

Cameras for Astronomy

Unparalleled flexibility and functionality



ANDOR CAMERAS FOR ASTRONOMY

Andor is the partner of choice for professional astronomers first and foremost due to the quality of our cameras. It places into the hands of the user a tool of unparalleled flexibility and functionality, which has been built into a robust and reliable framework. The hardware and software design allows seamless integration into a system of any complexity. It is therefore no surprise that when looking for a cutting edge, reliable camera to operate in some of the world's most challenging conditions and sites, people look to Andor.

Why 'off-the-shelf'?

Increasingly the Astronomy market is looking for robust 'off-the-shelf' cameras to provide ease-of-use solutions.

Andor provides the ideal solution. Our highend scientific cameras provide a bespoke level of quality and performance. This releases the astronomer from the burden of camera support and maintenance, enabling an uninterrupted focus on research. Our cameras can be found in some of the most challenging environments for astronomers on the planet. This includes Antarctica, high-altitude mountains and even at the very edge of space. Wherever they are used they deliver what Andor has become famous for: maintenancefree, high-quality performance.

Increasingly in modern astronomy, evolving applications are driving detector requirements, leading to the need to provide not only quality cameras but a range of camera types. At Andor we have created a portfolio of products aimed at the provision of camera solutions for the widest possible range of optical astronomical applications. Whether the application is surveying star fields for exoplanets with the lowest noise, highest QE CCD; fast-frame adaptive optical systems using EMCCDs to maximise low flux from natural guide stars; or mapping the surface interplay of the sun's titanic furnace across the corona in high spatial and temporal resolution with an sCMOS camera, we offer a solution, if not several.

ANDOR DRIVEN TO EXCEL

We say we are driven; not only do we continually seek new challenges, we strive to improve what we presently offer. The most important motivation for this drive is the Andor user community.

Andor's Innovation



ANDOR

NGINEERING

Andor's Added Value

At Andor we have an integrated approach, a focus on the parts that combine to create the optimal whole. We apply this approach to both our company and our products. This ethos as a company, along with our drive to excel, has imbued our market leading products with innovation, quality and reliability. We continue to grow and develop, building on the bedrock of experience and knowledge gained from over 20 years as a market leading company.

2013

hch of Zyla xpanding the S range with h QE sensor option

CONSTELLATIONS OF ANDOR CAMERAS

Which type of camera do I need?

To help you choose we have listed the main attributes of the three different camera types along with some suitable applications.

sCMOS Fast and Large!

Typical Applications

Applications that require a Large Field of View; on top of Fast Frame Speckle Imaging, Exoplanets, Rate, Low Noise, Temporal and High Spatial Resolution.

Solar Astronomy, Lucky Imaging, Near Earth Objects [NEO]







EMCCD TECHNOLOGY

Many areas of astronomy are placing unprecedented demands on detector technology. The significantly higher levels of sensitivity and speed that EMCCD technology offers are key requirements for adaptive optics applications. However, over recent years the EMCCD has grown in popularity and is now used as a primary imager.

iXon Ultra

ANDOR

EMCCDs operate by amplification of weak signal events 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. Back-illuminated sensors offer greater than 90% Quantum Efficiency (QE).

The single photon sensitivity of EMCCDs renders them unbeatable in the low light regime of few to tens of incident photons per pixel. This may sound very low, but there are a surprising amount of applications that fall within this light intensity regime. This is especially true when you also consider speed or temporal resolution requirements, which are increasingly pushing for faster frame rates in the applications used in astronomy today.

EMCCD initially earned acceptance in the astronomy community primarily as a Wave Front Sensor, where the characteristic fast frame rate and unrivalled sensitivity drove the development of the early generations of AO systems. The mature AO market today is still dominated by the iXon3 860, due to it's speed and flexible binning. Increasingly, with the rising popularity of Lucky and Speckle imaging techniques, we are seeing a surge in usage of EMCCD cameras as the primary scientific cameras. The ability to differentiate the smallest signal from the noise, alongside frame rates fast enough to freeze the effects of atmospheric seeing, pushes the detection limits on a range of exciting applications, most notably exoplanets and Gamma Ray Bursts.

Fig. 1 Atmospheric Seeing iXon Ultra 888

iXon Ultra 897

iXon3 860









(Images for illustration only)

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iXon **EMCCD** Range

The iXon portfolio encompasses a number of model variations, offering solutions for a wide range of application requirements. Whether your ultrasenstive requirements need further refinement by demands on speed, resolution, field of view or wavelength dependence, the iXon series of market-leading EMCCD cameras will provide a solution.

iXon Series

Overview			
	iXon Ultra 888	iXon Ultra 897	iXon3 860
Requirement	Largest Field of View EMCCD Supercharged!	Ultimate SensitivitySupercharged	Lightning Speed and Sensitivity
Pixel format	1024 x 1024	512 x 512	128 x 128
QE options	BV, EX2, UVB	EX2, BV, UVB	EX2, BV, UVB
Pixel size	13 µm	16 µm	24 µm
Frame rate	26fps (670 fps with 128x128 cropped mode)	56 fps (595 fps with 128 x 128 cropped mode)	513 fps (1044 fps with 64 x 64 cropped mode)

Relative Fields of View of iXon Sensor Types



The Andor camera was important to our experiment because the iXon's electron multiplication and binning abilities allowed us to operate at an effective speed and derive spatial information. The camera features allowed us to discover new, previously unobserved types of flickering aurora.

Dr. Takeshi Sakanoi

Why choose Andor's iXon high performance EMCCD?

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 -100°C deep cooling and complete protection of the sensor.

The iXon Ultra and iXon3 series are designed to be the most flexible yet easy to use EMCCDs on the market. They can be optimized 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, brandishing an unparalleled track record of reliability in the field.

The iXon series provides the full range of EMCCD sensors packaged in a versatile platform benefitting from an advanced feature set. This includes OptAcquire, Count Convert, Spurious Noise Filters, Cropped Sensor Mode, Signal Averaging and Enhanced Photon Capability. The EMCCD is managed and optimised by the patented functions EMCAL and RealGain, providing sustained quantitative EM gain calibration, a critical requirement for scientific cameras.



Features	Benefits
EX2 technology	Extended QE response
TE cooling to -100°C	Critical for elimination of dark current
Fringe suppression	Reducing etaloning in NIR
Cropped sensor mode	Specialized acquisition mode for continuous imaging with the fastest possible temporal resolution
iCam	Market-leading exposure time fast-switching
UltraVac™	Critical for sustained vacuum integrity
Selectable amplifier	'2 in 1' flexibility Con and EM amplifier
Baseline clamp and stability	Quantitative accuracy of dynamic measurements

iXon Ultra 888

Largest Field of View EMCCD...Supercharged!

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. The conventional mode's extremely low noise offers the capability to use as a standard CCD, making two cameras in one a reality.

With a 1024 x 1024 sensor format and 13 μ m 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 speckle imaging, AO with direct data access and other high time resolution astronomy.

Key Specifications	
Active pixels	1024 x 1024
Pixel size (µm)	13 x 13
Image area (mm)	13.3 x 13.3
Active area pixel wall depth (e [.])	80,000
Max readout rate (MHz)	30
Readout noise (e-)	< 1 with EM gain
Frame rate (fps; full frame)	26



Wavelength (nm)





iXon Ultra 897

Ultimate Sensitivity...Supercharged!

Facilitated by a fundamental redesign, the new iXon Ultra platform takes the popular back-illuminated 512 x 512 frame transfer sensor and overclocks readout to the quantitative limits of the sensor, 17 MHz, pushing speed performance to an outstanding 56 fps (full frame). The status of 'Ultimate Sensitivity' is also preserved in this model, offering thermoelectric cooling down to -100°C and extremely low clock induced charge noise. New EX2 Technology offers extended QE performance, maximizing the broadband response of the camera especially into the key NIR region.

Additional unique features of the iXon Ultra include USB connectivity and direct raw data access for on-the-fly processing, ideal for adaptive optics. EMCCD and conventional CCD

readout modes provide heightened application flexibility. A new 'low and slow' noise performance in CCD mode provides a real two-in-one option: the ability to perform both in short and long temporal domains without compromise.

The significant speed boost offered in the iXon Ultra 897 facilitates a new level of temporal resolution attainment. This is ideal for speed-challenged low-light applications such as Speckle Imaging, adaptive optics, Gamma Ray Bursts (GRB) and Lucky Imaging. The extremely low noise of the iXon Ultra 897, coupled with the new overclocked speed performance, will place this model at the forefront when it comes to upgrading any existing systems or building the latest cutting edge setup.







Key Specifications	
Active pixels	512 x 512
Pixel size (µm)	16 x 16
Image area (mm)	8.2 x 8.2
Active area pixel wall depth (e ⁻)	180,000
Max readout rate (MHz)	17
Frame rate (fps)	56
Read noise (e-)	89 @ 17 MHz 65 @ 10 MHz < 1 with EM gain
QE max	> 90% (EX2 available)





Fig. 1 Gravitation Microlensing

The gravitational lens effect created by a lens star (1) is used by the observer (2) to detect an orbiting exoplanet (3)

See EMCCD Case Study Two on p.19 for more details

iXon3 860

Lightning Speed and Sensitivity

The iXon3 860 is the smallest sensor with the largest pixel pitch. The camera in full frame can clock at 513 fps. However, with Andor's flexible control, offering binning and cropped mode operation, the full potential of the sensor can be unleashed, achieving amazing frame rates of up to 14,025 fps.

This incredible speed augment with the EM capability of the camera has made it the camera of choice for the AO community as a Wave Front Sensor [WFS]. To further enhance it's capabilities as a WFS we can supply an accessory splitter box, giving direct access to the raw data straight off the head.



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Key Specifications	
Active pixels	128 x 128
Pixel size (µm)	24 x 24
Image area (mm)	3.1 x 3.1
Active area pixel wall depth (e ⁻)	160,000
Max readout rate (MHz)	10
Read noise (e-)	< 1 with EM gain
Frame rate (fps; full frame)	513





The Van Gogh Sun

Mr. Kevin Reardon

INAF - Osservatorio Astrofisico di Arcetri, Italy

This image provides the most comprehensive view of the dramatic solar chromosphere yet obtained. The image was acquired using an array of nine Andor iXon EMCCD cameras 4

The image shows almost the entire array of 'chromospheric structures' - the dark sunspot and bright flare in the upper right, the bright magnetic network and dark filament running diagonally, and small brightenings from acoustic shocks scattered in the lower right.



EMCCD **Case Studies**

Flickering Aurora

High Temporal Resolution Measurement

The beautiful light displays known as aurora occur when energetic charged particles collide with atoms in the high-altitude regions of the atmosphere. One type of aurora, known as flickering aurora, rapidly fluctuates in a manner similar to the reaction of a candle's flame to a sudden draft of air.

Researchers from Tohoku University in Japan used an Andor iXon Electron Multiplying CCD (EMCCD) astronomy camera to learn more about flickering aurora. This type of aurora occurs only near the time of the auroral breakup, which is when the arcs of light rapidly grow brighter and twist into contorted shapes that sweep across the sky. Scientists believe that the generation of flickering aurora is related to auroral particle acceleration and wave-particle interactions that occur in the region where the Earth's magnetosphere and ionosphere meet. The magnetosphere is formed by the Earth's magnetic field interacting with and deflecting charged particles coming from the sun. The ionosphere is the upper part of the Earth's atmosphere that is ionized by solar radiation.

The researchers sought to better characterize the spatiotemporal characteristics of flickering With the EMCCD, the researchers were aurora. Field-aligned acceleration processes existing in the altitude range of several thousands of kilometers play a crucial role in the generation of auroras,' said Takeshi Sakanoi, who was part of the research team. 'Understanding these processes is one of the most important issues in our research field magnetosphere-ionosphere physics - as well as in fundamental plasma physics, which is used in, for example, plasma fusion.

study because of how fast they modulate and because of their weak intensity. Thus the researchers, led by Shoichi Okano, turned to an iXon EMCCD astronomy camera to allow them to observe the flickering aurora. 'The Andor camera was important to our experiment because the iXon's electron multiplication and binning abilities allowed us to operate at an effective speed and derive spatial information. The camera features allowed us to discover new, previously unobserved types of flickering aurora' Sakanoi said

However, flickering aurora are difficult to

The researchers made observations at the Toolik Field Station and the Poker Flat Research Range in Alaska during the winter. They used the iXon EMCCD astronomy camera with a 50 mm F1.2 lens and a 670 nm filter to measure allowed transition emissions from N2 1st positive band, operating at 100 Hz sampling rate. The field of view was 9.3° x 9.3°, which is about 16 x 16 km at 100 km altitude. They operated the EMCCD with a 64 x 64 pixel mode (8 x 8 binning for the entire 512 x 512 pixels).

able to acquire images of some new types of flickering aurora. They observed highfrequency events (greater than ~ 15 Hz, see figure), low-frequency events (less than ~ 15 Hz) with rotating features, and flickering stripes. They found that many of the flickering aurora events were in the high-frequency range

'With the advanced Electron Multiplying CCD technology, we could acquire auroral images with high temporal resolutions,' Sakanoi said. 'As a result, we found flickering auroral variation in a very high frequency range. These must be closely related to the acceleration process and should be helpful to understand it.



Fig. 1 This figure shows an example of a highfrequency auroral event. From top to bottom, (a) the dynamic spectrum of northsouth component, (b) east-west component of ELF magnetic field data, (c) dynamic spectrum of Electron Multiplying CCD image data averaged at the center 16 pixels, (d) Electron Multiplying CCD keogram of north-south direction. (e) 2DFFT dynamic spectrum of north-south and (f) east-west directions. Image reproduced by permission of the American Geophysical Union from Ayumi Yaegashi et al, Spatial-temporal characteristics of flickering aurora as seen by highspeed EMCCD imaging observations, Vol. 116. A00K04.

Earth-like Exoplanets

Gravitational Microlensing

The fast readout speeds, negligible readout noise, high spatial resolution and photometric accuracy of Andor's ultrasensitive iXon 897 EMCCD cameras improve the chances of discovering planets outside our solar system.

The prospect of success in the search for Earth-like exoplanets capable of supporting life is being enhanced with the adoption of the Andor iXon 897 EMCCD camera. The ultra-sensitive EMCCD device was chosen by the Stellar Observation Network Group (SONG) following a study led by Kennet Harpsoe from the Centre for Star and Planet Formation in Copenhagen.

Kennet Harpsoe's SONG is building their global network of robotic one-metre telescopes around the ultra-sensitive iXon 897 EMCCD camera. The ground-breaking improvement in spatial resolution offered by the iXon 897 was also instrumental in Jesper Skottfelt's latest discovery of two new variable stars in the crowded central region of the globular cluster NGC 6981 (see Figure 1). SONG are delighted to be playing such a pivotal role.

This shows that the camera's ability to produce images at very high readout speeds and negligible readout noise, even at very low light levels, is ideal for their high frame rate application. The study also shows that this ground-breaking improvement in spatial resolution is not at the expense of photometric accuracy or stability and could improve significantly the photometry of faint stars in extremely dense fields by alleviating crowding.

'Rare gravitational microlensing events, where a star's gravitational field deviates the light from a background source, enable us to detect objects as small as an Earthlike exoplanet,' says Kennet Harpsoe of SONG. 'However, the likelihood that two random stars become sufficiently aligned is

vanishingly small and almost all microlensing events occur towards the centre of the Galaxy in the densest fields in the night sky. Consequently, the stars appear as a continuum, where only the brightest stars can be distinguished as individual stars.

'The significant improvement in resolution, fast readout times and negligible readout noise brought about by the Andor EMCCD camera is a prerequisite for successfully observing gravitational microlensing events. Our work demonstrates that SONG's quest to find small, earth-like exoplanets capable of supporting life through our global network of robotic telescopes can go forward with confidence', concludes Harpsoe. In the 17 years since the discovery of the first planet in orbit around another star, more than 600 exoplanets have been detected. However, almost all are so-called 'Hot Jupiters' or 'Roaster Planets', giant planets orbiting close to their parent stars with very high surface temperatures, simply because they are the easiest to visualise. To date, telescopic detection of small Earth-like objects capable of supporting life has remained virtually impossible.

Gravitational microlensing is an astronomical phenomenon discussed by Einstein in 1915. It occurs when the light from a distant star or planet is bent due to the gravitational field of a foreground object when they are sufficiently aligned, leading to two unresolved images and observable brightening. Since microlensing observations do not rely on the radiation received from the lens object, astronomers can study objects no matter how faint. Therefore, it is an ideal technique to study the galactic population of faint or dark objects, such as brown dwarfs, red dwarfs, white dwarfs, neutron stars, black holes and exoplanets. Since the microlensing effect is wavelength-independent, source objects emitting any kind of electromagnetic radiation may be studied.



Fig. 1 Image of Globular Cluster NGC 6981

SCMOS (SCIENTIFIC CMOS) TECHNOLOGY



Scientific CMOS (sCMOS) is a breakthrough technology that offers an advanced set of features that render it ideal to high fidelity, quantitative scientific measurement, overcoming many of the performance drawbacks and trade-offs associated with CCDs.



This evolutionary camera is becoming the imager of choice for a gamut of astronomical applications. It is already popular with solar astronomers imaging the entire sun due to high spatial resolution and fast frame rates, enhancing observation of solar activities to realise new insights.

The same camera can also work in a guider role, or AO applications, where its small ROI and faster frame rates allow rapid temporal resolution. The ultra-low noise and high dynamic range is ideal for sensitive photometric measurements such as profiling star intensities or hunting for exoplanets, it is an extremely sensitive instrument.

The sCMOS camera delivers high spatial resolution, large field of view, fast frame rates, low noise and large dynamic range without compromise. This unrivalled performance package means that it is a true 'workhorse' design.

Features

(Rolling shutter only variant
1 e ⁻ read noise
5.5 megapixel sensor forma
Rapid frame rates
Dual-gain amplifiers
Extensive FPGA on-head da
Hardware timestamp
Dynamic baseline clamp
Spurious noise filter
Data flow monitor
iCam

Comprehensive trigger modes and I/O





Neo

sCMOS

The Neo is Andor's flagship platform. The vacuum-cooled camera has been engineered to realize the absolute highest performance potential of this exciting new technology. Neo offers an advanced set of unique performance features and innovations, including deep vacuum TE cooling to -40°C, extensive on-head FPGA data processing capability, a 4GB memory buffer and a Data Flow Monitor. Neo's differentiators from the Zyla are its deep cooling and 4 GB memory buffer.

This stable camera creates the perfect platform for a wide range of scientific instrumentation designs and applications. For example multiple array observatories, especially for remote survey work, were the critical requirement is for a flexible maintenance free operation.

The Neo is a perfect camera for such observatories and has already been placed in arrays for solar astronomy and transient technique exoplanets. with on-going integration in other applications such as Near Earth Objects and Oort cloud study. As an imager it is ideal for Lucky and Speckle Imaging, it is also utilized for photometry studies. The flexible and adaptable technology means AO setups are in development to optimise this technology for the next generation of AO systems.

Active pixels	2560 x 2160
Pixel size (µm)	6.5 x 6.5
Sensor size (mm)	16.6 x 14
Read noise (e [.])	1 @ 200 MHz 1.3 @ 550 MHz
Sensor cooling	-40°C
Pixel well depth	30,000
Max readout rate (MHz)	560 (280 x 2 outputs)
Max frame rates (fps)	Sustained: > 30 fps (Full frame) Burst: 100 fps (Full frame)
OF Max	60%

Zyla **s**CMOS

Andor's new Zyla sCMOS camera offers high-speed, high-sensitivity imaging performance in a remarkably light and compact, TE-cooled design. Zyla is ideally suited to many cutting-edge applications that push the boundaries of speed, offering sustained frame rate performance of up to 100 fps (faster with ROI). Zyla's differentiator from Neo is its sustained speed and compact design.

The sustained frame rate with the camera's sensitivity has seen a strong interest from the AO and guider community, which has been strengthened by splitter options allowing direct access to the data capture off the head.

The Zyla has a similar range of applications to the Neo: Solar Astronomy, Exoplanets, Near Earth Objects, Speckle imaging, Lucky imaging etc. The compact design makes it the optimal camera for weight or size constrained setups, for example when mounted as a guider on an instrument payload of a balloon.

This camera offers the professional astronomer, for the first time, a pricesensitive detector with incredible low noise, dynamic range and temporal resolution.

Two Zyla variants are available, rolling shutter only and global and rolling shutter both of variants can also be supplied with water only cooling on request.





Hot pixel blemishes are significantly reduced at deeper cooling temperatures, requiring much reduced pixel correction. Uncorrected images are shown above for 1 second exposure







Zyla 5.5 Key Specifications		
2560 x 2160		
6.5 x 6.5		
16.6 x 14.0		
1.2 @ 200 MHz 1.45 @ 560 MHz		
0°C (up to +35°C ambient)		
30,000		
560		
Sustained: 100 fps full frame		
60%		

Zyla 4.2 Key Specification

Active pixels	2048 x 2048
Pixel size (W x H; μm)	6.5 x 6.5
Sensor size (mm)	13.3 x 13.3
Read noise (e ⁻)	0.9
Sensor cooling	-10°C with water cooling
Pixel well depth (e ⁻)	30,000
Max readout rate (MHz)	540
Max frame rates	100 fps
QE Max	72%



CCD TECHNOLOGY

The CCD is still a critical technology for the modern astronomer. It offers a significant sensitivity advantage over EMCCD and sCMOS technologies when it comes to long exposures, typically of time regimes lasting from a tenth of a second to minutes. This is primarily due to the superior darkcurrent properties of Andor's vacuum-cooled CCD giving incredible low thermal noise over long exposures. Cameras such as the iKon-L bring the highest level of sensitivity to the next generation of astronomers excelling in applications such as deep sky surveys. These powerful cameras are being used for deep sky surveys, whether in single units or multiples. They are perfectly suited for the demands of continuous remote observation.

Features

Rapid Trame rate
Deep te cooling to -55°c 'Vibration free' mode -40°c
Highest resolution
Highest dynamic range
Ultra low noise
NIR performance
Ultravac™
Multi-MHZ readout
Accurate timestamp





912	
iKon-M	
934	
iKon-L 936	
Clara	







CCD

iKon-L

The iKon-L slow scan CCD offers industry-leading low noise performance alongside unparalleled thermoelectric cooling to -100°C, enabling the best signal to noise for long exposures. The camera's large sensor comes in a range of options including BR-DD, which gives enhanced response in the NIR.

The principle of the transient technique in the search for exoplanets





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Key SpecificationsActive pixels 2048×2048 Pixel size (W x H; μ m) 13.5×13.5 Image area (mm) 27.6×27.6 Active area wall pixel depth (e-)100,000Max readout rate5MHzReadout noise (e-)2.9Frame rate0.95 FPS (Full Frame)
2.115 FPS (512×512)

Typical Applications

Deep sky survey
Photometry
Astrometry
Exoplanets



This platform has the same industryleading low noise performance and thermoelectric cooling as the iKon-L, just in a smaller package. Its size and flexibility makes it ideal for applications such as Near Earth Objects (NEO) and smaller optical telescopes.

iKon-M

The camera range provides options for faster frame rates along with greater dynamic range, or higher spatial resolution with lowest noise and with the broadest range of sensor options.





Key Specifications (934) Active pixels 1024 x 1024 Pixel size (W x H; μ m) 13.0 x 13.0 13.3 x 13.3 Image area (mm) Active area wall pixel depth (e-) 100,000 Max readout rate 5MHz Readout noise (e-) 2.9 4.4 FPS (Full Frame) 8.5 FPS (512 x 512) Frame rate QE Options: BV, FI, BR-DD, BEX2-DD, BU2

Key Specifications (912)

Active pixels	512 x 512
Pixel size (W x H; μm)	24 x 24
Image area (mm)	12.3 x 12.3
Active area wall pixel depth (e-)	300,000
Max readout rate	2.5MHz
Readout noise (e-)	3
Frame rate	8.1 fps (Full Frame) 28.3 fps (128 x 128)
QE options:	BV, FI

Typical Applications

Deep sky survey
Photometry
Astrometry
Exoplanets
Near Farth Objects (NEO)





CCD Case Study

Clara CCD

The Clara, an interline CCD built around the Sony ICX 285, offers a powerful tool in a small package. Its versatility allows both fast framing and long exposure imaging as and when required. Designed to achieve an incredibly low noise profile with extremely efficient thermal management, it excels at long exposures. The camera's small size, integrated hardware, software, along with USB 2.0 connectivity and c-mount design make it ideal for small project integration. This platform also has an option for enhanced QE performance in the extended NIR.



Key Specifications				
Active pixels	1392 x 1040			
Pixel size (W x H; µm)	6.45 x 6.45			
Image area (mm)	27.6 x 27.6			
Active area wall pixel depth	8.98 x 6.71			
Max readout rate (MHz)	20			
Readout noise (e ⁻)	2.9			
Frame rate	0.95 FPS (Full Frame) 2.115 FPS (512 x 512)			

Typical Applications

Photometry
Astrometry
Near Earth Objects (NEO)



Super-Earths

SuperWASP (Wide Angle Search for Planets) has proven to be one of the most successful projects for exoplanets. It has found more than a third of all confirmed transiting planetary systems through its two telescopes, each equipped with eight Andor iKon-L cameras.

Its successor, the Next Generation Transit Survey (NGTS), aims to build on those successes through a 12-strong array of telescopes (see figure 1) at the European Southern Observatory in Chile equipped with custom-designed, red-sensitive CCD cameras, 600-900 nm, from Andor (see Figure 2).

Compared to SuperWASP, NGTS will extend the limits of detection from giant Jupiter-like planets into the Neptune and super-Earth regime. The space-borne Kepler probe has shown that these objects are very common. However, most of the examples found so far are too faint to be confirmed and followed up to measure their composition and atmospheric properties. The ground based NGTS will search a sky area more than 16 times greater than Kepler, covering many more bright stars, searching for planetary systems. Where suitable they will pass on potential targets to the VLT and ELT for detailed scientific follow up.

Interestingly, the transit geometry could also allow during secondary eclipse, the period when the star occults the thermal emissions from the planet, the planet's thermal emissions to be calculated. This is a technique that is already successfully carried out by larger telescopes such as the VLT.

Finally, and most excitingly, observation of the planet during transit at many different wavelengths may allow the stellar transmission, the light passing through the atmosphere of the planet, to be identified.

This technique can be used to identify key chemical markers such as water or carbon dioxide on these exoplanets, indicators of life.

'The rollout of the NGTS programme follows successful trials with two prototype instruments that demonstrated white noise characteristics to sub-mmag photometric precision,' says Dr Peter Wheatley, one of NGTS' Principle Investigators. 'Having had great success with the Andor cameras in WASP, we chose to work with Andor on our NGTS camera. Our requirement was for large-format, deep depletion CCDs but we were unaware of any manufacturer offering these off-the-shelf. However, Andor offer smaller format (1k x 1k pixel) deep depletion detectors as a catalogue item so we paired up two of these for our prototype instrument we operated during 2010 before going ahead with the custom units.

'Andor were helpful when it came to custom design work. For instance, we changed the standard window for one with high near-IR throughout. We also changed the camera shutter to accommodate the f/2.8 beam from our telescope and we changed the faceplate of the camera to allow a custom interface to our telescope. The fully robotic telescope will be sited at ESO Paranal.

'Detailed simulations predict that when we begin scientific operations in 2014 about 30 bright super-Earths and up to 200 Neptunes could be discovered and we have been pleased by the support we received from Andor,' concludes Wheatley.



Fig. 1 Concept drawing of the full observatory array



One of the autonomous telescopes in the array

Specification Overview

	iXon Ultra 888	iXon Ultra 897	iXon3 860	
Active pixels (H x V)	1024 x 1024	512 x 512	128 x 128	
Pixel size (W x H; μ m)	13 x 13	16 x 16	24 x 24	
Sensor area (mm)	13.3 x 13.3	8.2 x 8.2	3.1 x 3.1	
Pixel well depth (e-, typical)	80,000	180,000	160,000	
Maximum full frame rate (fps)	26	56	513	
Read noise (e-, typical)	< 1 with EM gain @ 30 MHz	< 1 to 98 @ 17MHz	< 1 to 48 @ 10 MHz	
Dark current (e- / pix / sec)	0.0005	0.001	0.002	
Vertical clock speeds (μ s)	0.6 to 4.33	0.3 to 3.3	0.0875 to 0.45	
Minimum sensor temp (°C)	-95	-100	-100	
Digitization	16-bit	16-bit	14 and 16-bit	
Pixel readout rates (MHz)	30, 20, 10, 1	17, 10, 5, 1	10, 5, 3, 1	
PC interface	USB 3.0	USB 2.0	PCI, PCIe	
Sensor QE options	EX2, BV, UVB	EX2, BV, UVB	BV, UVB	EMO



Accessories

Andor supplies a range of accessories that are useful additions to our cameras. A few examples can be found below. Their order codes with details can be found in the order step guides located on page four of the camera specification sheets. Most are 'off-the-shelf' and can be ordered at the time of camera purchase, or by themselves, as required. If you have a specific request not catered for, then this can be processed via our CSR process [see page 33]

Cable Extenders

We offer a range of extenders from electrical to FO extenders, offering distance solutions for all of our platforms. Extensions are available from a few metres to > 1 km.

Water Cooler and Recirculator

We offer a range of water recirculators and coolers, which can enhance the minimum cooling of Andor cameras.

Computer

Increasingly the computer has an impact on the overall performance of the system. At Andor, as well as giving computers specifications, we also offer a range of suitable computers ranging from minimum to highest specification.

	Clara	iKon-M 934	iKon-M 912	iKon-L 936	
Active pixels (H x V)	1392 x 1040	1024 x 1024	512 x 512	2048 x 2048	
Pixel size (W x H; μm)	6.45 x 6.45	13 x 13	24 x 24	13.5 x 13.5	
Sensor area (mm)	8.98 x 6.71	13.3 x 13.3	12.3 x 12.3	27.6 x 27.6	
Pixel well depth (e-, typical)	18,000	100,000	300,000	100,000	
Maximum full frame rate (fps)	11	4.4	8.1	0.95	
Read noise (e-, typical)	2.4 @ 1 MHz	2.9 @ 50 kHz	3.0 @ 50 kHz	2.9 @ 50 kHz	
Dark current (e- / pix / sec)	0.0003	0.00012	0.0006	0.000059	
Vertical clock speeds (µs)	6.5	11.3 to 67.3	11.4 to 45	38 to 76	
Minimum sensor temp (°C)	-55	-100	-100	-100	
Digitization	14 and 16-bit	16-bit	16-bit	16-bit	
Pixel readout rates (MHz)	20, 10, 1	5, 3, 1, 0, 0.5	2.5, 1, 0.05	5, 3, 1, 0.05	
PC interface	USB 2.0	USB 2.0	USB 2.0	USB 2.0	
Sensor QE options	SIL	BU2, BV, FI, BR-DD	BV, FI	BV, FI, BU2, BR-DD	





Spectrographs and Spectroscopy

Customer Special Request (CSR)

Andor's market-leading technical know-how extends into high performance spectroscopic detectors complemented by a comprehensive range of high-end Spectrographs.

Our cameras are most extensively used with custom built echelle systems, where spectroscopic information is measured, normally large bandwidth with low spectral resolution, for astronomical objects such as Supernova. Combined systems of camera and spectrographs setups are more diverse but have been used for applications including meteor investigation.

Shamrock 303i







Shamrock 750

Shamrock 163



Mechelle 5000



Spectroscopy Brochure

Want to learn more? Andor

offer a dedicated brochure that covers in detail all of our spectroscopic products, spectrometers, detectors, gratings and much more!



At Andor we realise that, sometimes, even our adaptable and flexible 'off-the-shelf' products are not enough to meet some of the more demanding application requirements of our customers.

For this reason we provide a bespoke solutions, design development, quotation and final delivery of the product.







service to our customers, whereby a dedicated highly experienced team of engineers and application specialists provide customer specific solutions. The process involves discussing core requirements, advising on possible

The CSR service is a the heart of the Andor ethos of offering high performance, high quality products and solution developments for each and every customer.

Our extensive capabilities, married to our flexible and adaptable approach, complements the specific needs that often arise in astronomy.

Software

Notes

Andor Solis

Solis is Andor's own camera control and analysis software platform specifically designed to run imaging cameras and associated Realtime imaging with full experiment and camera control.



Andor SDK

Andor's Software Development Kits allow control of the full range of cameras from within your own application. Available as 32 and 64bit libraries for Windows (XP, Vista and 7) as well as Linux. Compatible with C/C++, C#, Delphi, VB6, VB.Net, Labview and Matlab.



Third Party Software

The range of third party software drivers for Andor cameras is always expanding. Please contact Andor for further details.









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Image courtesy of Qiu Peng, National Astronomical Observatories, Chinese Academy of Sciences (NAOC)





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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Front cover image: "Horsehead Nebula" courtesy of Tony Hallas.

