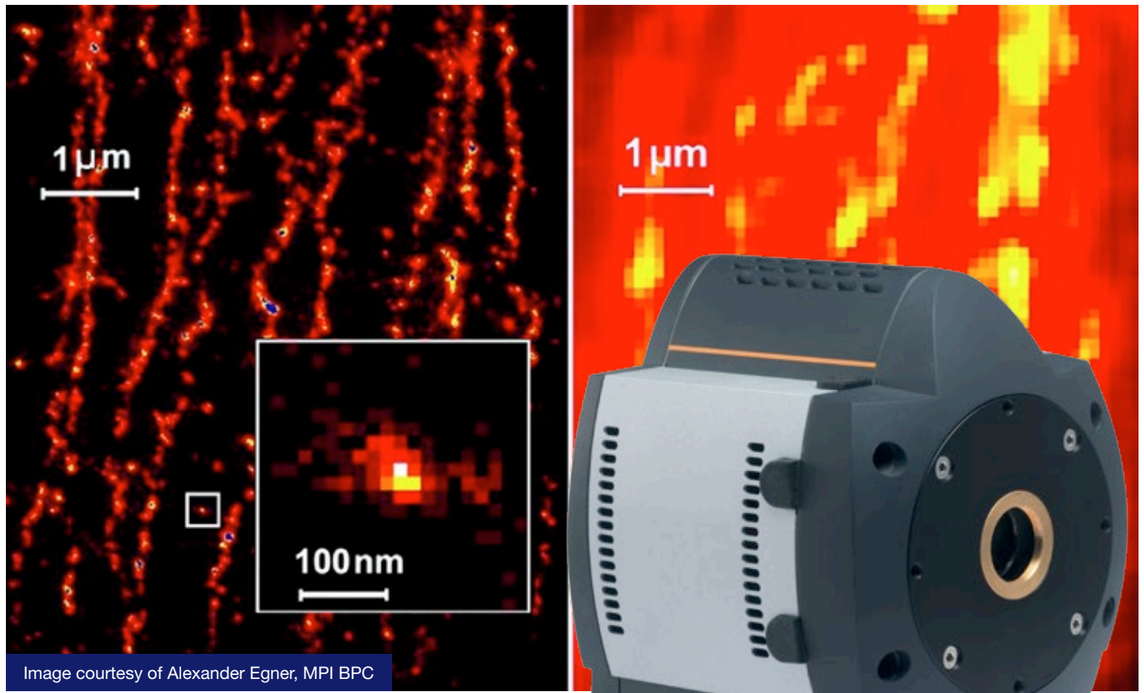


Image courtesy of Alexander Egner, MPI BPC

Andor's iXon3 860 back-illuminated EMCCD is designed for dedicated rapid imaging of low light events, without use of Region of Interest (ROI). The 128 x 128 sensor of the iXon3 860 combines > 500 fps frame rate with single photon detection capability and > 90% Quantum Efficiency.

Thermoelectric cooling down to -100°C minimizes EM-amplified dark current, whereas industry fastest vertical shift speeds minimize both clock induced charge noise and vertical smear during frame transfer. The absolute EM gain multiplication can be varied linearly from unity up to a thousand times directly via RealGainTM, a true quantitative EM gain scale.

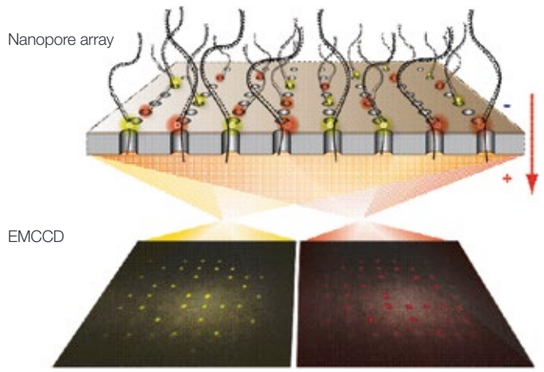
Sub-millisecond biology is readily accessible through use of sub-array selection and pixel binning. The speed and sensitivity of the 860 also renders it ideal for adaptive optics.

Key Specifications	
Active pixels	128 x 128
Pixel size (w x h; µm)	24 x 24
Image area (mm)	3.1 x 3.1
Active area pixel well depth (e)	160,000
Max readout rate (MHz)	10
Frame rates (fps)	513 (full frame) up to several thousands
Read noise (e^-)	48 @ 10 MHz < 1 with EM gain
QE max	> 90%

Key Applications
Single Molecule Detection
Calcium Flux
Voltage Sensitive Dyes
Adaptive Optics
FRET
Fluorescence Correlation Spectroscopy (FCS)

Specification sheets available at andor.com/ixon

Features and Benefits	
513 full fps	Fast frame rates ideal for ion signaling microscopy and adaptive optics.
TE cooling to -100°C	Critical for elimination of dark current detection limit.
RealGain™	Absolute EMCCD gain selectable directly from a linear and quantitative scale.
OptAcquire™	Optimize the highly flexible iXon3 for different application requirements at the click of a button.
Count Convert	Quantitatively capture and view data in electrons or incident photons. Applied either in real time or post-processing, Count Convert does this important conversion for you.
iCam	Exposure time fast switching provides market leading acquisition efficiency.
UltraVac™	Critical for sustained vacuum integrity and to maintain unequalled cooling and QE performance, year after year.
Crop Mode	Specialized acquisition mode for continuous imaging with fastest possible temporal resolution.
Spurious Noise Filter	Intelligent algorithms to filter clock induced charge events from the background. Real time or post-processing.
Enhanced photon counting Modes	Intuitive single photon counting modes to overcome multiplicative noise. Real time or post-processing.
Superior Baseline Clamp and EM stability	Essential for quantitative accuracy of dynamic measurements.



Schematic diagram of the single molecule Optipore sequencing method, with an illustration of the 'enzyme-free' nanopore array through which DNA strands are electrophoretically drawn. iXon3 860 cameras were used to capture two color sequencing data at 1000 fps.

Courtesy of Professor Amit Meller, Department of Biomedical Engineering and Physics, Boston University, USA

> The use of the highly sensitive and ultra-fast back-illuminated iXon 860 EMCCD is central to our high-speed single molecule gene sequencing method, as we rely on fast multi-color optical readout from many nanopores simultaneously.
>
> Prof Amit Meller, Associate Professor of Biomedical Engineering and Physics, Boston University, USA

Performance & Innovations

Industry Fastest Frame Rate

Maximum frame rate performance in EMCCDs is a function of two parameters; (1) Pixel Readout Speed (horizontal); (2) Vertical Clock speed.

The former dictates how rapidly charge is pushed horizontally through the EM gain register and the remaining readout electronics, while the latter dictates the speed at which charge is vertically shifted down through both the exposed sensor area and masked frame transfer area of the chip.

iXon offers industry fastest vertical shift speeds, resulting in faster frame rates and reduced smearing, significantly faster under commonly employed conditions of sub-array/binning.

Notably, the iXon Ultra 897 overclocks the pixel readout speed from the standard 10 MHz to 17 MHz, further boosting the frame rate by >60%, yielding 56 fps (full frame). The new iXon Ultra 888 takes this a big step further, thrusting clock speed to 30 MHz! This permits video rate frame rate from this large field of view sensor, and enables as fast as 93 fps from a 512 x 512 ROI in Crop Mode.

Key Features

- iXon Ultra overclocked up to 30 MHz pixel readout speed: 3x faster full frame rate
- Fastest vertical shift speeds yield further speed gains with ROI / binning
- Minimized smearing through faster vertical shifts
- 'Optically Centered Crop Mode' for industry fastest ROI speeds, ideal for live cell super-resolution microscopy

Pushing Frame Rates with Crop Mode

The OptoMask enables faster frame rates in Crop Mode

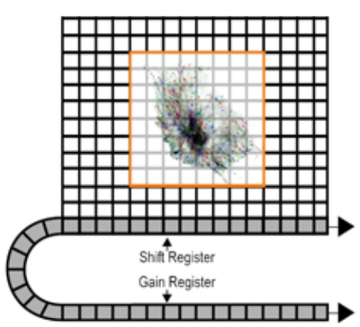
Through this acquisition mode, significant increases in frame rates are accomplished by "fooling" the sensor into thinking it is smaller than it actually is. In standard sub-array/ ROI readout mode each frame still carries the time overhead to readout all pixels to the left and right of the selected area and to vertically shift all pixels above and below the selected area. The charge from these pixels is then dumped before an image is sent from camera to PC. In Crop Mode, the number of pixel readout steps outside of that required to read out the requested sub-array is significantly reduced, resulting in markedly higher frame rates.

However, this mode requires that light is not allowed to fall onto the area of the sensor outside of the defined active sub-area. In optical microscopy, this can be realized in conjunction with the new OptoMask accessory, which inserts easily between the microscope output and the camera. Using the OptoMask, a sub-array can be readily defined through positioning of the masking blades, and a cropped area matched to this in software.

Crop Mode

The active imaging area of the sensor is defined in a way that only a small section of the entire chip is used for imaging.

The remaining area has to be optically masked to prevent light leakage and charge spill-over that would compromise the signal from the imaging area. By cropping the sensor, one achieves faster frame rates because the temporal resolution will be dictated only by the time it requires to read out the small section of the sensor.



Optically Centered Crop Mode: Enabling Live Cell Super-Resolution

The iXon Ultra now comes with 'Optically Centered Crop Mode', which gives the user the option to break away from the corner tethered requirement of standard crop mode and select a number of pre-defined ROIs that are located in the centre of the image field.

This is achieved with only minimal sacrifice in achievable frame rate, for example a 128 x 128 optically centered ROI delivering 697 fps. Optically centring of the ROI makes this mode extremely appealing to a number of microscopy techniques, including 'pointillism' live cell super-resolution microscopy.

For example, the camera can be operated in full 512 x 512 resolution at a frame rate suited to generation of fixed cell super-resolved images, then Optically Centered Crop Mode can be invoked with a 128 x 128 ROI for generation of super-resolved live cell images showing dynamic events.

Key Features

- iXon Ultra overclocked up to 30 MHz pixel readout speed: 3x faster full frame rate
- Fastest vertical shift speeds yield further speed gains with ROI / binning
- Minimized smearing through faster vertical shifts
- 'Optically Centered Crop Mode' for industry fastest ROI speeds, ideal for live cell super-resolution microscopy

251

The **iXon Ultra 888** can achieve a blistering **251 fps from a 256 x 256 ROI** in **Optically Centered Crop Mode.**

Binning	512 x 512	256 x 256	128 x 128	64 x 64	1024 x 100	1024 x 32	1024 x 1
1 x 1	93 (78)	190 (251)	670 (697)	2,053 (1,319)	259	778	9,690
2 x 2	170 (143)	350 (426)	1,150 (1,019)	3,123 (1,646)	492	1,416	-
4 x 4	291 (245)	601 (653)	1,772 (1,504)	4,109 (1,857)	887	2,370	-

Frame rates achievable by the iXon Ultra 888 in Crop Mode - 'Optically Centered Crop Mode' frame rates in brackets

Count Convert

iXon offers the capability to quantitatively capture and present data in units of electrons or photons, this important conversion is applied either in real time or as a post-conversion step.

The standard way to present quantitative data in scientific detectors has been in units of 'counts', relating to the digitized steps of the Analogue to Digital Converter (ADC) used in the camera. Each Analogue to Digital Unit (ADU) relates to a precise number of 'photo-electrons' that were generated originally from photons striking and being captured by the detector pixel.

In the iXon, this conversion factor is very accurately recorded within the camera. Knowing this value, alongside the EM gain (RealGainTM) and baseline (bias) offset, facilitates back calculation from the signal in ADU counts per pixel to the signal in electrons per pixel. Furthermore, knowledge of the Quantum Efficiency (QE) and light throughput properties of the camera at each wavelength enables this process to be taken a step further, allowing the signal to be estimated in photons incident at each pixel, provided the spectral spread of the signal is not too broad.

The Count Convert functionality of the iXon provides the flexibility to acquire data in either electrons or incident photons, with negligible slow down in display rate. Furthermore, the option exists to record the original data in counts and perform this important conversion to either electrons or photons as a post-conversion step, while retaining the original data.

Key Features

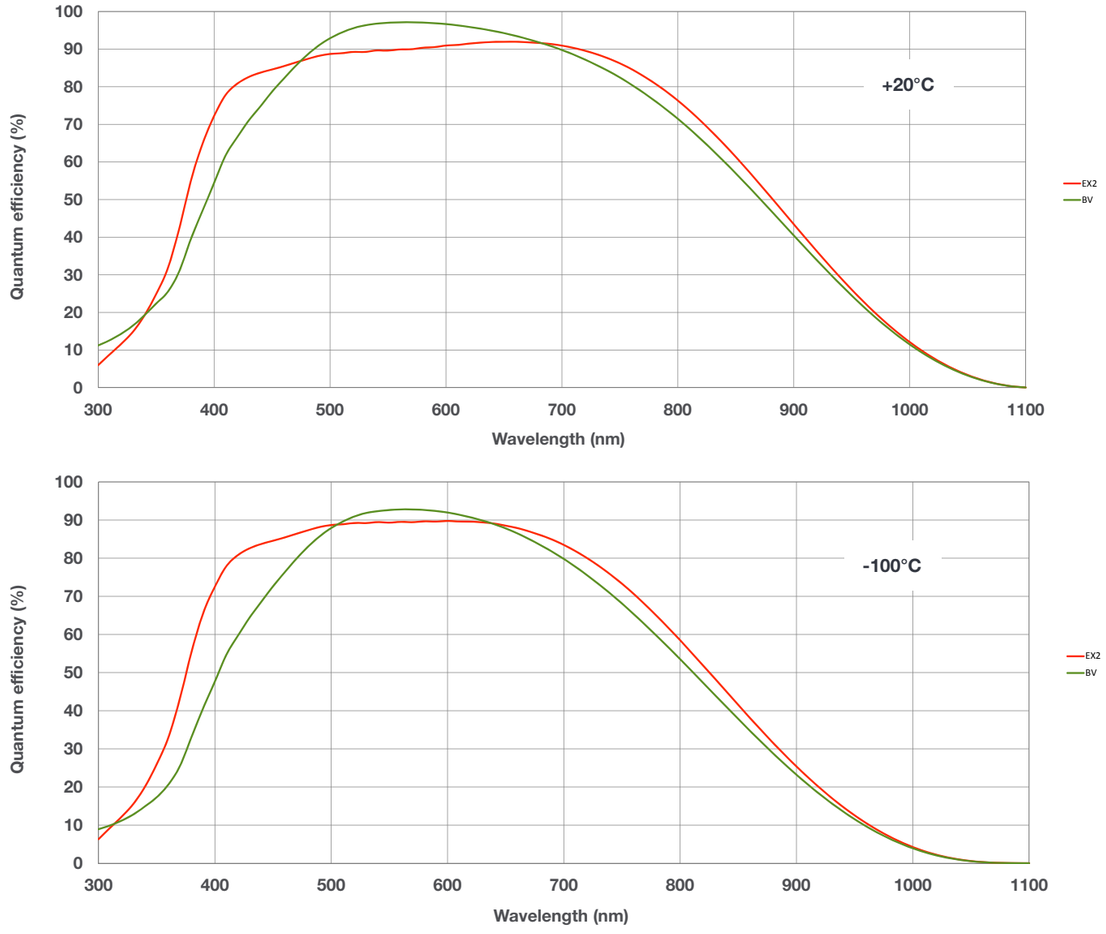
- Quantify data in electrons or incident photons
- Convenient estimate of sample signal intensity at the detector
- Real time or post-convert
- Reference between different samples, users and set-ups
- Meaningful signal relating to PALM/STORM localization accuracy

Performance & Innovations

EX2 Technology – Extended QE from Dual AR sensor coating

Selected iXon models are now available with a new Dual Anti-Reflection coating applied to the back-illuminated sensor, affording a significant enhancement of the Quantum Efficiency performance.

Available on the new speed-boosted iXon Ultra 897 and 888 models, EX2 technology facilitates broadening of the QE range of the back-illuminated sensors through implementation of a new dual AR coating process, developed by sensor manufacturer e2v. The net effect is to offer significantly improved sensitivity in both the blue and NIR wavelength regions, whilst maintaining ~ 90% QE across the remainder of the visible region.



Back-illuminated EMCCD sensor QE curves, comparing standard 'BV' mid-band AR coating versus new EX2 dual AR coating. Reference data available at +20°C and -100°C sensor cooling temperatures.

Fringe Suppression Sensors

Selected iXon models are now available with a new Fringe Suppression property in the sensor design, reducing spatial etaloning effects that can arise through monochromatic imaging in the Near Infra-Red (NIR) wavelength range.

Etaloning is particular to back-illuminated sensors and is caused by interference between reflections off the front and back parallel sensor surfaces. For NIR applications, such as imaging of Bose Einstein Condenates, etaloning effects, often observed more notably beyond ~ 750 nm, can sometimes restrict the ability to perform high integrity quantitative imaging.

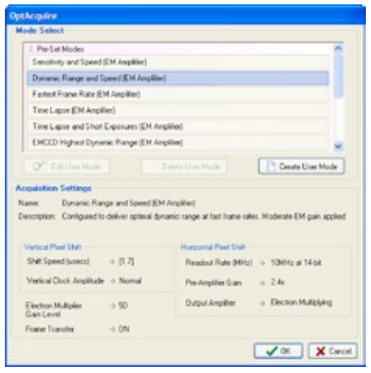
Fringe Suppression refers to a sensor design modification that significantly reduces the amplitude of etaloning effects. The design has been implemented by sensor manufacturers e2v and based on a tried and trusted process, successfully validated over several years of CCD manufacture. Fringe Suppression is available on iXon Ultra 897 and 888 models.

> We have successfully used Andor iXon cameras for many years for super-resolution microscopy, the resolution and sensitivity of these cameras is exceptional.
>
> Dr. Mike Heilemann, Institute of Physical and Theoretical Chemistry, Goethe-University, Germany

OptAcquire – Flexibility need not be complicated

The control architecture of the iXon is extremely flexible, meaning the camera can be adapted and optimized for a wide variety of quantitative experimental requirements, ranging from single photon counting through to slower scan, 16-bit Dynamic Range measurements. However, we are starkly aware that optimizing EMCCD technology is far from trivial, with various set-up parameters influencing and trading off between different camera performance characteristics. We have developed OptAcquire, a unique interface allowing users to conveniently choose from a predetermined list of camera set-up configurations.

The user need only choose how they would like their camera to be optimized, e.g. for 'Sensitivity and Speed', 'Dynamic Range and Speed', 'Time Lapse'. Parameters such as EM gain value , vertical shift speed, vertical clock amplitude, pre-amp sensitivity and horizontal readout speed will then be optimized accordingly, 'behind the scenes'. Furthermore, the option exists to create additional user-defined configurations.



16-bit

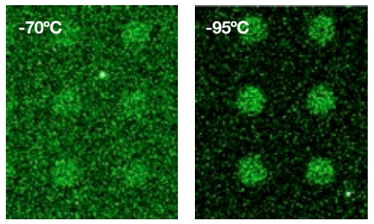
The **iXon's** flexibility ranges from single photon counting through to slower scan, **16-bit Dynamic Range measurements**.

Key Features
Convenient 'one-click' set-up
Opens the market leading flexibility of the iXon to less advanced users
Optimize for range of experimental requirements
Create additional user defined modes

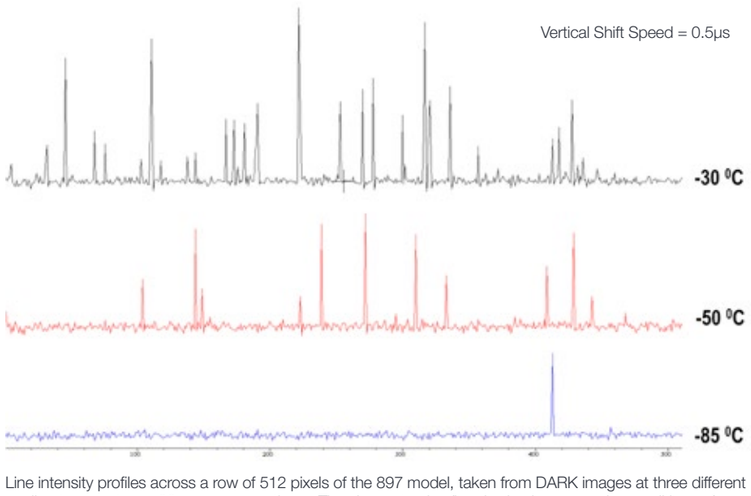
Performance & Innovations

Deep Thermoelectric Cooling

Single thermal electrons are amplified by the EMCCD gain mechanism. Deep vacuum TE cooling is critical to optimize the sensitivity performance of EMCCD sensors, otherwise the raw sensitivity will be compromised, even under conditions of short exposures.



Images of extremely weak LED signal (signal intensity typical of weak luminescence experiments) acquired with iXon3 888 at cooling temperatures -70ºC and -95ºC (water cooling to achieve latter), 120 sec exposure times, sub-region show. The need to push to such deeper cooling temperatures can be readily observed under such extreme low light conditions.



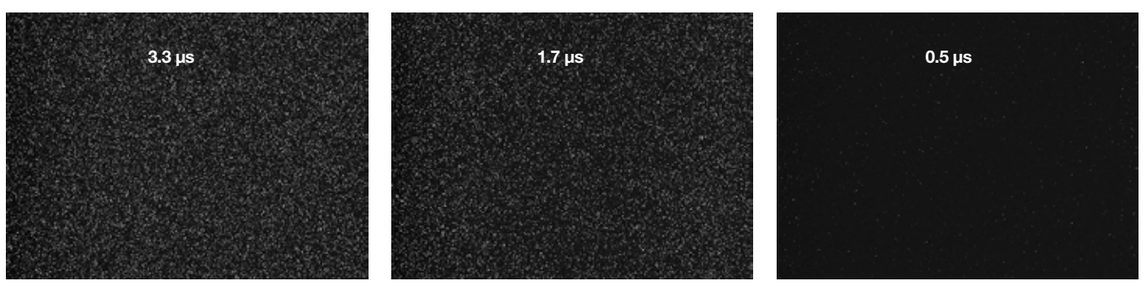
Line intensity profiles across a row of 512 pixels of the 897 model, taken from DARK images at three different cooling temperatures, 29 ms exposure times. The cleanest noise floor is clearly seen under conditions of deep cooling, even for such short exposure times.

Key Features

Cooling down to -100ºC
Lowest EM-amplified dark current
Fewer pixel blemishes (hot pixels)
Low power consumption vacuum cooling

Minimized Clock-Induced Charge

After having minimized dark current through deep cooling, the remaining detection limit in back-illuminated EMCCDs is given by the number of Clock-Induced Charge noise events. Andor's industry-exclusive combination of high resolution clocking parameters and sub-microsecond clock speeds are fundamental to minimizing CIC, enabling truly 'high-end' EMCCD sensitivity to be claimed.

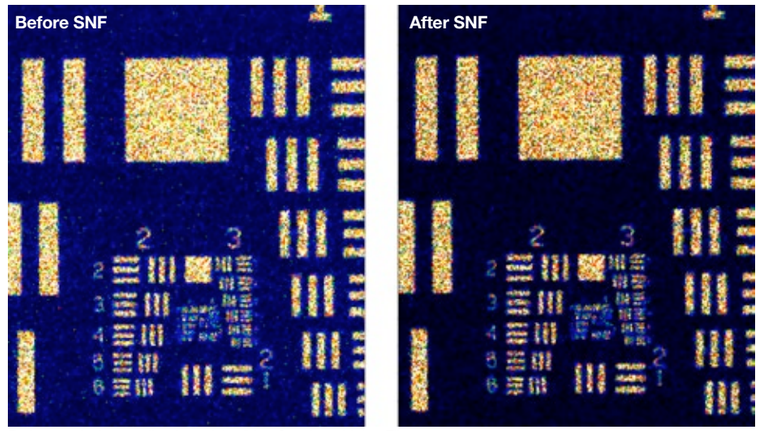


DARK IMAGES taken with the iXon3 897 at x1000 gain at different vertical shift speeds, 29 ms exposure time. Cooling temperature was -85ºC to ensure minimal dark current contribution.

Spurious Noise Filter

It can still be desirable to optionally filter the remaining spurious noise (Clock-Induced Charge or photons) to give as 'black' a background as possible, eradicating any remaining 'salt and pepper' noise. It is important to utilize noise selection and filter algorithms that are intelligent enough to accomplish this task without impacting the integrity of the signal itself.

This is realized through the new Spurious Noise Filter (SNF) functionality of iXon, which offers the user a choice of advanced algorithms to try. SNF can be applied either in real time or as a post-processing step.



Before and after application of the iXon Spurious Noise Filter

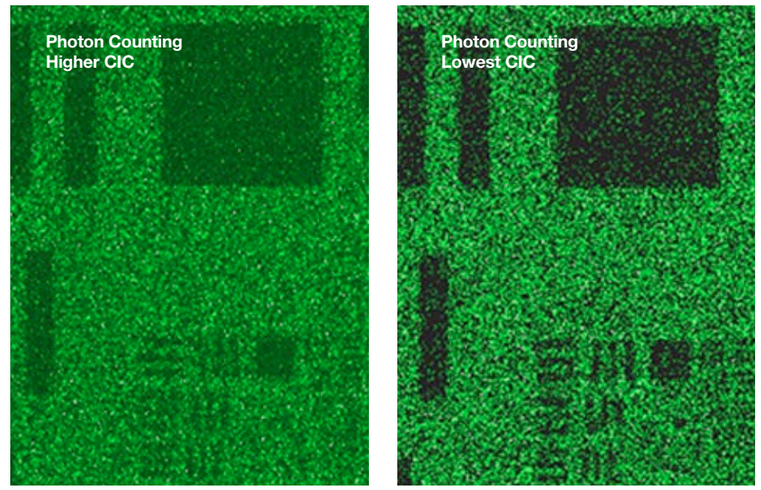
Enhanced Photon Counting

To successfully photon count with EMCCDs, there has to be a significantly higher probability of seeing a 'photon spike' than seeing a dark current/CIC 'noise spike'.

The iXon Ultra 897 combines deepest thermoelectric cooling and low CIC performance, yielding market leading photon counting performance and higher contrast images.

Real-time and post process photon counting...

The advanced photon counting modes of the iXon allow for both real time and post-process photon counting. The latter offers the flexibility to 'trial and error' photon count a pre-recorded kinetic series, trading-off temporal resolution vs SNR.



Performance & Innovations

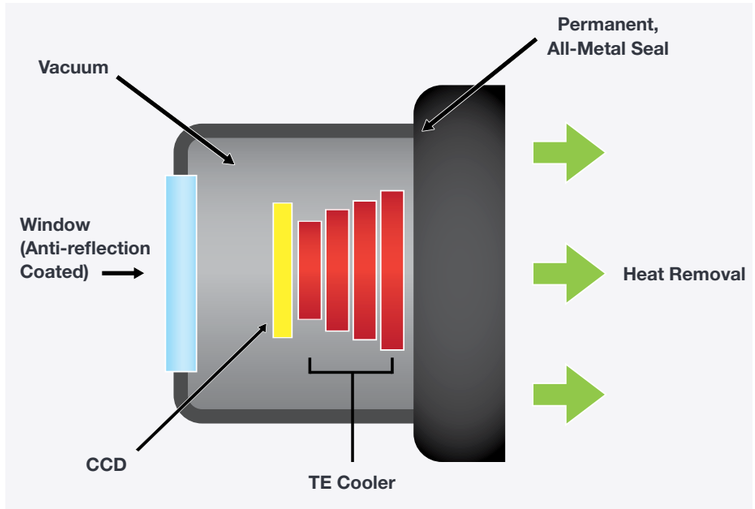
UltraVac™ Permanent Vacuum Head

It is important that a back-illuminated sensor is housed in a hermetically sealed permanent vacuum head with minimized outgassing, otherwise both cooling performance and the sensor QE will steadily degrade. It is this compelling reason that drove Andor to develop UltraVac.

Andor's proprietary UltraVac process has a proven track record of field reliability, accumulated over more than 15 years of shipping high-end vacuum cameras. UltraVac also enables use of only one input window, improving photon-throughput by 8%.

Key Features

No QE degradation
Sustained deep TE cooling
No maintenance / re-pumping
One input window
No condensation



Schematic of a Permanent Vacuum Head

Seven Year Vacuum Warranty

Unlike other vacuum EMCCDs on the market, the iXon family has now been shipping with a vacuum enclosed sensor for almost 10 years, with statistical data that substantiates our extremely robust vacuum claims. With the iXon, Andor are proud to offer an extended 7 year warranty on the vacuum enclosure as standard.

RealGain™, Anti-Ageing and EMCAL™

In early 2006, Andor once again raised the bar by introducing some significant new technology innovations. These particular pioneering steps, were to set new high standards in quantitative EMCCD usage and general EMCCD longevity expectations, which others in the industry are now adopting.

RealGain™
Select absolute EM gain direct from a linear and directly quantitative software scale, x1 to x1000. The EM gain you ask for is the EM gain you get.

Anti-Ageing
Internally configured to significantly inhibit saturation-induced decay of EM gain.

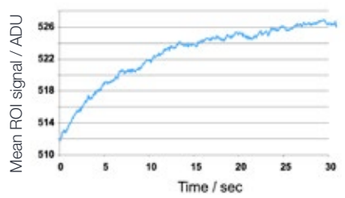
EMCAL™
Innovative user-initiated self-recalibration of EM gain, utilizing a patented method of automated EM gain assessment and Andor's unique Linear and Real Quantitative gain implementation.

Temperature Compensated
Calibration holds across all cooling temperatures. No need to recalibrate on each use in multi-user laboratories and facilities.

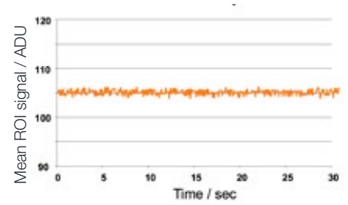
Superior Quantitative Stability

The iXon is well regulated in terms of both Baseline (bias offset) rigidity and superior EM gain stability, lending for enhanced quantitative reliability throughout and between measurements.

Baseline Clamp OFF

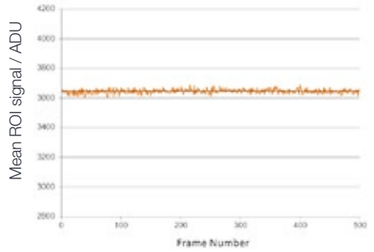


Baseline Clamp ON



iXon Baseline Clamp (bias stability) in operation

EM Gain Stability



EM Gain stability in the iXon Ultra 897 @ 55 fps. 500 frame kinetic series; frame transfer (overlapped) acquisition; 17.8 ms exposure time; x300 EM Gain.

Direct Data Access (iXon Ultra)

Under standard operation the iXon Ultra uses the USB interface (USB 2.0 or USB 3.0, model dependent) for all control and data transfer with the PC. However, some users require a more direct access to the image data stream, in order that they can perform real-time analysis, possibility using external hardware. Such operation can be particularly important for rapid closed feedback applications such as adaptive optics. Direct real time access to data can also be useful for data intensive applications such as super-resolution microscopy or whole genome sequencing, whereby it can be desirable to carry out real time processing of data on an external GPU, for example.

In order to facilitate such functionality, the iXon Ultra includes an additional Camera Link output port. The Camera Link channel intercepts the image data stream in the camera head immediately after the on-head FPGA processing step, but before the USB frame buffer, therefore undergoes the same amount of on-head image processing.

Key Features

Direct Data Access via Camera Link output
Minimal latency or jitter
USB data stream concurrently accessible
Compatible with any Camera Link card interface
On-the-fly data processing
Ideal for closed loop feedback systems, such as adaptive optics

Performance & Innovations

‘2 in 1’ Performance - EMCCD and CCD

Three of the back-illuminated iXon models offer ‘2 in 1’ performance flexibility, in terms of operating as a single photon EMCCD or a low noise conventional CCD, readily user selectable through software selection. Such versatility is attractive in laboratories that can require the camera to operate in low light conditions under both fast and slow frame rates.

In photon starved applications, choosing the EMCCD amplifier usually yields better signal to noise ratio when under faster frame rates conditions (> 1 fps), whereas often the CCD amplifier can yield better signal to noise ratio when longer exposures can be applied and when the sensor can be read out slowly (i.e. ‘seconds per frame’ rather than ‘frames per second’).

This a rule of thumb guide however, and often the choice of amplifier depends ultimately on the light levels available during desired exposure time. Usually it is worth experimenting with the CCD amplifier if the temporal demands are sufficient to readout the sensor at 1 MHz or slower.

Signal to Noise plots, comparing EMCCD mode at any readout speed vs CCD mode at 1 MHz and 80 kHz readout speeds (the latter exclusive to iXon Ultra 897). Higher signal to noise can be secured with the 80 kHz CCD amplifier for light levels greater than 12 photons/pixel, but note that this corresponds to a max frame rate of 0.3 fps.

EMCCD	CCD
✓ Single photon sensitive	× 3 to 6 e- read noise
× Multiplication noise	✓ No Multiplication noise
✓ Faster frame rates possible	× Restricted to slower frame rates

The basic trade-offs between EMCCD and conventional CCD amplifiers

Software Solutions

Andor Solis
Solis is a ready to run Windows package with rich functionality for data acquisition and image analysis/processing. Available on 32-bit and 64-bit versions of Windows (XP, Vista, 7 and 8). Andor Basic provides macro language control of data acquisition, processing, display and export.

Andor iQ
A comprehensive multi-dimensional imaging software package. Offers tight synchronization of EMCCD with a comprehensive range of microscopy hardware, along with comprehensive rendering and analysis functionality. Modular architecture for best price/performance package on the market.

Andor SDK
A software development kit that allows you to control the Andor range of cameras from your own application. Available as 32 and 64-bit libraries for Windows (XP, Vista, 7 and 8) and Linux. Compatible with C/C++, C#, Delphi, VB6, VB.NET, LabView and Matlab.

Bitplane Imaris®
Imaris delivers all the necessary functionality for visualization, segmentation and interpretation of multidimensional datasets. By combining speed, precision and intuitive ease-of-use, Imaris provides a complete set of features for handling multi-channel image sets of any size up to 50 gigabytes.

Third party software compatibility
Drivers are available so that the iXon range can be operated through a large variety of third party imaging packages, including:

Metamorph (Molecular Devices Corporation)
NIS Elements (Nikon)
LAS (Leica)
Xcellence (Olympus)
Image Pro (Media Cybernetics)
MicroManager (UCSF)
Till Photonics Live Acquisition (Till Photonics)
Imaging Workbench (Indec)
WinFluor (University of Strathclyde)
Maxim DL (Diffraction Limited)
LabView (National Instruments)
Matlab (MathWorks)

Extensive Imaging Portfolio

The Andor Imaging Range

Have you found what you are looking for? As an alternative to the iXon series, Andor offers an extensive portfolio of high performance low light imaging camera technologies.

iKon CCD **Deep cooled, low noise CCD**
-100ºC cooling
Back-illuminated > 90% QE
1 Megapixel to 4 Megapixel
Enhanced NIR versions
'PV Inspector' model (Optimized for EL / PL in-line inspection)
USB 2.0 true plug and play

Clara Interline CCD **High performance interline CCD**
Industry lowest interline read noise (2.4 e^-)
-55ºC fan cooled; -40ºC vibration free mode
1.4 Megapixel
USB 2.0 true plug and play

iXon EMCCD **High performance EMCCD platform**
Single photon sensitive and back-illuminated
Industry fastest frame rates
-100ºC cooling
Flexible yet intuitive
Quantify in electrons or photons

Neo sCMOS **Vacuum cooled, lowest noise sCMOS**
1 electron read noise @ 30 fps
5.5 Megapixel / 6.5 µm
-40ºC vacuum cooling
30 fps sustained; 100 fps burst
4 GB on head memory
16-bit data range
Fan off vibration free mode

Zyla sCMOS **Fast, sensitive, compact, light sCMOS**
1 electron read noise @ 30 fps
5.5 and 4.2 Megapixel sensors / 6.5 µm
0ºC cooling at +35°C ambient
100 fps sustained (10-tap Camera Link)
Cost effective USB 3.0 option
16-bit data range

Application & Technical Notes

Andor's high-performance EMCCD cameras have been the technology favorite of the vast majority of EMCCD-enabled laboratories across the globe.

The following section is dedicated to providing a greater depth of understanding of the performance innovations underlying the iXon family of high-end EMCCD cameras, outlining the core technical reasons why Andor is still very much considered the EMCCD industry leaders, notably so in the key areas of sensitivity, speed, stability, longevity, quality and accessibility.

Visit the Learning Center now to discover more at andor.com/learning.

Key iXon Resources include:

- Maximizing frame rate performance in EMCCDs
- UltraVac™ permanent vacuum head and performance longevity
- Count Convert - Quantifying data in Electrons and Photons
- New EMCCD Sensor Enhancements: Extended QE and Fringe Suppression
- Deep Vacuum TE Cooling and Darkcurrent Elimination
- Minimizing Clock Induced Charge - finesse charge clocking
- iXon Ultra Camera Link Output for Direct Data Access
- RealGainTM, Anti-Ageing and EMCAL™
- Making Sense of Sensitivity
- iXon Ultra and iXon3 Trigger Modes

ANDOR
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Customer Support

Andor products are regularly used in critical applications and we can provide a variety of customer support services to maximize the return on your investment and ensure that your product continues to operate at its optimum performance.

Andor has customer support teams located across North America, Asia and Europe, allowing us to provide local technical assistance and advice. Requests for support can be made at any time by contacting our technical support team at andor.com/support.

Andor offers a variety of support under the following format:

- On-site product specialists can assist you with the installation and commissioning of your chosen product
- Training services can be provided on-site or remotely via the Internet
- A testing service to confirm the integrity and optimize the performance of existing equipment in the field is also available on request.

A range of extended warranty packages are available for Andor products giving you the flexibility to choose one appropriate for your needs. These warranties allow you to obtain additional levels of service and include both on-site and remote support options, and may be purchased on a multi-year basis allowing users to fix their support costs over the operating life cycle of the products.

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