Version 1.0

ZEISS Axiocam Family

Your Guide to Microscope Camera Technology from ZEISS.

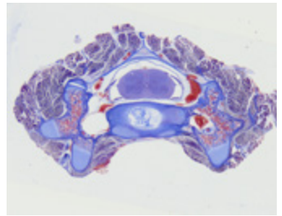
The moment your data change scientific minds.

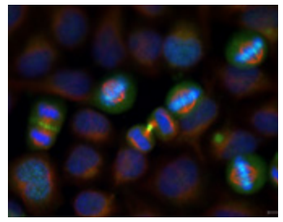
This is the moment we work for.

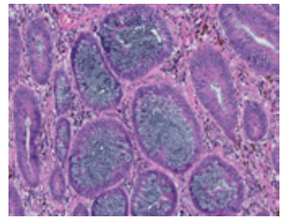
// INNOVATION
MADE BY ZEISS

Visualization and Documentation

Camera technology as diverse as your imaging and documentation tasks.







Recent years have seen rapid developments in the processing and documentation of microscopic images. Technology has evolved from video cameras connected by frame-grabbing control cards to today's purely digital cameras operated via USBs, FireWire or quick Ethernet interfaces. Whichever camera technology you are using for microscopy, you will always need high contrast resolution, good sensitivity and dynamic performance, and a high readout speed. Often, short exposure times and the option of recording a quick series of images will be just as important as exact color reproduction.

All things considered, there is simply no such thing as the perfect microscope camera – it just depends on the applications at hand. This guide aims to give you an overview of the whole portfolio of ZEISS Axiocams. These dedicated microscope cameras range from compact color cameras for routine documentation to fast, sensitive monochrome cameras for gentle live cell imaging. Explore typical applications and use the performance matrix to decide which Axiocam is the right one for you. Use the camera terminology chapter to learn about fundamental principles and the words we use to describe them.

Select Your ZEISS Axiocam to Match Your Requirements.

Welcome to the fascinating world of microscope cameras. In this compendium we have brought together the whole portfolio of ZEISS Axiocams with many exciting applications for you to discover. Use it as a guide to selecting the right camera for all your imaging and documentation.

Cameras for Teaching and Routine Labs

These cameras meet the needs for easy operation and efficiency.
You benefit from live images with exactly the right resolution and crisp contrast.

Page 8

High End Color Cameras

These cameras all deliver outstanding true color images in high resolution. Their high dynamic range and high frame rates meet the needs of even the most demanding pathology or histology imaging.

Page 22

High End Fluorescence Cameras

These sensitive monochrome cameras are dedicated to capture even faint signals from your living samples. Each Axiocam contributes a unique combination of resolution, sensitivity and speed to your most demanding live cell imaging experiments.

Page 32

Integrated Network Cameras

These cameras can be connected to your WiFi – giving you freedom of sharing your images with colleagues. Already integrated into the microscope stand, these cameras are always well adjusted.

Page 44

Software

Each Axiocam comes with a bundle of free software for basic imaging tasks. Or can be combined with several high end modules of ZEN imaging software tailored to your applications.

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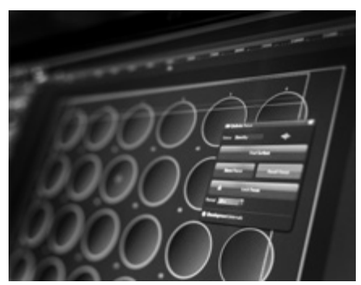

Knowledge Base

Learn about fundamental terms of camera technology and their meaning. See how sensor type, resolution, frame rate and sensitivity are interconnected and influence your results.

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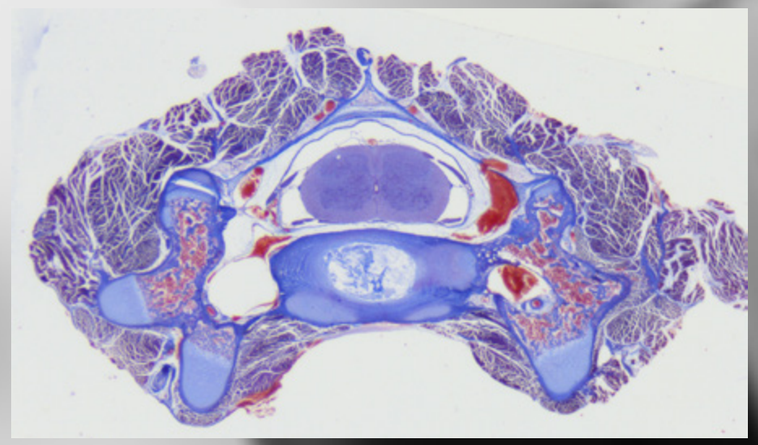
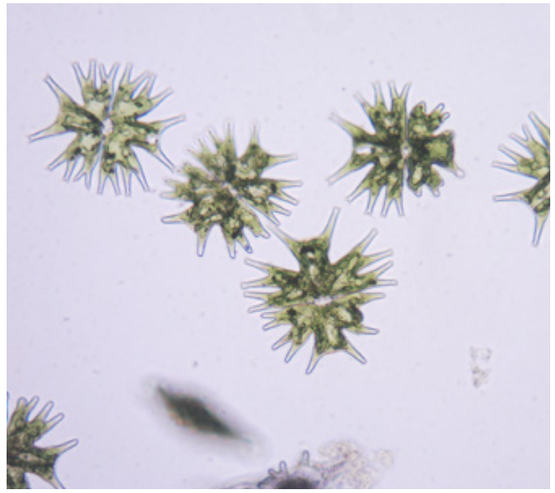
Cameras for Teaching and Routine Labs

Enjoy Efficient, Easy Operation.

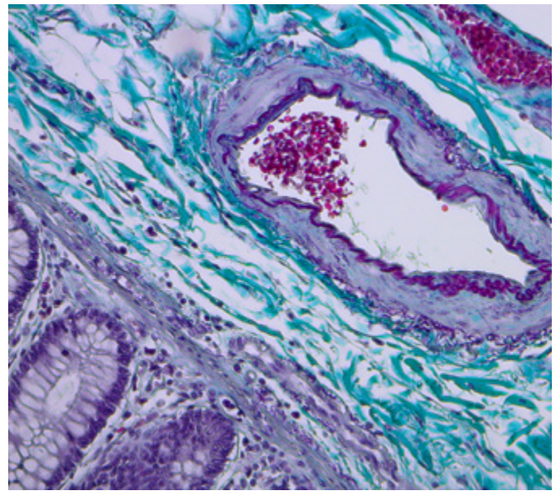


ZEISS Axiocam ERc 5s

Your 5 Megapixel Standalone Microscope Camera



Micrasterias radiata (algae), brightfield



Pig gut, May-Grünwald-Giemsa staining

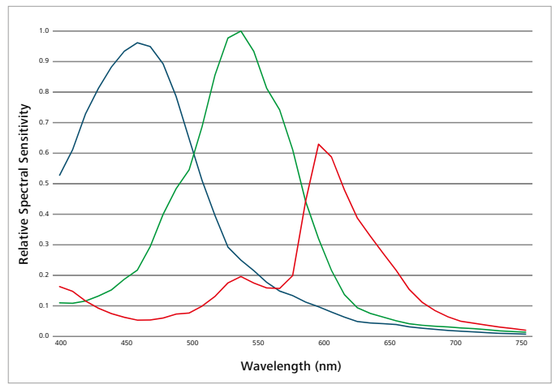
This 5 Megapixel CMOS camera from ZEISS offers you flexible technology at an impressive price-performance ratio.
With Axiocam ERc 5s you capture the finest details of structures in your sample in high resolution. Connect your camera in a multitude of ways. Attach it to your PC to acquire crisp images with ZEN or use it as a digital video camera by connecting it directly to a monitor. Produce an exceptional live image for observing dynamic processes. Or exploit the full flexibility of Axiocam ERc 5s as a standalone camera in your lab. You can store your images directly onto an SD card and transfer them to a computer later, making your laboratory processes even more efficient.
The camera can also be connected to a network via Ethernet cable. Wirelessly connect your iPad on the same network and access the controls via Labscope. This means you can check in on your sample away from the system, freeing you to work on other tasks. Or share the live image by connecting multiple iPads to promote discussion amongst students or colleagues.

Recommended for

- Applications with bright samples
- Documentation
- Education / Teaching
- Routine tasks
- Industrial work
- Quality assurance / Quality control

Simpler. More intelligent. More integrated.

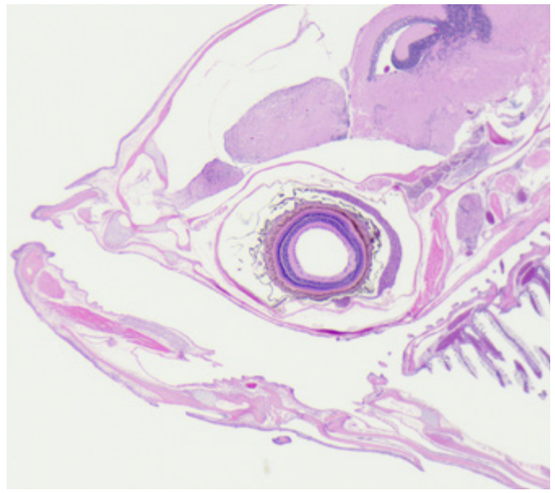
- 5 megapixel CMOS sensor
- 8 bit digitization
- High resolution with 2.2 µm pixel
- Color and black & white imaging modes
- Flexibility – use Axiocam ERc 5s in multiple ways:
  - As a stand-alone camera – acquire images / movies directly to an SD card
  - As digital video camera – stream HD (720p60 or 1080p30) via HDMI cable directly to a monitor or projector. Control the camera via remote control – define your acquisition settings and store for later use to carry out routine tasks independent of any computer
  - Via Labscope with a network connection and an iPad
  - Efficient operation with ZEN via an easy to install USB connection to a PC



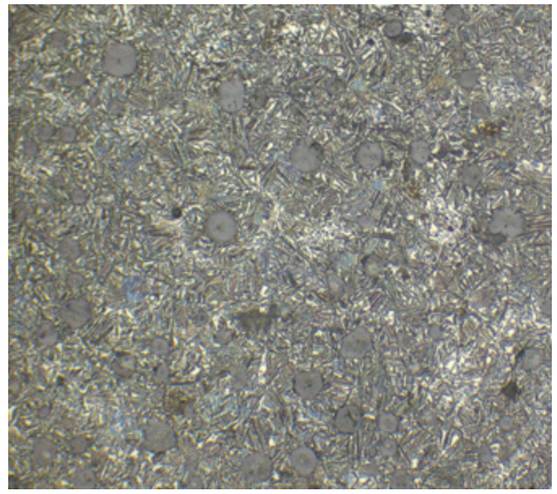
Relative spectral sensitivity

ZEISS Axiocam 105 color

Your 5 Megapixel Microscope Camera for Documentation in Routine Labs



Fish, HE staining, brightfield, acquired with ZEISS Stemi 305



Graphite in brightfield, objective: EC Epiplan-NEOFLUAR 20×

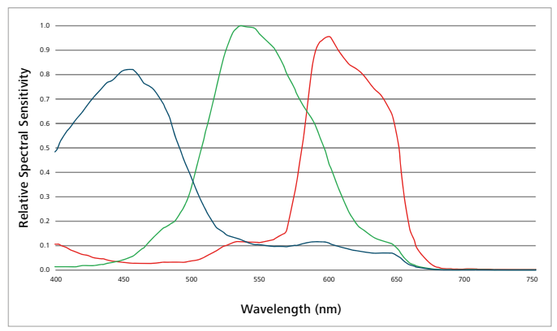
Axiocam 105 color is your small, no-frills microscope camera. With its compact design, it makes quick and efficient work of your daily documentation needs.
With its USB 3.0 connection, experience a high speed data transfer rate for handling your high resolution 5 megapixel color images. Offering an exposure time range of 100 µs to 2 s and a live frame rate of up to 33 images per second, the camera allows you to be well prepared to cover multiple tasks. Document your results quickly and conveniently.
With its attractive price-performance ratio, you can also expand the capability of your fluorescence imaging system with color imaging. Axiocam 105 color is ideal as a secondary camera on fluorescence microscopes that are traditionally equipped with monochrome cameras.
The camera's small form factor also lends itself well to environments with limited space.

Recommended for

- Applications with bright samples
- Documentation
- Education / Teaching
- Routine tasks
- Materials testing
- Quality assurance / Quality control

Simpler. More intelligent. More integrated.

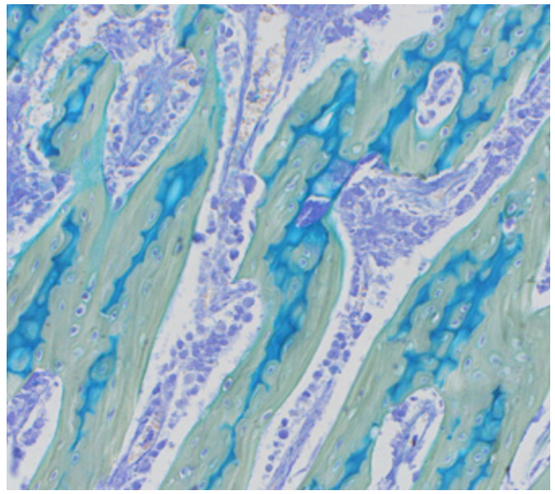
- 5 megapixel CMOS sensor
- 15 images per second at full 5 megapixel color resolution
- 8 bit digitization
- High resolution with 2.2 µm pixel
- Easy to use super-speed USB 3.0 connection
- Color and black & white imaging modes
- Fast and efficient operation with ZEN imaging software



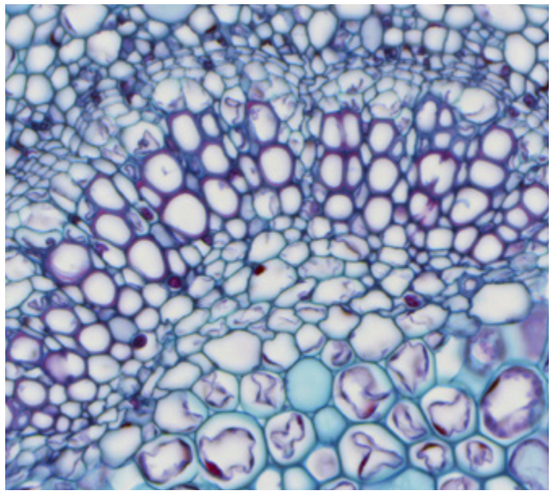
Relative spectral sensitivity

ZEISS Axiocam ICc 1

Your 1.4 Megapixel CCD Camera



Rat foot acquired with ZEISS Axio Imager, objective: EC Plan-NEOFLUAR 20×



Privet leaf, acquired with ZEISS Axio Imager, objective: EC Plan-NEOFLUAR 40×

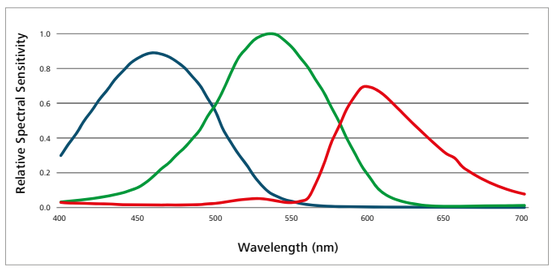
Focus down through your samples smoothly and without delay with Axiocam ICc 1. By offering 1.4 megapixel resolution, this camera alleviates your from large files and slow data handling, allowing you to easily monitor dynamic processes and moving specimens with a responsive live image. Handle your linear and uncompressed data without stress with even the most basic PC. Due to its design, this camera is particularly well-suited for brightfield and phase contrast imaging.
With two FireWire interfaces on the camera body, daisy chain two cameras by directly connecting them to one other and control them from a single computer. This gives you flexibility, optimizing the workload of your devices and increases efficiency.

Recommended for

- Brightfield and phase contrast applications
- Education
- Routine tasks
- Materials testing
- Quality assurance / Quality control

Simpler. More intelligent. More integrated.

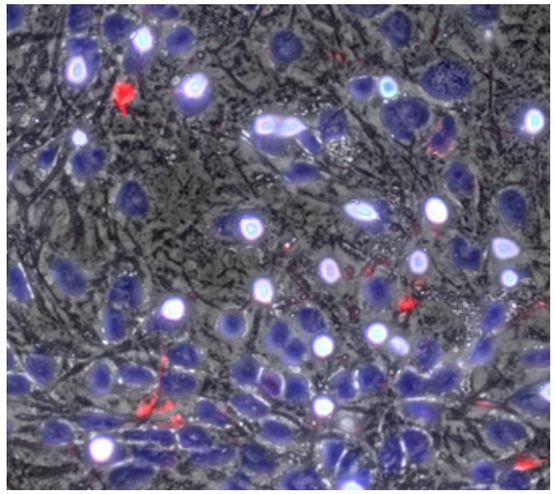
- 1.4 megapixel CCD sensor for smaller data strain
- 16 fps @ full resolution, 21 fps @ HD resolution
- 12 bit digitization offers finer gradation in signal
- 4.65 micron pixels resulting in shorter exposure times
- FireWire B connection
- Fast and efficient operation with ZEN imaging software



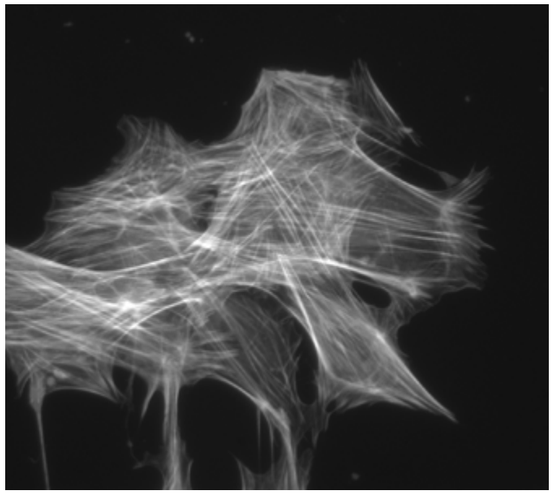
Relative spectral sensitivity

ZEISS Axiocam ICm 1

Your 1.4 Megapixel Monochrome Microscope Camera for Bright Fluorescence Signals



Astrocytes, objective: EC Plan-NEOFLUAR 40× / 0.63



VSMC cells, acquired in fluorescence contrast, 1-channel image, objective: EC Plan-NEOFLUAR 40× / 0.63

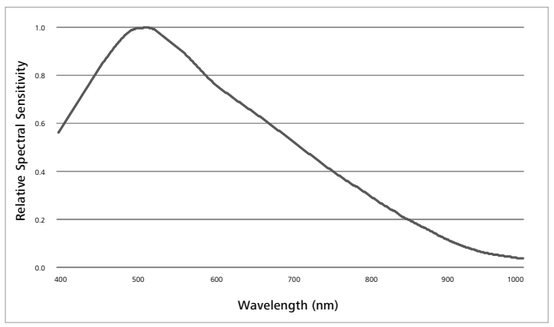
Make basic fluorescence microscopy accessible to your routine lab and open up a range of application possibilities. This 1.4 megapixel monochrome CCD camera carries over the feature set of the color variant, Axiocam ICc 1, to the fluorescence imaging world.
Handle your files with ease with its 1.4 megapixel resolution and avoid slow data handling from large files. Document bright fluorescence in 12 bits, offering fine gradation in signal and an appealing level of quality. Capture more light at shorter exposure times with 4.65 micron pixels.
With two FireWire interfaces on the camera body, daisy chain two cameras by directly connecting them to one other and control them from a single computer. This gives you flexibility, optimizing the workload of your devices and increases efficiency.

Recommended for

- Histochemistry
- Clinical routine
- Quality assurance
- Cell culture

Simpler. More intelligent. More integrated.

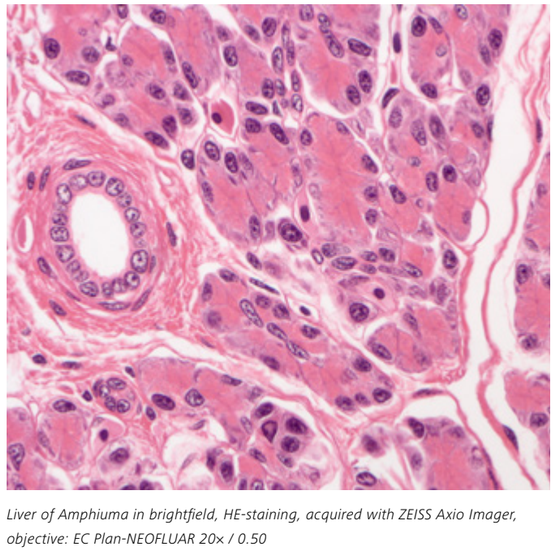
- 1.4 megapixel CCD sensor for smaller data strain
- 16 fps @ full resolution, 21 fps @ HD resolution
- 12 bit digitization offers finer gradation in signal
- 4.65 micron pixels resulting in light sensitivity and shorter exposure times
- Spectral sensitivity 400 nm – 1000 nm supports near IR dyes
- FireWire B connection
- Fast and efficient operation with ZEN imaging software



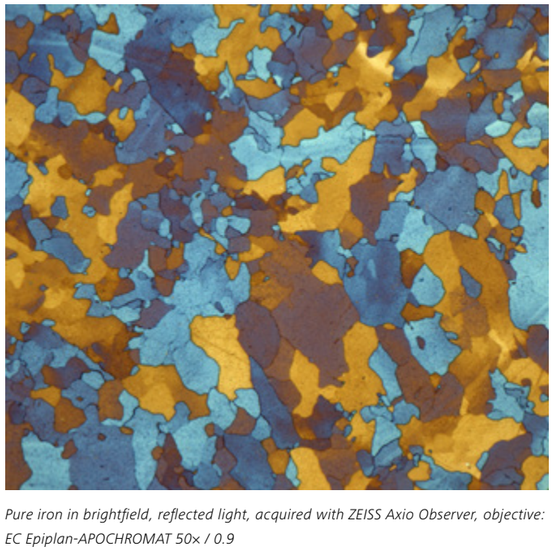
Relative spectral sensitivity

ZEISS Axiocam 305 color

Your Fast 5 Megapixel Microscope Camera for Routine and Research Labs



Liver of Amphiuma in brightfield, HE-staining, acquired with ZEISS Axio Imager, objective: EC Plan-NEOFLUAR 20× / 0.50



Pure iron in brightfield, reflected light, acquired with ZEISS Axio Observer, objective: EC Epiplan-APOCHROMAT 50× / 0.9

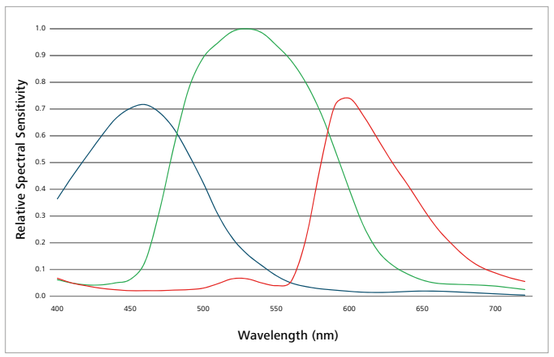
Axiocam 305 color is your 5 Megapixel camera for high resolution imaging at fast speeds. With state-of-the-art CMOS global shutter technology, you can follow and capture samples distortion-free and with great accuracy. Thanks to this highly sensitive sensor technology and precise camera engineering, your Axiocam 305 color allows the capture of quality color images for a wide range of applications. Acquire great color images with crisp contrast or use the optional black & white mode to document basic fluorescence.
With this fast camera offering up to 36 frames per second at full resolution, achieve efficient searching, fast focusing and ergonomic handling at your digital microscope workplace.
Cover more of your area of interest with its ⅔" sensor format and produce great color images on your compound, stereo, or zoom microscope.
Though a simple and fast USB 3.0 connection, control the camera and experience robust performance with easy to use ZEN imaging software and its intuitive user interface.

Recommended for

- Applications with bright samples
- Documentation
- Routine tasks
- Materials Research
- Quality assurance / Quality control
- Fast high resolution live image for co-observation
- Fast image acquisition and time-lapse recording

Simpler. More intelligent. More integrated.

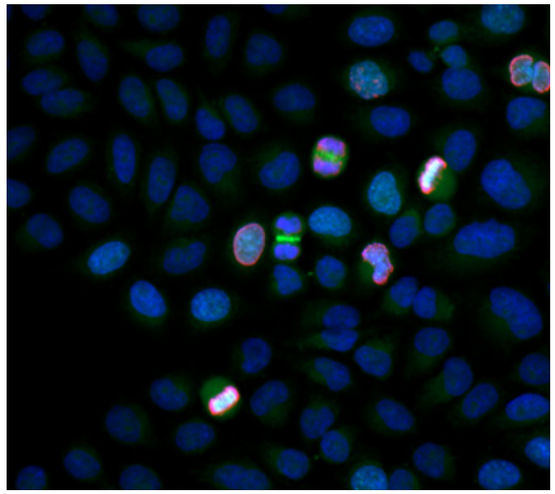
- 5 megapixel CMOS global shutter sensor
- 11.1 mm image diagonal
- Fast readout with 36 images per second in full color resolution
- 12 bit digitization finer gradation in signal
- Small 3.45 micron pixels for better sampling at low magnifications
- Global shutter architecture for distortion-free images
- Active thermal stabilization of the sensor for extremely reproducible image quality
- Easy to use super-speed USB 3.0 connection
- Color and black & white imaging modes
- Fast and efficient operation with ZEN imaging software



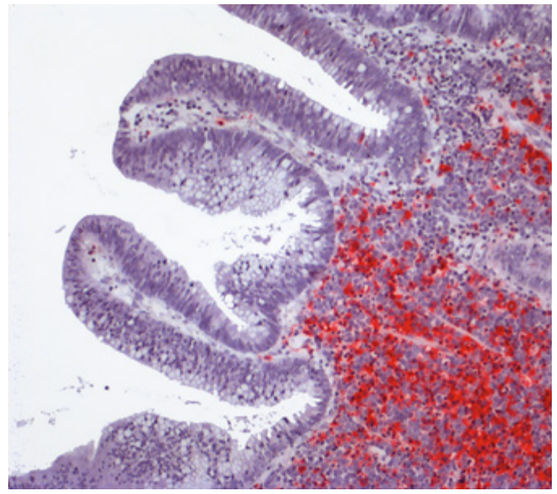
Relative spectral sensitivity

Cameras for Teaching and Routine Labs

Pathology & Histology



HeLa cells, green: Tubulin Alexa 488, red: pHistone 3 – Alexa 568, blue: Hoechst 33342, acquired with ZEISS Axio Imager, objective: Plan-APOCHROMAT 40× / 1.4



Histological section, red: MPOX2, blue: nuclear counterstaining, objective: EC Epiplan-NEOFLUAR 10× / 0.3
Courtesy of: A. Schmitt-Gräff, Pathology, University of Freiburg, Germany

The field of pathology aims to better understand the causes, mechanisms and consequences of disease by studying the structural and functional changes that take place in cells and tissues during disease processes. Soon after microscopes became available, pathologists began to realize how much help these instruments would be in carrying out such studies. Especially in conjunction with staining techniques, microscopes became powerful tools for identifying normal and abnormal tissue as well as cell-morphologies. This consequently developed into the science of histology, which would have been impossible without such progress in optics and microscope manufacturing.

At ZEISS, the use of optical instruments in the battle against disease dates back to Robert Koch's groundbreaking discovery of the causative agent of tuberculosis. Today, you carry out research and routine diagnosis in pathology and histology with different kinds of microscopes and preparation techniques, and this is one of the most important procedures in practical medicine. Among the most famous stainings for transmitted light applications is the classic Hematoxylin and Eosin stain (HE) that colors different tissue portions in violets and reds, according to their composition.

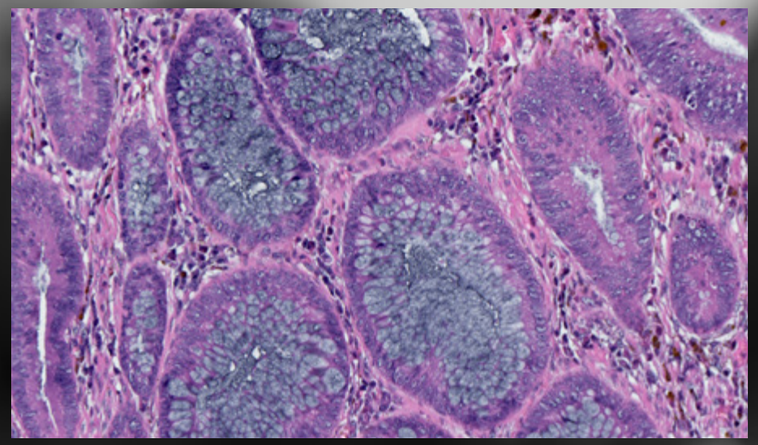
But nowadays it's not just color stainings for transmitted light illumination that are used. You also employ fluorescent dyes to label and identify different kinds of cells and structures. This helps you to get more specific information and, by multiplexing with many dyes, allows to extract a lot more information in one workflow step.

In both cases, the microscope has the task of presenting you an image that corresponds perfectly to the real features of the specimen. This is true for observations through the oculars, but even more so when digital cameras are used, since a digital image might be re-evaluated after the original specimen is long gone or destroyed-sometimes even decades later.

Color cameras from ZEISS reproduce color stains exactly the way they have to be, reliably and reproducibly. For fluorescence applications, ZEISS monochrome cameras offer the sensitivity and dynamic range to reveal even the faintest signals. Be they monochrome or color, your Axiocam will match your ZEISS microscope perfectly and always give you the best available resolution for the structures you have to see.

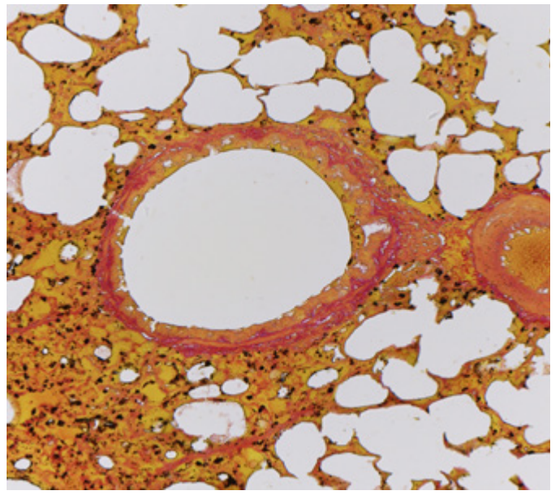
High End Color Cameras

Get True Color Images in High Resolution

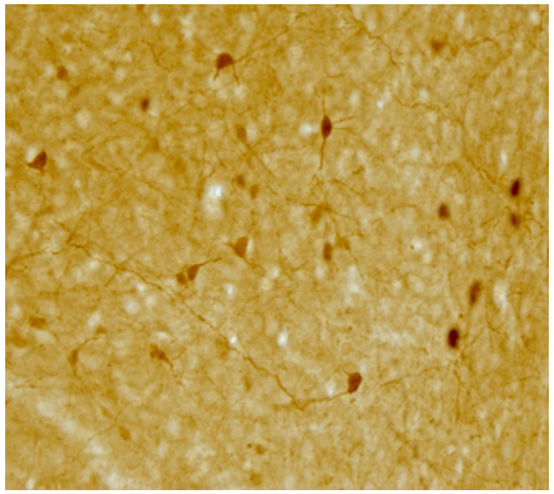


ZEISS Axiocam 503 color

Your 3 Megapixel Microscope Camera for Fast Image Acquisition in Research Labs



Lung of sheep, objective: Plan-APOCHROMAT 10× / 0.45



Hippocampus of rat, objective: Plan-APOCHROMAT 20× / 0.8

This fast 2.8 megapixel scientific grade color camera allows high resolution live images and time-lapse recordings at video speed. Axiocam 503 color brings the convenience of fast color HDTV cameras to the digital domain, including all the advantages of extended parameter control and the image quality you expect from scientific camera products.

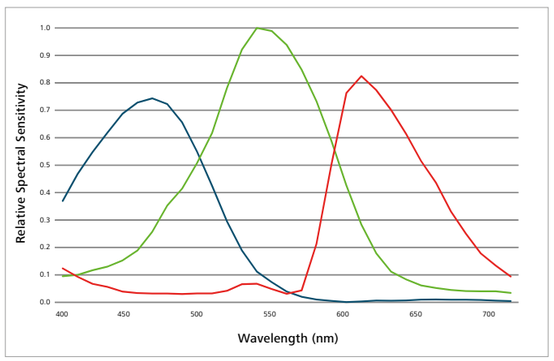
Such speed makes it the best choice for analysis of colored samples where sample navigation and visualization are your maximum priorities – for example, in pathology, cytology or scientific materials research.

Recommended for

- Life and materials sciences
- Co-observation with fast high resolution live image in high quality color
- Fast image time-lapse recording
- High quality documentation of colored samples i.e. in pathology, cytoloty or materials research
- Broad range of intensities and exposure times

Simpler. More intelligent. More integrated.

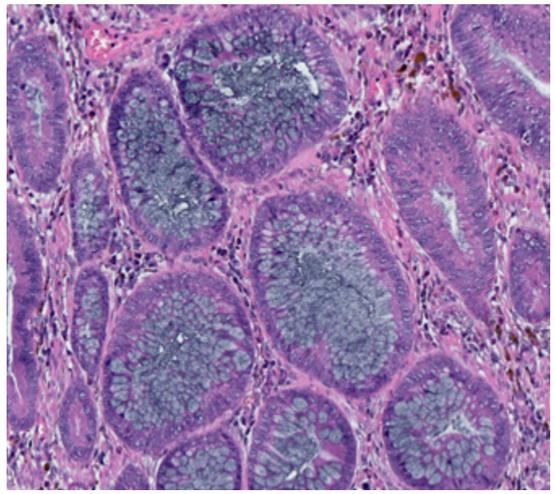
- 2.8 megapixel CCD sensor with standard 11 mm image diagonal
- 38 images per second in color
- High image contrast with 14 bit signal conversion
- Optimum 4.54 micron pixels for best combination of resolution and light sensitivity
- Fast quad-port read-out with global shutter architecture for distortion-free images
- Active thermal stabilization of the sensor for extremely reproducible image quality
- Easy to use super-speed USB 3.0 connection
- Color and black & white imaging modes
- Thermo electrical cooled sensor



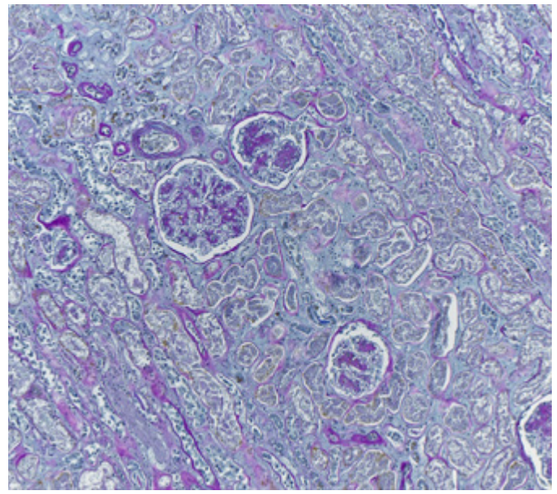
Relative spectral sensitivity

ZEISS Axiocam 506 color

Your 6 Megapixel Microscope Camera for Fast Imaging in True Color



Human intestinal polyps, HE staining, acquired with ZEISS Axio Imager, Objective: Plan-APOCHROMAT 20× / 0.8



Human kidney, Azan staining, acquired with ZEISS Axio Imager, Objective: Plan-APOCHROMAT 10× / 0.45

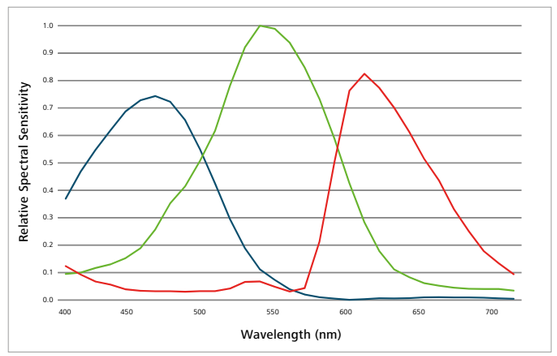
This high quality 6 megapixel color camera offers you an amazingly fast live image and acquisition speed despite its large pixel count and the very large 16 mm diagonal field of view. This makes it the camera of choice whenever large sample areas have to be screened and recorded by taking many image tiles repeatedly in a minimum amount of time due to reduced number of tile positions.
This is extremely benificial in acquiring large pathological tissue sections or large colored materials samples.

Recommended for

- Color imaging applications in life sciences and materials science
- Co-observation with fast high resolution live image in high quality color with a very large field of view
- Large pathology, cytology and materials samples
- Fast tile scanning applications
- Broadest range of intensities and exposure times

Simpler. More intelligent. More integrated.

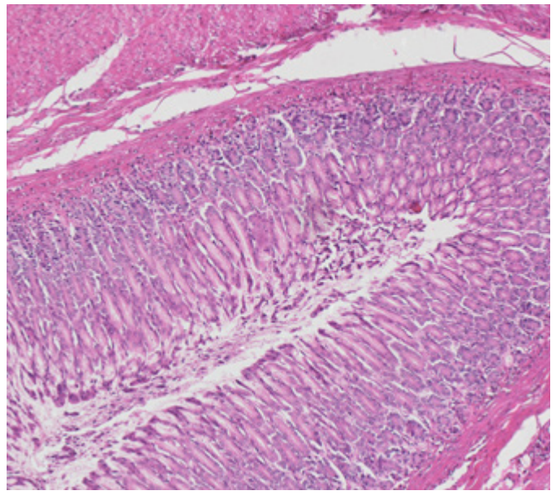
- 6 megapixel CCD sensor with 16 mm image diagonal
- 19 full resolution color images per second
- High image contrast with 14 bit signal conversion
- Small 4.54 micron pixels for optimal resolution
- Fast quad-port read-out with global shutter architecture for distortion-free images
- Black & white imaging mode
- Reproducible image quality due to active thermal stabilization of the sensor
- Easy to use super-speed USB 3.0 connection
- Thermo electrical cooled sensor



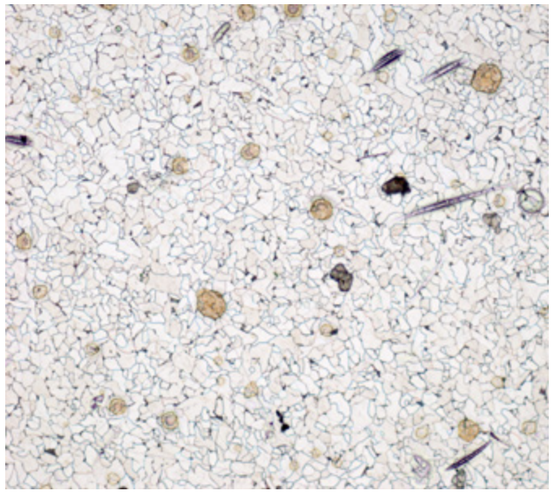
Relative spectral sensitivity

ZEISS Axiocam 512 color

Your 12 Megapixel Microscope Camera for Imaging of Large Sample Areas – Fast, in True Color, and High Resolution



Intestine of rat, HE staining, acquired with ZEISS Axio Imager, objective: Plan-APOCHROMAT 10× / 0.45



Steel with ferrite perlite grains in reflected light brightfield, acquired with ZEISS Axio Observer 7, objective: EC Epiplan-NEOFLUAR 10×

This 12 megapixel scientific grade color camera has a 1" (16 mm diagonal) CCD sensor. Given its large sensor size combined with small pixel sizes, you are able to acquire large object fields with low magnification and high aperture objectives without stitching. You can zoom into the digital image and still see the finest details of your sample. The USB 3.0 interface delivers an excellent live image at high acquisition speeds.

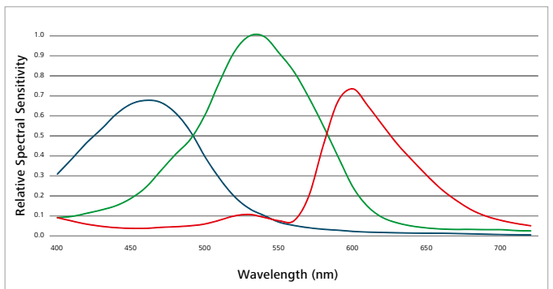
Axiocam 512 color is a highly evolved digital color camera addressing the needs of scientific microscopy, including documentation, reporting and analysis. Fast and artifact-free imaging with optimized color reproduction makes your work comfortable and efficient. In addition, exploring your sample on the screen, instead through the oculars, becomes a true and very convenient alternative.

Recommended for

- Color imaging applications in life sciences and materials science
- Quality control and inspection
- Pathology, cytology and colored materials
- Macroscopic imaging applications, e. g. with Axio Zoom.V16

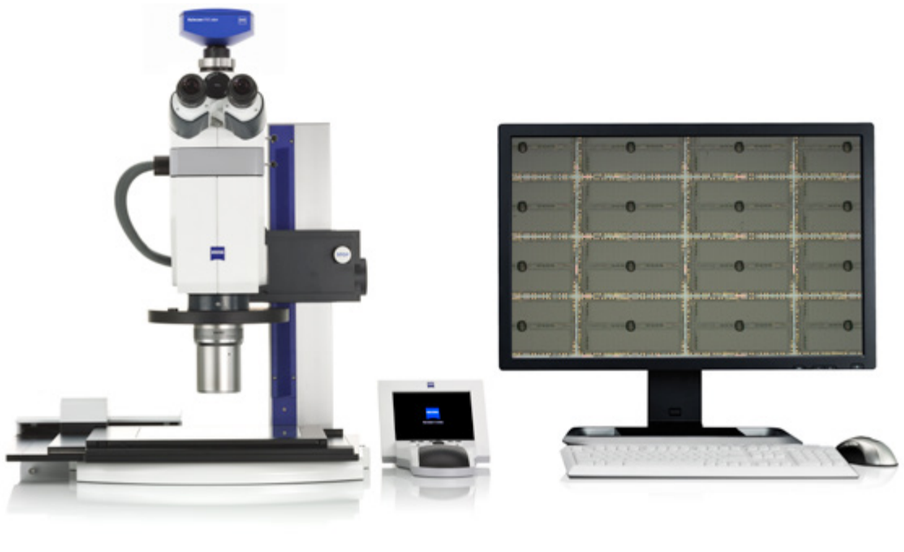
Simpler. More intelligent. More integrated.

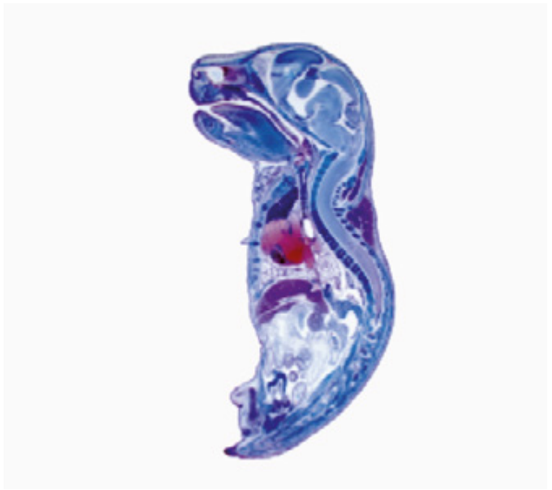
- Large field of view with high resolution of 12 megapixels
- CCD sensor with a size of 1" (diagonal 16 mm)
- Excellent live image and high acquisition speed
- Pixel size of 3.1 µm to detect small structures
- Simple PC connection through USB 3.0 interface technology
- Thermo electrical cooled sensor



Relative spectral sensitivity

Large Area Imaging





Young mouse, cross section brightfield, acquired with ZEISS Axio Zoom.V16, objective: PlanApo Z 0.5× magnification 6×

Foil capacitor, cut open, with dielectric in between; acquired with ZEISS Axio Zoom.V16, reproduction of object/camera 0.8

You use microscopes to make small structures appear bigger. Nevertheless, these small structures are often embedded in larger collections of cells or in tissues. This is the case throughout the life sciences, but also in materials science, forensics and in diagnostic applications. Examples include tiny synapses of large neurons in brain tissue, inclusions and defects on the surfaces of polished materials as well as sperms, hair, skin and other remains on forensic evidence.

These samples in their entities are usually too big to be seen or captured within a single field of view of a microscope or digital camera, even at low magnifications. Often it will be crucial to image the entire area – or at least a large part of it – to answer your question. After a large area has been digitized, you can identify rare events or make a more accurate statistical analysis on the images.

Generally, a very common approach to achieving large area imaging is to scan the sample with the aid of a motorized scanning stage and then create a tile image that can be merged into one seamless reproduction of the sample. A perfect demonstration of this approach is digital slide scanning for research pathology. Axio Scan.Z1, for example, is an instrument that has driven a fast scanning regime in transmitted or fluorescent applications with on-the-fly stitching and merging of tile image data to perfection.

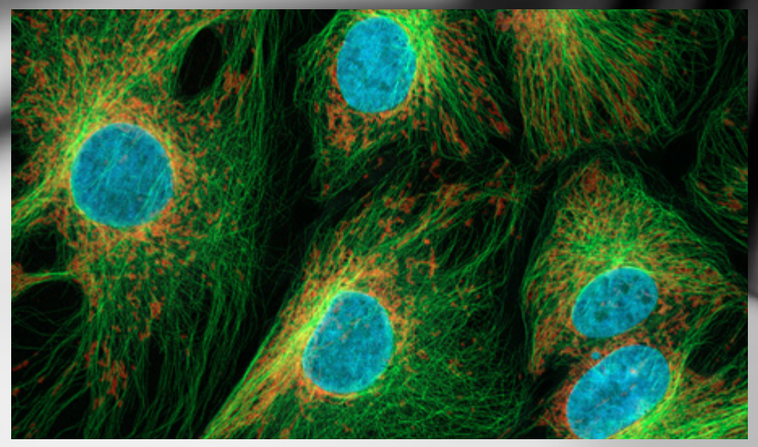
While this procedure has commonly been used for many years, the current generation of ZEISS Axiocams is able to speed things up greatly and at the same time generate higher quality data. When using lower magnifications, you need cameras with small pixels, large sensor diameter and high pixel counts to retain resolution in the final image.

In addition, since 2014 the scientific community explores a new technique called ‘expansion microscopy’. This involves physically inflating biological tissues, which means that even small biological specimens such as single cells can get quite large and, consequently, the imaging procedure may take several times longer than before. The exciting new possibilities that come with it – for example, an increased level of detail – have to be paid for by imaging a larger area, thus resulting in longer imaging time.

Your Axiocam with high pixel counts and small pixel sizes matches your micro- and macroscopic ZEISS microscope perfectly, making most of their objectives with high numerical apertures at low magnifications. Whether for classic scanning of tissues and materials or for imaging of inflated and expanded specimens.

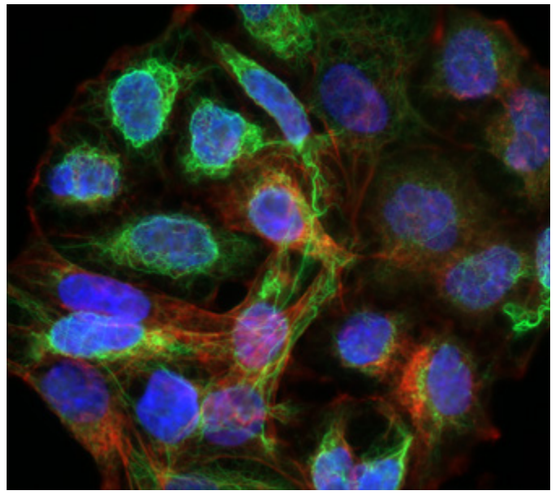
High End Fluorescence Cameras

Capture Even Faint Fluorescent Signals.

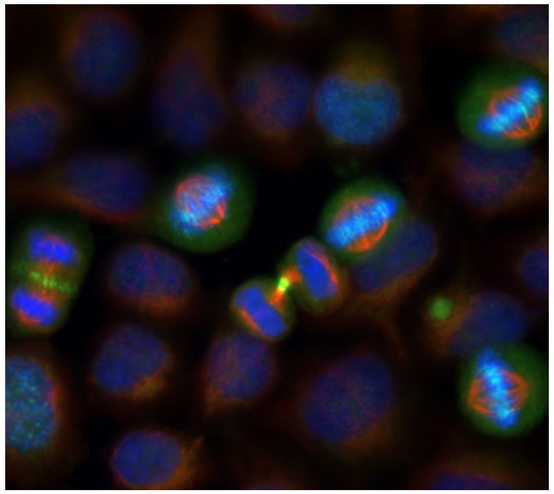


ZEISS Axiocam 503 mono

Your Flexible and Sensitive 3 Megapixel Microscope Camera for Live Cell Imaging



SK8 / K18 cells, staining: intermediate filaments labeled tagged with GFP (green), Aktin Alexa 546 (red), DAPI (blue), acquired with ZEISS Axio Imager, objective: Plan-APOCHROMAT 63× / 1.4



HeLa cells, staining: AuroraB – Alexa 488 (green), Tubulin – Alexa 568 (red), Hoechst 33342 (blue), acquired with ZEISS Axio Imager, objective: Plan-APOCHROMAT 63× / 1.4

This 3 megapixel microscope camera is your best workhorse. The camera features a ⅔" sensor with an image diagonal of 11 mm. In combination with the number of pixels, you have all the advantages of high resolution imaging. The cooled quad-port CCD camera with its four outputs provides exceptional versatility and offers you benefits such as a wide range of exposure times, binning up to 5×5 for super sensitive detection, a choice of lowest noise single port or high-speed multiport read-out modes, and very low levels of read-out noise.

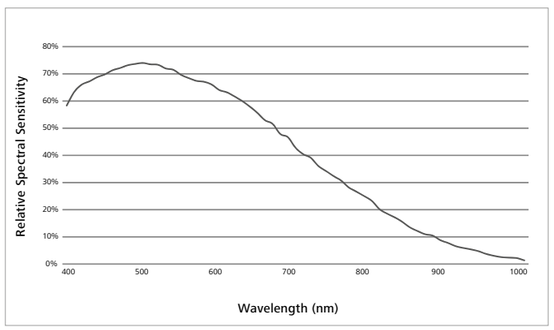
You will enjoy working with a high quality and rapidly refreshed live image as well as extreme sensitivity for low light and live cell imaging. Its high sensitivity lets you use short exposure times, even with weak fluorescent markers, preventing damage to your samples.

Recommended for

- Live and fixed cell imaging
- Fluorescence applications with high dynamics

Simpler. More intelligent. More integrated.

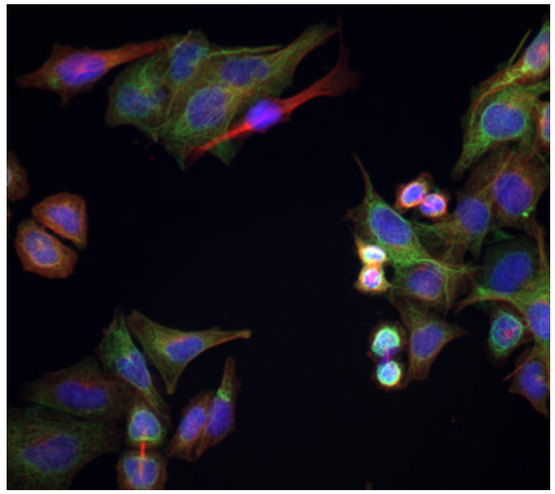
- USB 3.0 interface technology with fast 5-gigabit/s data transfer rate
- High-end quad-port CCD sensor technology for a fast image refresh rate of 38 images per second
- Up to 90 images per second with binning
- Ideal for high-aperture and low-magnification objective lenses, thanks to small (4.54 µm) pixel structures
- Thermo electrical cooled sensor



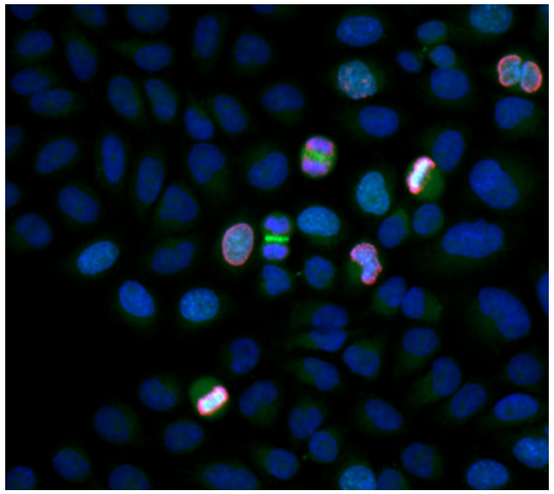
Relative spectral sensitivity

ZEISS Axiocam 506 mono

Your 6 Megapixel Microscope Camera for Live Cell Imaging – Fast, Flexible, and Sensitive



SK8 / K18 cells, staining: intermediate filaments labeled tagged with GFP (green), Tubulin Antibody label (red), DAPI (blue), acquired with ZEISS Axio Imager, objective: EC Plan-NEOFLUAR 40× / 0.7



HeLa cells, staining: Tubulin Alexa 488 (green), pHistone 3 – Alexa 568 (red), Hoechst 33342 (blue), acquired with ZEISS Axio Imager, objective: Plan-APOCHROMAT 40× / 1.4

This flexible 6 megapixel microscope camera is a true all-rounder. It produces a high quality and rapid live image as well as the highest level of sensitivity for low-light and live cell imaging. Its high sensitivity enables you to use short exposure times, even with weak fluorescent markers, preventing damage to your samples. You can increase sensitivity through pixel binning – and still have enough resolution for optimal imaging.

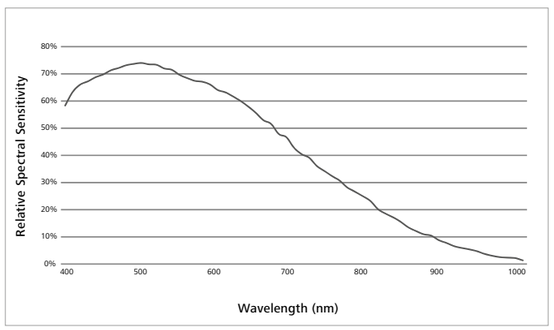
The camera's 1" sensor combines with the large number of pixels to give you a field of view twice as large as that of ⅔" cameras. You will always have a good overview of your sample.

Recommended for

- Live cell imaging
- High-resolution fluorescence imaging
- Fluorescence scanning applications

Simpler. More intelligent. More integrated.

- Excellent coverage of the microscopic field of view and sample overview, thanks to the 1" sensor – twice the field of view compared to ⅔" cameras
- USB 3.0 interface technology with fast 5 gigabit data transfer rate and qad-port, high-end CCD sensor technology for rapid frame rates
- 2752 horizontal pixels × 2208 vertical pixels gives high resolution, even when using pixel binning
- Up to 56 fps with binning 5 × 5
- Expanded area of application for high-aperture and low-magnification objectives, thanks to 4.54 µm small pixel structures – highest resolution with a large field of view
- Thermo electrical cooled sensor



Relative spectral sensitivity

ZEISS Axiocam 512 mono

Your 12 Megapixel Microscope Camera for Imaging of Large Sample Areas

With a sensor size of 1" (16 mm diagonal) this 12 megapixel CCD sensor delivers an excellent live image of fluorescent samples. That lets you acquire large object fields with low magnification and high numerical aperture objectives, and with good resolution – all in one shot.

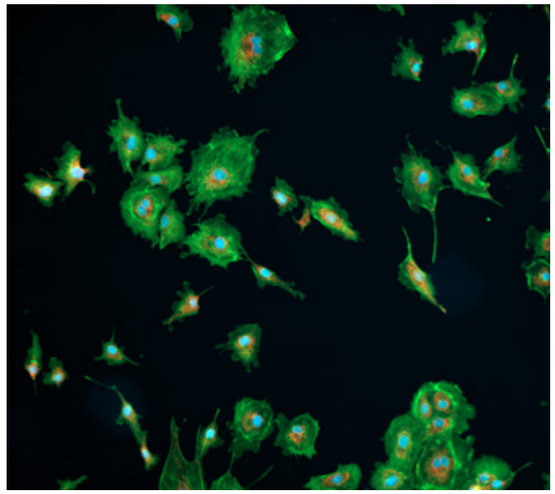
Images acquired with typical optical microscopes always feature a compromise between the level of detail in the image and how much of a sample can be shown. For example, densely packed individual cells often cannot be distinguished in an image that shows an entire organism, larger colonies or cells.
With Axiocam 512 mono you capture tissues and other samples in a way that allows the study of fine details.

The number of images necessary for large area acquisition is significantly reduced so you get more valuable data in less time, not only in screening applications.

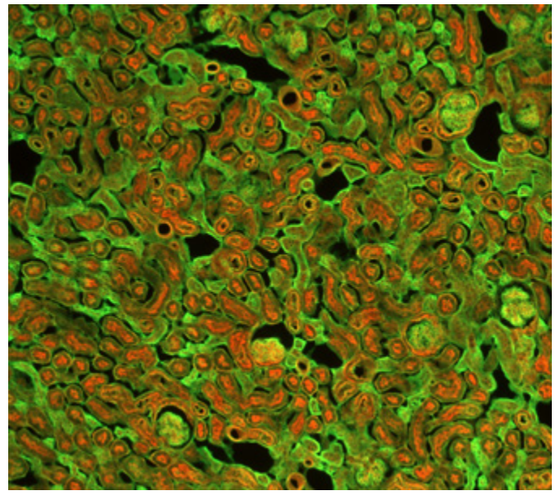
If you need to increase sensitivity for your live cell applications, you can do this with pixel binning and at the same time benefit from an increased frame rate.

Recommended for

- Fluorescence scanning applications
- Applications with elevated throughput
- High sensitivity monochrome imaging with extended spectral range



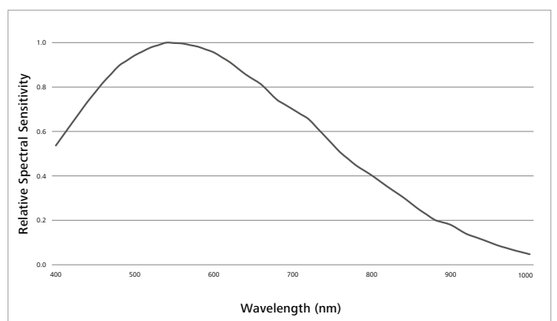
Indian Muntjac fibroblast cells, objective: Plan-APOCHROMAT 10× / 0.45. AlexaFluor 488 Phalloidin & MitoTracker Red CMXRos. Samples courtesy of: Michael Davidson, Florida State University.



Mouse kidney, objective: Plan-APOCHROMAT 10× / 0.45.

Simpler. More intelligent. More integrated.

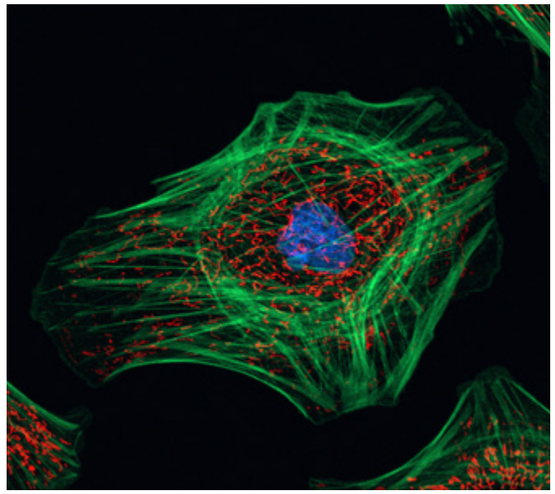
- Large field of view with high resolution of 12 megapixels
- 1" CCD sensor (diagonal 16 mm)
- Excellent live image and high acquisition speed
- 10 fps at full resolution of 4248 × 2832
  22 fps in HD format (1936 × 1080)
- Highest resolution with a large field of view: 3.1 µm pixels make it perfect for high-aperture and low-magnification objectives
- Simple PC connection through super-speed USB 3.0 interface technology
- Thermo electrical cooled sensor



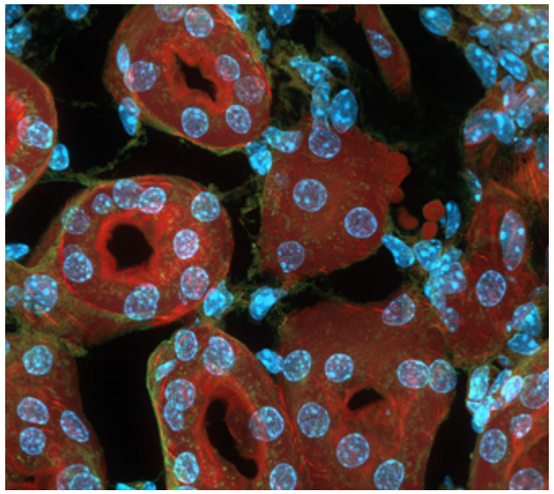
Relative spectral sensitivity

ZEISS Axiocam 702 mono

Your 2.3 Megapixel Microscope Camera for Fast Low Light and Live Cell Imaging



Indian Muntjac cultured cells.
Sample courtesy of: Michael W. Davidson, Florida State University



Mouse kidney section.
Sample courtesy of: Michael W. Davidson, Florida State University

Fundamental to the investigation of weak and rapidly changing signals in biology is the recent advancement in camera technology. Axiocam 702 mono offers cell biologists and all other researchers a high-speed, sensitive CMOS imaging solution that is user-friendly and affordable.
If provides sensitivity and temporal resolution at a very budget friendly price.

This high-performance CMOS microscope camera has 2.3 megapixels and a 1/1.2" sensor (diagonal 13.3 mm), making it the ideal choice for fast and sensitive fluorescence imaging.

Peltier cooling ensures low noise and reproducible image quality, particularly when you are dealing with long exposure times and dark areas in the sample.

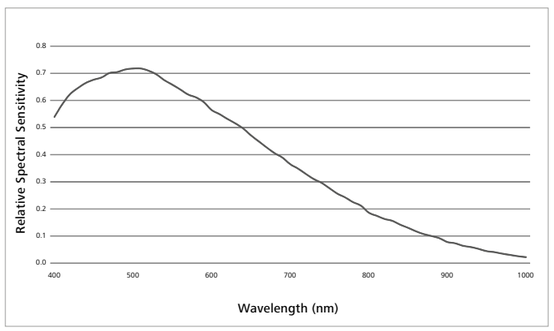
Highest light sensitivity combined with low noise and high frame rates give you the temporal resolution that you always longed for in live cell imaging.

Recommended for

- Live cell imaging with high temporal resolution
- Low light applications
- Imaging at higher magnifications

Simpler. More intelligent. More integrated.

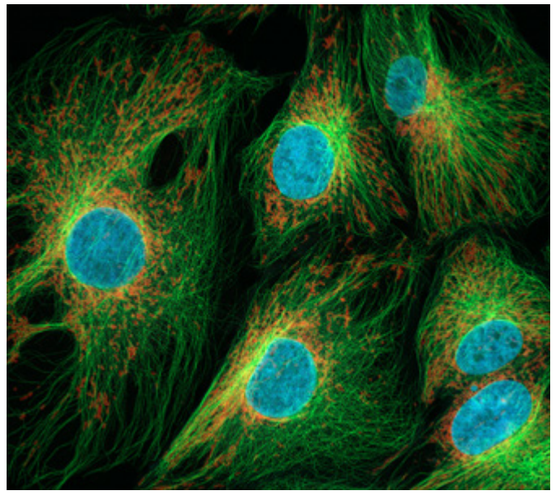
- Monochrome CMOS microscope camera with 2.3 megapixels
- Sensor size of 1/1.2" (diagonal 13.3 mm) and 1920×1216 pixels
- Pixel size of 5.86 µm
- Up to 128 fps at full resolution and up to 1000 fps @ 1024×128 pixels
- Dynamic range > 5000:1 (>74 dB) at typical < 6e read noise
- Thermo electrical cooled sensor



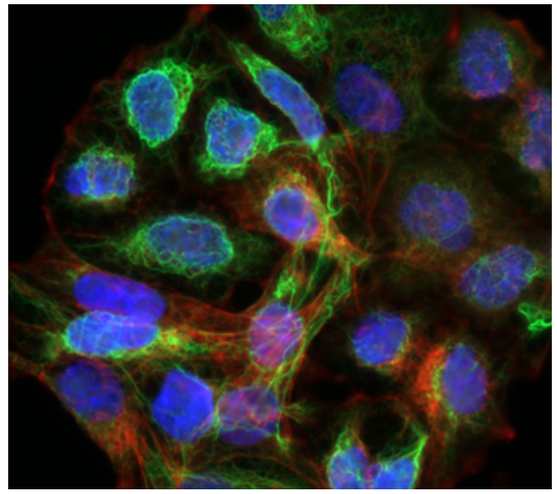
Relative spectral sensitivity

High End Fluorescence Cameras

Live Cell Imaging



BSC-1; African green monkey kidney cells, DAPI, Alexa 488 Tubulin, Alexa 568 TOMM20, acquired with ZEISS Axio Imager.Z2, ZEISS Axiocam 506 mono, ZEISS Apotome.2 with deconvolution



SK8 / K18 cells, green: intermediate filaments labeled tagged with GFP, red: Aktin Alexa 546, blue: DAPI, acquires with ZEISS Axio Imager, ZEISS Axiocam 503 mono, objective: Plan-APOCHROMAT 63× / 1.4

Fluorescence has revolutionized biological research in many areas. It started some decades ago with still images and single or dual stainings. Today, multiple fluorescence stainings or many fluorescent proteins in a live cell approach have become the standard. Often, you are also attempting 3-dimensional imaging to obtain more information from the sample at every time-point.

Tracking vesicles, observing changes in nuclear architecture or organelles and following differentiation of stem cells are just a few examples of live cell imaging applications that are becoming more and more frequent. This often means acquiring hundreds or even thousands of images to get the data you want from your sample.

Your challenge is that most cell types of mammals and other animals – and even plants – are not used to being exposed to light during their physiological processes. That makes it the natural goal for you when imaging living specimens to minimize exposure to light, all the while ensuring image quality is good enough to address your scientific question. High intensity light itself is damaging to cells and further phototoxic effects will result from fluorophore photobleaching. In addition to decreasing the available fluorescence signal with each exposure, photobleaching leads to free radicals and other reactive products.

This poses many challenges to the imaging system and especially to the camera. The most critical experimental challenge in collecting meaningful live cell microscopy data is to minimize photodamage while acquiring images with a sufficient signal-to-noise ratio.

Furthermore, emission spectra of fluorescent dyes and proteins are distributed across almost the entire spectrum. Cameras have to be sensitive in all spectral ranges where the relevant dyes fluoresce, such as in the near-infrared range.

There are specialized techniques such as lightsheet fluorescence microscopy (LSFM) to achieve this, and ZEISS has transferred this process into a product called Lightsheet Z.1. On the other hand, the right choice of microscope and camera also make a big difference when you are imaging with classic light microscopes, such as Axio Observer or Axio Imager, or novel automated imaging platforms, such as Celldiscoverer 7 and Axio Scan.Z1.

Short exposure times are key for successful live cell imaging experiments. To detect dim fluorescent signals, it is essential to use cooled scientific grade cameras with low read-out Noise. And such systems need to be precisely controlled so that the sample is only exposed to light during the actual exposure time of the camera.

The Axiocam portfolio leaves the researcher with a choice between cameras with two different types of sensors. You can choose a camera with a CCD sensor that is flexible and allows you to switch between higher resolution applications and live cell applications by binning pixels. Or you select a CMOS-type camera that allows extremely fast imaging at low-light conditions with excellent noise level.

In addition, your Axiocam is always precisely controlled by the imaging software from ZEISS and ideally matched to the optical properties of our imaging stands and systems. That lets you exploit the possibilities of the newest sensor technology to the maximum.

Integrated Network Cameras

Connect Your Microscopes and Your Students.

Integrated Network Cameras

Your Digital Classroom

Your students use microscopes to learn about the morphology of human, animal or plant cells. They will need a deeper knowledge of sample preparation, staining procedures and finally sample examination if they are to learn to identify, for example, blood cell disorders.

Some lectures also require a thorough knowledge of various microscopy techniques and software for image acquisition and documentation.

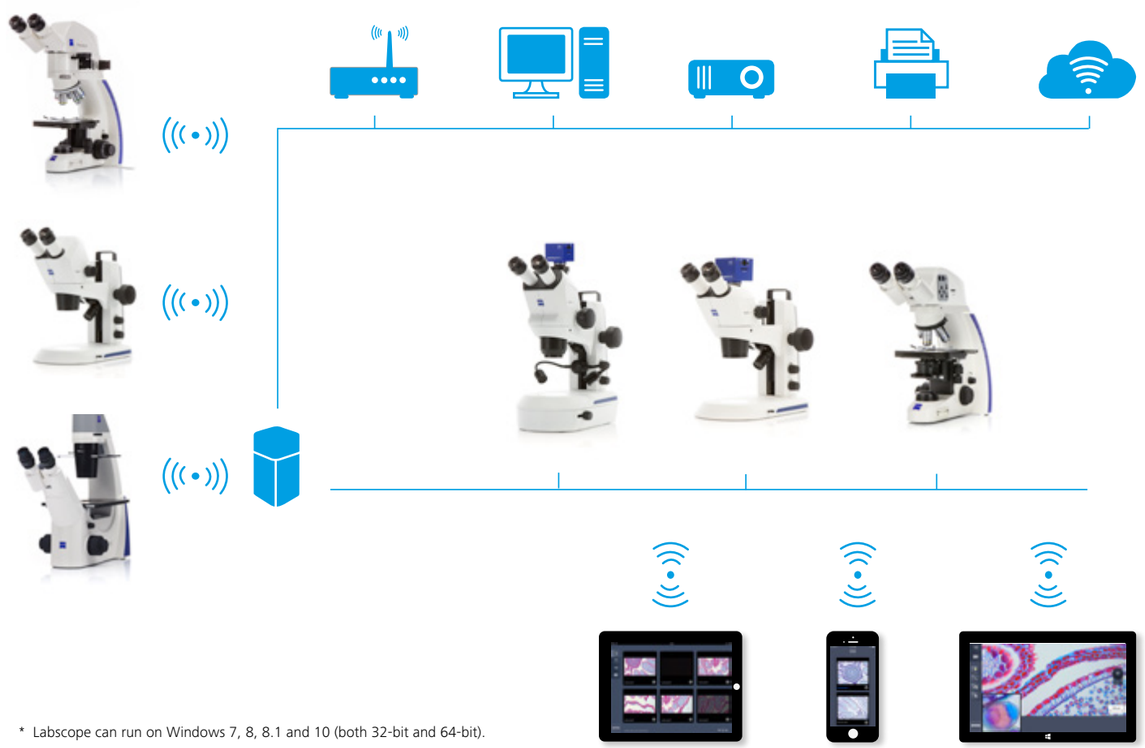
Hand drawings of samples like onion ephithelium or oral mucosa still play an important role in understanding morphology. In addition, digital school equipment such as smart boards, tablets, e-learning and interactive video courses are becoming an essential part of your learning and teaching methods.

Whenever you consider buying new school equipment, think about installing a digital classroom. An interactive digital classroom will help you produce the engaging atmosphere that motivates students to discover their field of study and reach their learning goals.

ZEISS microscopes and the imaging software Labscope make it easy to create a digital classroom with a network of connected school microscopes. You can now monitor all student microscopes from your own iPad or iPhone. And get your students encouraged by interactively involving them in your teaching. They will get on with their learning success in an enjoyable way and have fun in your training session by sharing their microscope images in their networks.

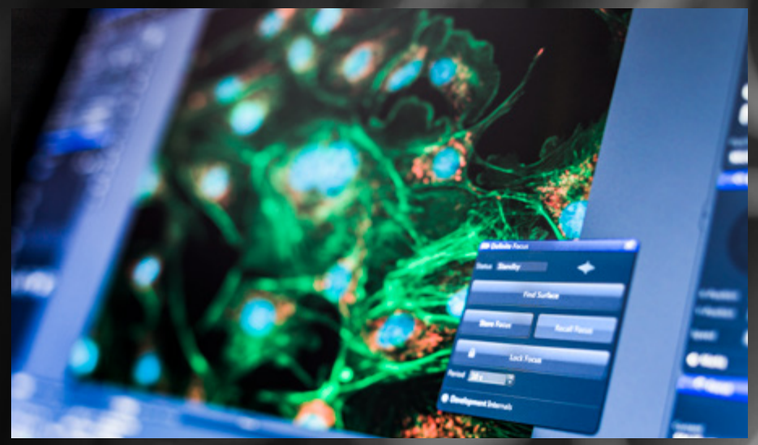
Document and archive your results.
And share the images in your digital network.
It is full of possibilities.

Windows 10 * Download on the App Store



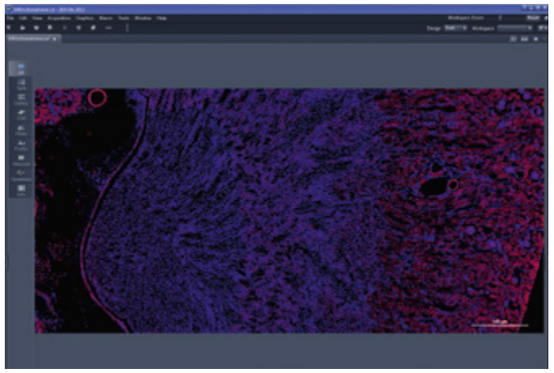
* Labscope can run on Windows 7, 8, 8.1 and 10 (both 32-bit and 64-bit).

Use ZEISS Imaging Software to Make Most of Your Axiocam



ZEISS ZEN Imaging Software

All Axiocam models come with a free version of ZEN, the user-friendly imaging software from ZEISS. ZEN unleashes all of your camera features so you will quickly and easily be acquiring brilliant images with your microscope. It presents all Axiocam functions in a simple user interface. Turn on automatic functions to support your imaging needs and get great results – fast! Non-destructive image handling and file formats, developed specially for microscopy, are just two benefits that guarantee you will get maximum information content in your images. In addition, the free ZEN packages are extended with useful features such as recording movies or exporting to various image data formats. Image scaling information is made available and stored together with your image data. Or simply use ZEN imaging software as an image viewer for both simple and complex images with multiple dimensions acquired on ZEISS microscopy systems.



ZEN lite

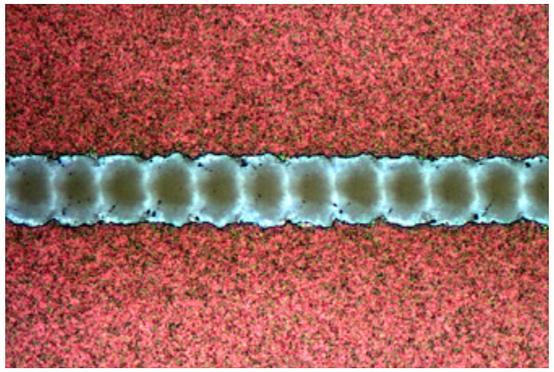
Your Microscope Software for Applications in Life Sciences

ZEN lite brings you into the core functionality of advanced ZEN software. For instance, you can modify your user interface color scheme to better suit your environment. Use ZEN lite in compact mode for a clear overview, or use the full view for quick access to all functions. ZEN lite saves your imaging conditions together with the metadata in the .CZI file format.

- Control ZEISS Axiocam microscope cameras
- Create, manage and export manually-scaled microscope images and record videos
- Use the manual focus of your microscope to create extended depth of focus images
- Stitch images together using the panorama functionality
- Use basic measurement functions to analyze your sample
- Review the metadata in your .CZI image files

Upgrade ZEN lite with optional features:

- Acquire multichannel images of your specimens
- Acquire time-lapse images of your specimens
- Use extended measurement functions to evaluate your sample
- Create image analysis workflows/wizards



ZEN 2 starter

Your Microscope Software for Industrial Applications

The free microscope software ZEN 2 starter brings you these key features for materials applications:

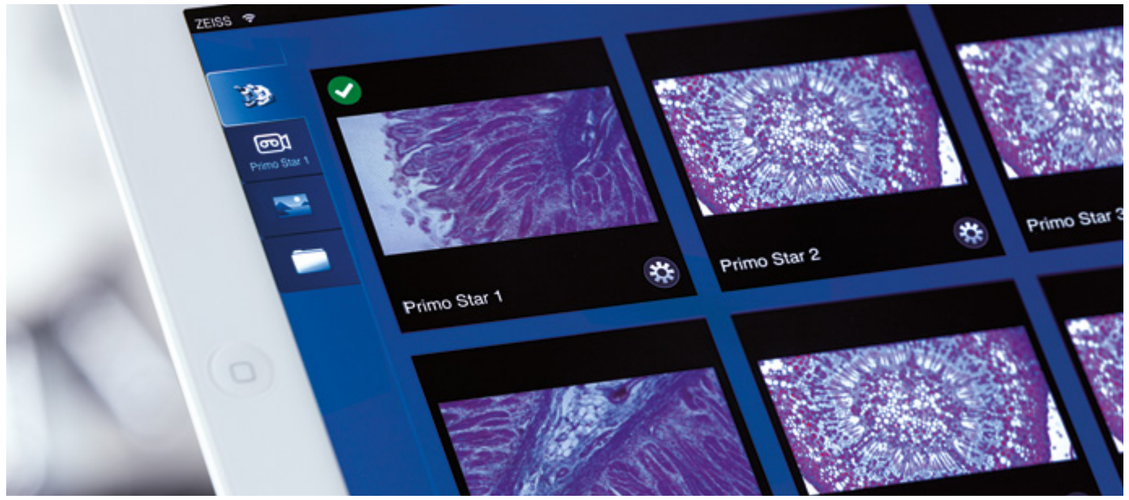
- Control ZEISS Axiocam microscope cameras
- Use customizable workbenches
- Create, manage and export manually-scaled microscope images and record videos
- Use the manual focus of your microscope to create extended depth-of-focus images
- Stitch images on-the-fly using the automated panorama functionality
- Use basic measurement functions to analyze your sample
- Create Microsoft Word reports
- Save your data and documents in the Data Archive

Upgrade ZEN 2 starter with optional features:

- Control ZEISS microscopes
- Use workbenches for repetitive application tasks
- Analyze your images automatically
- Control and acquire temperature-triggered image sequences with the Linkam heating stage
- Manage and link your data to IMS
- Correlate your images between light- and scanning electron microscopes
- Take advantage of GxP functionalities for audit trail and process insurance

ZEISS Labscope

Your Imaging Software for Digital Classrooms and Routine Laboratory Work



Labscope is your easy-to-use imaging software for connected microscopy. Be it for the laboratory, university, school or even your hobby – it's easier than ever before to snap images, record videos and measure your microscopic samples.

Labscope transforms your ZEISS network-compatible microscopes into a WiFi-enabled imaging system. You can easily create digital classrooms or digital labs – just connect to any of the microscopes at any point in time and from anywhere in your room. Explore the advantages of an interactive learning atmosphere where you can engage your students fully and enthuse them with the content of your lessons. You don't need to invest in parallel IT-equipment for your sequential processes. Control your cell laboratory microscopes with a connected iPad, iPhone or Windows PC, store images by workplace and observe cell cultures comfortably from your office. Then share your images – at the touch of a finger.

Configured to Your Requirements

Microscopes
All microscopes with a camera interface
Primo Star HDcam
Primovert HDcam
Stemi 305 cam

Camera
Axiocam ERc 5s

Software
ZEISS iPad imaging software Labscope
(free download in iTunes store)

Functionality
Documentation, image processing, camera control, storage on SD, iPad, iPhone, PC, server (cloud), report function, social media, measurements / annotations, parallel display of several microscope cameras

Simpler. More Intelligent. More Integrated.

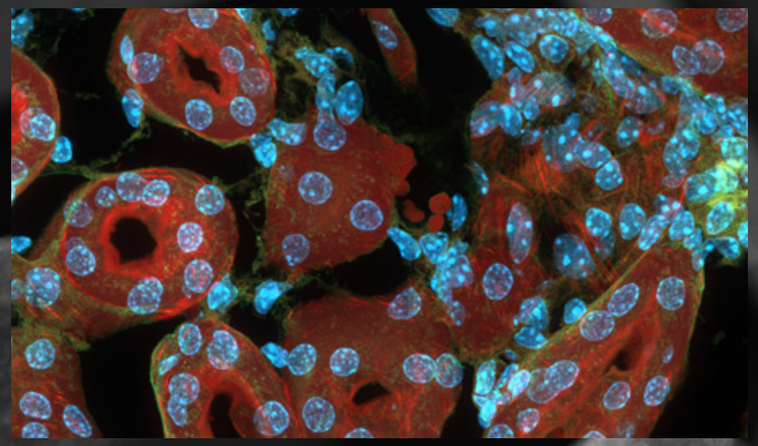
- Take your choice: HDMI, USB, and LAN interfaces and an SD card slot offer you many options
- Use the HDMI interface to view directly on a screen without a PC
- Simply save images and videos to an SD card at the touch of a button
- Connect the camera to your Wi-Fi network and enjoy the benefits of the imaging software Labscope
- Use the integrated laser pointer to lead your students to areas of interest. Let them do their hand drawings with the drawing tube function

Created for Your Applications

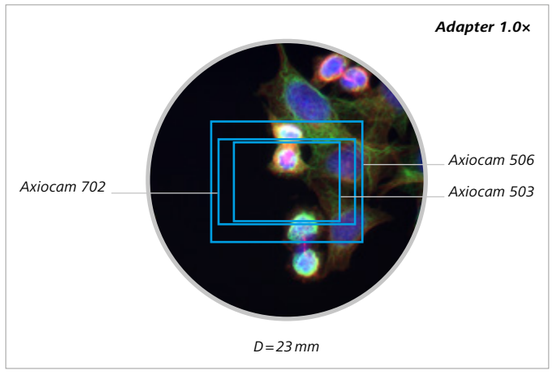
- Document results or dynamic processes for specific microscopes with images and videos directly on your iPad
- Make direct comparisons with other images
- Take measurements, annotate the results and save them on the file server integrated into the network
- Load application images onto the iPad for talks and presentations, and use its image processing tools
- Create individual reports with ease
- Give a live presentation with your iPad, iPhone or Windows PC
- Network your classroom and move around freely while teaching

Knowledge Base

Your Resource for Camera Terminology



Sensor Size vs Camera Adapter vs Field of View (FOV)
Use a c-mount camera adapter to mount your camera onto your microscope. Depending on the magnification factor of the adapter, the camera's sensor may cover more (lower magnification) or less (higher magnification) of the image coming out of your microscope (intermediate image). Typical intermediate image sizes are 25 mm for Axio Imager, 23 mm for Axio Observer or 23 mm for Axio Zoom.V16.



Different sensor sizes in relation to field of view.

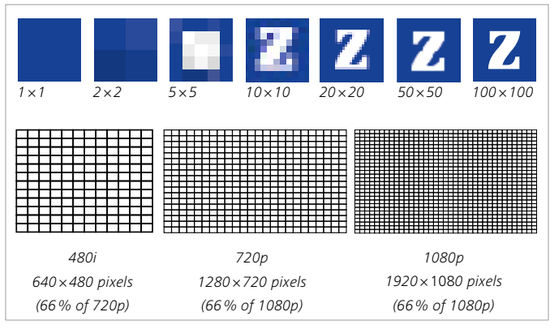
Typical image sensor diameters are 7.9 mm (½" format), 11 mm (⅔" format) or 16 mm (1" format).

Different C-mount adapter magnifications are 1×, 0.63×, 0.5×. Using a lower adapter magnification such as 0.63× causes into a:

- Demagnification of the intermediate image, resulting in a larger field of view for the final image
- Enlargement of pixel size, thus increasing light intensity detected by the sensor
- Enlargement of pixel size, which reduces the effective camera resolution

Resolution
The spatial resolution of a digital camera is related to the pixel density, which is defined by the pixel count per sensor area. The smaller the pixel aperture, the finer is the sampling of the presented structure. The reproduction of fine structures (lines) requires at least two pixels per structure sequence (line pair). Depending on the spectral composition of the signal, the optical resolution of color cameras can be slightly lower compared to monochrome cameras because of the color filter array. However, elaborate interpolation algorithms allow color cameras to provide optimal image quality.

Pixel Size



The pixel size defines the resolution.

One pixel is the smallest effective area on the sensor which is to become one image picture element.

The unit cell size can be estimated by taking the geometrical length (height) of one sensor line (column) and dividing it by the number of all pixels in one line (column).

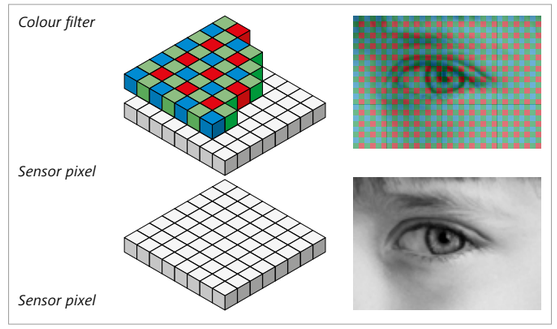
Effects of pixel size:
Smaller pixels are

- good for higher resolution
- lower in dynamic range
- less light sensitive
- noisier

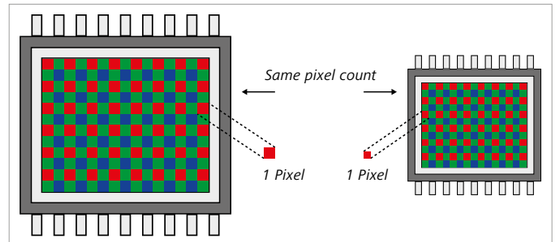
Larger pixels are:

- good for better light sensitivity
- less noisy
- higher in dynamic range
- reducing the spatial resolution

The best pixel size is a balance between sensitivity (larger pixel) and resolution (smaller pixel) to get the best possible compromise for the imaging requirements at a given optical setup.



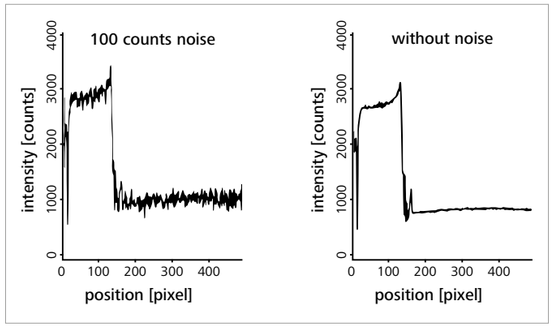
Monochrome and colour sensors – a comparision.

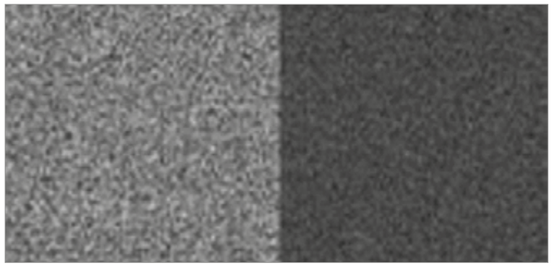


Even when the pixel count is the same, the image taken with the larger-sized pixels is less noisy because the CCD sensor is larger.

Name of Effect	Related Limitation	Counter Measure
Dark current Spurious signal by thermally generated electrons inside the sensor silicon material. This signal varies from pixel to pixel and causes an exposure time dependent signal offset for each individual pixel. In addition it contributes to the signal noise.	Maximum exposure time, Low light sensitivity, dynamic range, single pixel defects (hot pixels)	Given for a specific sensor-technology, active thermo-electrical cooling
Readout noise Noise added to the signal during read-out	Low light sensitivity, directly limiting the potential low light detection threshold, dynamic range	Sensor design and analog signal management dependent, signal amplification by EMCCD architecture
Photon shot noise Physical property of light, proportional to square root of produced electrons	Detection precision at high intensity levels, noisy, low light images	Theoretical and practical limit of detection is absolute, therefore no direct countermeasures
ADC effects Differential and integral linearity effects, quantitation errors	Detection precision, intensity errors	Use of good ADCs, use more bits than needed, software calibration algorithms
Static sensor artefacts Defective pixels, non-uniformity effects of photo response, dark current, dark offset, electronic glow, hot pixels, column or row offsets, black offset non-uniformities	Visible cosmetic defects, fixed patterns in image overlaying image information	On the fly processing of the image data with correction algorithms, black reference, pixel wise dark current maps, use of selected sensors, Correction by calibration of static effects, dead pixel storage memory in camera
Dynamic sensor artefacts Blinking pixels, hot pixels, pixel and line offset flicker effects, electro-magnetic crosstalk of high frequency interference effects, etc.	Visible cosmetic defects, traveling overlaid patterns in image, subsequent artefacts in multi channels or Z-stack images causing errors in 3D renderings, errors in post processing algorithms like segmentation, counting, etc.	High quality electronic design, electronic shielding, high quality cables and connectors, on the fly dynamic correction algorithms, selection of high quality components, high quality sensors and dark current calibration.

Overview





Dark Noise *(Thermal Noise): origin by thermal electrons in the CCD cooling about 8 – 10° reduces dark rushing by factor two*

Noise

Noise in a digital camera is a random fluctuation of the image signal which causes a detection error. Noise can come from various physical sources and it limits the detection capability of a given camera. Post-processing algorithms can be used to minimize noise, but this sacrifices other image factors such as resolution.

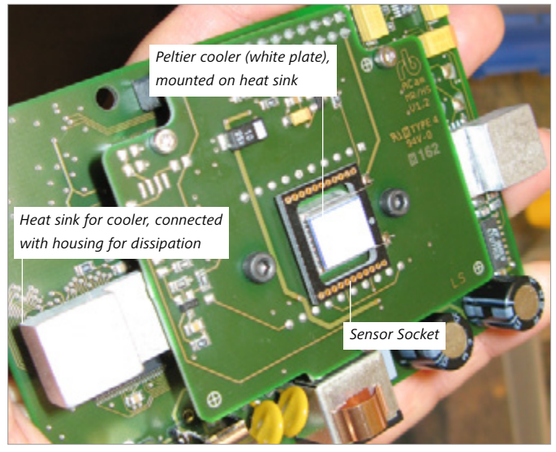
Sensor Cooling

Cooling is used to minimize the thermal generation of electrons (dark current) in the sensor silicon material and the resulting dark current noise. You can reduce the dark current by approximately a factor of two by lowering the sensor temperature by 7 °C. Active thermo-electrical cooling prevents the sensor from being heated by the power dissipation inside the camera electronics.

Electronic Signal Gain

Description	Explanation	Advantage	Disadvantage
Analog Gain	Amplification of the analog voltage signal at the output of an image sensor before the Analog-Digital-Converter (ADC)	■ Increases the brightness impression of the signal ■ Needed to optimally adapt the analog signal output from the camera sensor to the input range of the Analog-Digital Converter (ADC) within the camera electronics Special case: in the case of a bottleneck from the ADC input range → analog gain can be used as sensitivity improvement	■ Standard case: when the ADC can handle the full signal amplitude of the sensor no sensitivity improvement can be achieved by analog gain ■ Images look very noisy ■ Reduction of available intra-scene dynamic range
EM-Gain	Electron Multiplication-Gain. Dedicated on-chip high-voltage acceleration stage	■ Compensation for read noise limitation → real detection improvement of low light image signals ■ In combination with back thinning technology and large pixels → providing best possible low light sensitivity	■ Image affected by new noise source → random bright pixel events → minimization of EM-gain required ■ Gain efficiency affected by ageing → limited durability of EM gain ■ Reduction of available intra-scene dynamic range
Digital Gain	Multiplication of the digital pixel value by a numerical factor	■ Mathematical way to increase brightness ■ Commonly used for adapting different intensities to display different fluorescence channels in a multichannel image	■ No increase in detection sensitivity ■ Histogram representation affected → gaps in the histogram data ■ Reduction of available intra-scene dynamic range

Ways to amplify signals in cameras



Digital CCD cameras and common effects dark current – Thermo Electrical Cooling

Cooling requires a heat sink to dissipate power from the thermo-electrical cooler itself. Additional measures are needed to prevent condensation from humidity on the cold sensor surface. Modern sensors show a vastly reduced amount of dark current compared to devices from the past. Extremely low temperatures – say, –20 °C – are not always required. Cooling is still unavoidable for EMCCD cameras, due to their specific working principle. All other camera technologies have a benefit by cooling only at long exposure times (after some 30s and more), when the low dark current sums up and gets disturbing again.

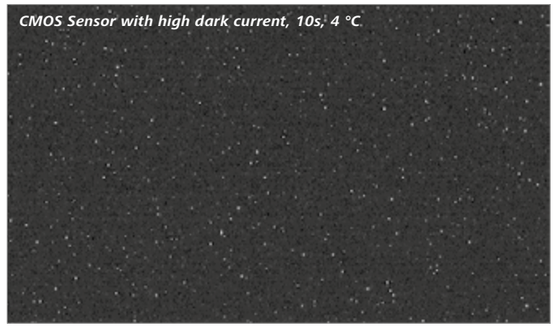
Binning

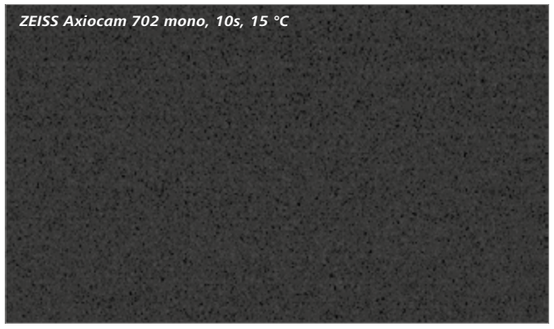
Camera sensitivity can be increased by combining photo generated signal charges from neighboring pixels during read-out. This also increases the camera frame rate. One side effect is the loss of image resolution. Binning factors can range from 1 × 1 (no binning) up to multiple pixels such as 5 × 5. Multiple charge binning is mainly available for CCD sensors. Binning in CMOS camera sensors is traditionally done in the digital domain by adding neighboring pixel values, which gives no extra sensitivity.

Framerate

The frame rate of a digital camera denotes the number of images which can be delivered per second (fps = frames per seconds). Unlike TV cameras, scientific cameras are not limited to standard video frame rates. Digital camera frame rates depend on various parameters:

Exposure time	shorter = faster: Exposure time limits the absolute frame rate independent from all other technical factors. If the time to collect photons lasts for 100 ms, the maximum achievable frame rate is 1 / 100 ms = 10 fps.
Sensor readout speed/clock speed	higher = faster: Total time to readout: accumulate photon signal+ conversion into a digital signal + transmission to a PC. Exposure and Readout correspond to a full cycle of an image acquisition.
Pixel count	less = faster: The more pixels, the longer the readout cycle, the slower the frame rate. The interface bandwidth can become the bottleneck if the pixel count cannot be transferred within the sensor readout time.
Sensor sub frame / region of interest	smaller = faster: Definition of sensor sub areas (ROI) help reduce the amount of transmitted image data → frame rates can be increased, Prerequisite: exposure time is shorter then readout time of ROI
Bandwidth of digital interface	higher = faster: Data transfer capacity of the interface. Effective USB 3.0 bandwidth is approximately 320 Mbytes/s.
Parallel readout architecture of CMOS sensors	more = faster: CMOS sensors exceed the frame rates of comparably sized CCD sensors due to significantly more parallel output structures on the sensor. The interface bandwidth is more likely to be the data transfer bottleneck.
Trigger signal synchronization	Synchronization of external trigger components with image acquisition → reduction of the maximum achievable frame rates with improvement of precision.
Overlapping readout and exposure	Special optimization for fast time series acquisition (fast time-lapse) without switching external components → overlap of exposure event while readout of the previous image. Only if exposure time is longer than readout → frame rate limited by exposure time.





ZEISS Axiocam 702 mono offers extended flexibility for long exposure times up to 60 s

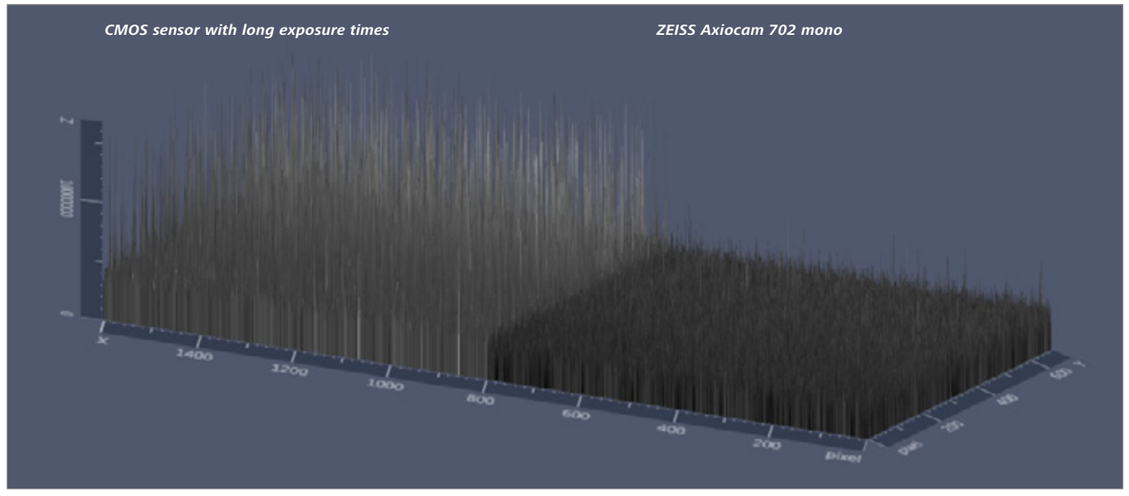
Hot Pixel

Cosmetic sensor defects are caused by a local emission of electrons in the sensor material. Hot pixels are visible as static single bright pixels against the black background. Their intensity varies widely and scales with exposure time and sensor temperature. The signal cannot be differentiated from photon generated electrons. If the sensor is temperature stabilized, the dark current can be compensated for by subtracting the spurious signal in correspondence with exposure time. Saturated pixels need to be interpolated because image information in these pixels is lost and cannot be reconstructed. Cosmic radiation can induce new hot pixel defects over time.

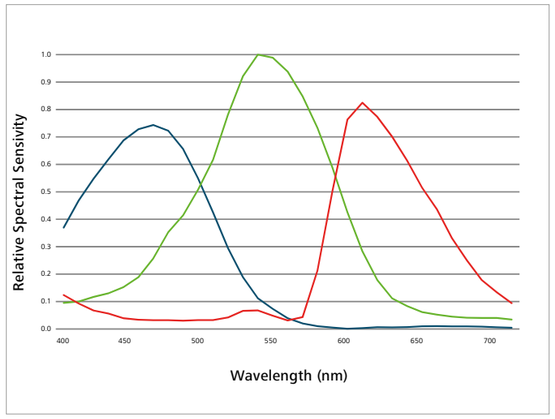
Spectral Sensitivity/Quantum efficiency

All kind of light detectors show a wavelength dependent light sensitivity. The conversion efficiency is the ratio of incoming photons to generated signal electrons stated as a percentage. Detection range of silicon based sensors like CCD or CMOS can stretch from approximately 350 nm up to 1000 nm, with a peak between 500 nm – 600 nm. For detection of radiation outside of this spectral range, other materials need to be used.

Modern front illuminated devices offer a typical QE in the range of 70 %. Monochrome peak QE can be improved with back thinned technology by up to 95 % in peak.



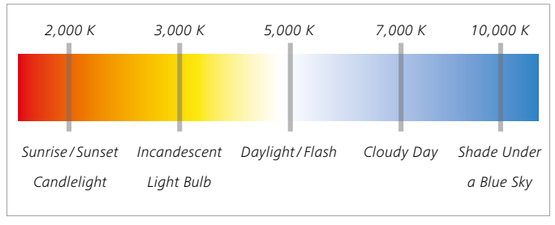
Left: Dark background, non uniformity from common CMOS sensor at 10s,
Right: ZEISS Axiocam 702 mono with modern CMOS sensor at 10s with very dark background, low non uniformity



Spectral Sensitivity ZEISS Axiocam 506 color and ZEISS Axiocam 503 color

The spectral sensitivity of color cameras is lower than monochrome cameras. The color filter dyes on the pixels reduce the peak spectral QE by approximately 15 %. Color cameras also need an IR filter as color is only defined in the visible spectrum.

Color Temperature



Color temperature is a temperature value (in Kelvin) of a light source and is used to describe the spectral characteristic of the corresponding spectral emission. It indicates the color impression of a light source: lower temperatures are more red, higher temperatures are more blue.

The color temperature of the light influences how the human eye perceives color.

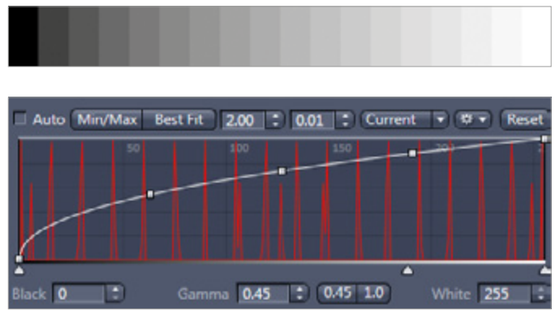
White Balance

The color of the illuminating light source influences the color of an object. The relative intensity of the color channels of a color camera needs to be adjusted to assure a neutral color reproduction. For this, you will need a manual or automatic selection of a neutral (grey) point in the image. Fine-tune the color reproduction by assigning slightly shifted target values for the neutral point. Adjust the color temperature of the monitor (i.e. 3,200 K) to reach the desired color reproduction.

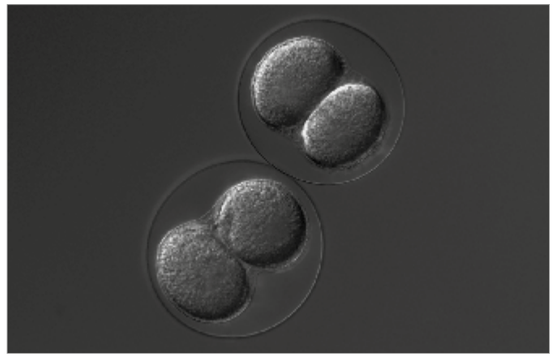
Display Curve

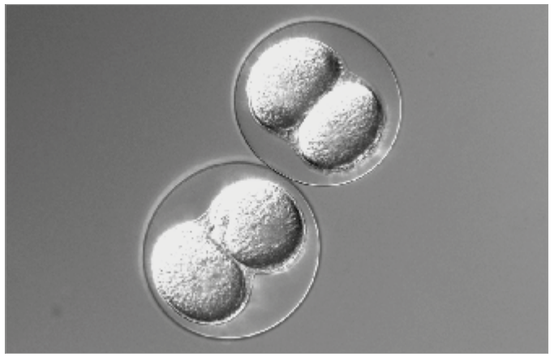
The image display curve is a powerful tool in ZEN imaging software, used to define how image data is displayed on a computer screen without changing the raw image data. Use this tool to adjust dark areas of your image visually by selectively changing the curvature or the steepness of the curve. Shift the minimum or maximum points to allow for the limitation of the visualized intensity range. The color rendition can be influenced by a Gamma curvature. Image characteristics are applied to the image data, if the image gets exported into non .CZI image formats.

Gamma adjustment – linear display



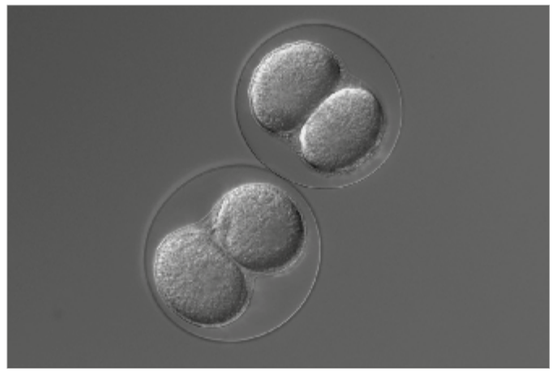
Gamma Adjustment – Gamma 0.45





A nearly linear Gamma over the whole dynamic range delivers a rather dark display of this transmitted light image.

The same image displayed with a steep display curve – cutting away some of the dark and bright information – shows too much contrast.



As seen here, a nonlinear Gamma curvature in the range of 0.45 over the whole dynamic range often delivers good results for transmitted light images.

Advantages of Monochrome Cameras for Fluorescence Applications

Monochrome cameras are better suited for fluorescence imaging than color cameras due to multiple reasons:

Feature	Explanation
Spectral Sensitivity Range	Full spectral range of the silicon, effective range from 350 nm up to 1000 nm due to for the lack of an IR blocking filter.
Absolute QE	Higher quantum efficiency of +8 % up to +30 % depending of the wavelength, due to no color filters on the pixels.
Spatial Resolution	Higher spatial/optical resolution, since there is no color filter pattern on the pixels. With a color camera, the pixels are 25 % red, 25 % blue and 50 % green. With the monochromatic signal from fluorescence, only a fraction of these pixels is then stimulated, and is thus less efficient.

Advantages of Monochrome Cameras for Fluorescence Applications

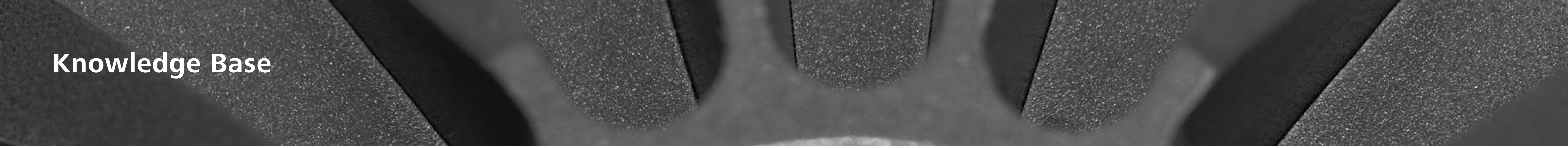
Dynamic Range

The available range of measurable intensities within one single image can be computed as the ratio between the brightest and the dimmest point in an image.

Maximum range is the difference between the saturation of the sensor (full well capacity) and the noise floor (read noise).

For example, full well 15,000 e^-/read noise 6 e^- = 2,500 resolvable intensity values in one image. In this case, a 12 bit analog-digital converter (ADC) is necessary to properly display these values.

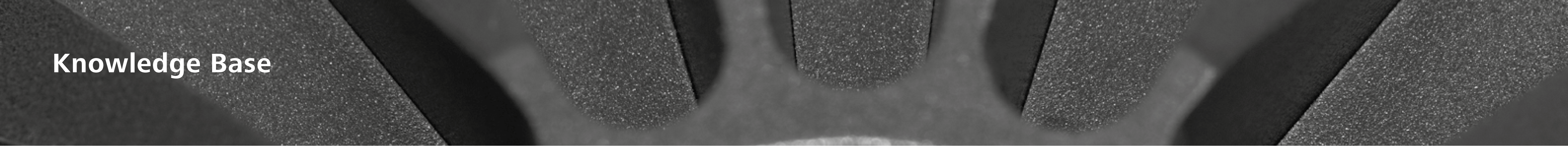
Sensor Technology	Explanation	Advantage	Disadvantage
CCD	"Charge Coupled Device", Proven reliable technology with a long history of optimization. Stable technology and quality	High sensitivity, good dynamic range, very homogenous image quality, low number of image artefacts, Usable for long exposure times with cooling. Minimum amount of post-processing needed, Global shutter architecture for simultaneous acquisition, Front illuminated and back illuminated solutions, Wide selection of pixel counts and pixel sizes available, different architectures (Interline global shutter, frame transfer)	External driver electronics and ADC required, Relatively high heat production from external support circuitry, Limited readout speed due to charge transport mechanism, Speed limitation due to architecture
CMOS	"Complementary Metal Oxide Semiconductor" Successor of CCD technology, recent breakthrough for mass production of quality products, currently high innovation rate	Products with broad range of different quality and performance levels. Fastest image readout due to massive parallel readout architecture, highest dynamic range, high light sensitivity, rolling and global shutter technology available, high quality mass production technology, sensor control and signal processing including on-chip ADC, wide selection of pixel counts and pixel sizes, Front illumination as standard, growing mass production of back thinned global shutter devices.	Limited range of usable exposure time, massive post-processing of image data due to high amount of non-uniformities and cosmetic defects, Widely used rolling shutter architecture can cause geometrical distortions from moving objects. Charge binning feature is not commonly available.
sCMOS	"Scientific Complementary Metal Oxide Semiconductor" High end CMOS breakthrough technology	Breakthrough technology, very low average readout noise enables very good low light signal detection, high dynamic range, high frame rates possible, sensor control and signal processing including on-chip ADC, large field of view	Only rolling shutter, mandatory post-processing of image data due to non-uniformities and cosmetic defects, limited exposure range, cooling required due to high dark current, blinking pixel noise, extreme bandwidth requires dedicated interface technology, i.e. camera link currently no charge binning feature
sCMOS Back Thinning	High end CMOS technology with back thinned technology for higher QE	Further improved sensitivity by higher QE up to 95 %	Expensive, low volume manufacturing, Only rolling shutter architecture, mandatory post-processing of image data due to non-uniformities and cosmetic defects, limited in maximum usable exposure time, cooling required to suppress higher dark current, new type of noise, currently no charge binning feature
EMCCD	Electron multiplication CCD, Back thinned Frame Transfer CCD with dedicated structure for amplification of photo generated electrons	Highest available detection sensitivity with semiconductor imagers, best choice for super low light imaging requirements, amplification architecture is built to skip the read noise limitation for detection of lowest signals	Low resolution, low pixel count, Possible artefacts due to frame transfer architecture, limited dynamic range, ageing effect of on-chip amplification structure, deep cooling mandatory for correct function, very high pricing



Technical Data

	Axiocam ERc 5s	Axiocam 105 color	Axiocam ICc1	Axiocam ICm1	Axiocam 305 color	Axiocam 503 color
Sensor type	CMOS, Rolling Shutter color / mono	CMOS, Rolling Shutter	CCD, Progressive Scan	CCD, Progressive Scan	CMOS, Global Shutter	CCD, Quad Port Progressive Scan
Sensor size	5.7 mm × 4.28 mm, equivalent 1/2.5" (diagonal 7.1 mm)	5.70 mm × 4.28 mm, equivalent to 1/2.5" (diagonal 7.1 mm)	6.3 mm × 4.8 mm, equivalent 1/2" (diagonal 7.9 mm)	6.3 mm × 4.8 mm, equivalent 1/2" (diagonal 7.9 mm)	8.5 mm × 7.1 mm, equivalent 2/3" (diagonal 11.1 mm)	Effective sensor size: 8.8 mm × 6.6 mm, Image diagonal 11 mm, equivalent to 2/3" sensor format
Pixel Count	5.0 megapixel: 2560 (H) × 1920 (V)	5.0 megapixel: 2560 (H) × 1920 (V)	1.4 megapixel: 1388 (H) × 1038 (V)	1.4 megapixel: 1388 (H) × 1038 (V)	5.07 megapixel: 2464 (H) × 2056 (V)	2.83 megapixel: 1936 (H) × 1460 (V)
Pixel size	2.2 µm × 2.2 µm	2.2 µm × 2.2 µm	4.65 µm × 4.65 µm	4.65 µm × 4.65 µm	3.45 µm × 3.45 µm	4.54 µm × 4.54 µm
Full Well Capacity	–	–	–	–	10,500 e^-	15,000 e^-
Quantum Efficiency						
Binning	Yes	Yes	No	No	Yes, digitally	Yes
Readout Noise	–	–	–	–	typ. 2.2 e^-	typ. < 6.5e (39 MHz), typ. 6 e^- (13 MHz)
Dark current	–	–	–	–	typ. < 1.0 e^-/p/s @ 25 °C	< 0.06 e^-/p/s @ 18 °C
Bit Depth	8 bit	8 bit	12 bit	12 bit	12 bit	14 bit
Exposure Time Range	10 µs – 2 s	100 µs – 2 s	1 ms – 4 s	1 ms – 4 s	100 µs – 4 s	250 µs – 60 s
Frame rate live image / time lapse recording	Not recommended for time-lapse imaging	15 fps @ 2560 × 1920 33 fps @ 1920 × 1080 (ROI in HD format) 62 fps @ 1280 × 720 (ROI in HD format)	16 fps @ 1388 × 1038 21 fps @ 1280 × 720 (ROI in HD format)	16 fps @ 1388 × 1038 21 fps @ 1280 × 720 (ROI in HD format)	36 fps @ full frame 67 fps @ 1920 × 1080 (ROI in HD format) 99 fps @ 1280 × 720 (ROI in HD format)	38 fps @ 1936 × 1460 (slow); 76 fps @ 640 × 484 (medium); 93 fps @ 384 × 292 (fast), 45 (ROI in HD format)
Cooling system	–	–	–	–	Sensor temperature stabilized at 25 °C	Delta-T 20 °C, sensor temperature 18 °C
External trigger	No	No	No	No	No	Yes
Spectral Sensitivity	Approx. 400 nm – 700 nm, IR filter	Approx. 400 nm – 650 nm, IR filter	Approx. 400 nm – 700 nm, IR filter	Approx. 400 nm – 1000 nm	Approx. 380 nm – 720 nm, coated IR cut filter	Approx. 400 nm – 720 nm, coated IR cut filter
Interface	1× SD card slot, 1× mini USB 2.0, 1× RJ 45 (LAN), 1× HDMI (DVI-D)	USB 3.0 Micro-B (Camera) to USB 3.0 Standard A (PC / Board)	2× FireWire IEEE 1394b	2× FireWire IEEE 1394b	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;

	Axiocam 503 mono	Axiocam 506 color	Axiocam 506 mono	Axiocam 512 color	Axiocam 512 mono	Axiocam 702 mono
Sensor type	CCD, Quad Port Progressive Scan	CCD, Quad Port Progressive Scan	CCD, Quad Port Progressive Scan	CCD, Quad Port Progressive Scan	CCD, Quad Port Progressive Scan	Active Pixel CMOS, Global Shutter, octa port readout
Sensor size	Effective sensor size: 8.8 mm × 6.6 mm, image diagonal 11 mm, equivalent to 2/3" sensor format	Effective sensor size: 12.5 mm × 10.0 mm; image diagonal 16 mm, equivalent to 1" sensor format	Effective sensor size: 12.5 mm × 10.0 mm; image diagonal 16 mm, equivalent to 1" sensor format	Effective sensor size: 12.5 mm × 10.0 mm; image diagonal 16 mm, equivalent to 1" sensor format	Effective sensor size: 12.5 mm × 10.0 mm; image diagonal 16 mm, equivalent to 1" sensor format	Effective sensor size: 11.3 mm × 7.1 mm; image diagonal 13.3 mm, equivalent to 1/1.2" sensor format
Pixel Count	2.83 megapixel: 1936 (H) × 1460 (V)	6 megapixel: 2752 (H) × 2208 (V)	6 megapixel: 2752 (H) × 2208 (V)	12 megapixel: 4250 (H) × 2838 (V)	12 megapixel: 4250 (H) × 2838 (V)	2.4 megapixel: 1920 (H) × 1216 (V)
Pixel size	4.54 µm × 4.54 µm	4.54 µm × 4.54 µm	4.54 µm × 4.54 µm	3.1 µm × 3.1 µm	3.1 µm × 3.1 µm	5.86 µm × 5.86 µm
Full Well Capacity	15,000 e^-	15,000 e^-	15,000 e^-	9,000 e^-	9,000 e^-	32,000 e^-
Quantum Efficiency	74 % @ 500 nm		74 % @ 500 nm		74 % @ 500 nm	78 % @ 525 nm
Binning	Yes	Yes	Yes	Yes	Yes	Yes, digitally
Readout Noise	typ. < 6.5e (39 MHz), typ. 6 e^- (13 MHz)	typ. < 6.5 e^- (39 MHz), typ. 6 e^- (13 MHz)	typ. < 6.5 e^- (39 MHz), typ. 6 e^- (13 MHz)	typ. < 6.8 e^- (39 MHz), typ. 6.5 e^- (13 MHz)	typ. < 6.8 e^- (39 MHz), typ. 6.5 e^- (13 MHz)	6.0 e^- @ gain 1×, 3.9 e^- @ gain 4× (opt), 3.75 e^- @ gain 16×
Dark current	< 0.06 e^-/p/s @ 18 °C	< 0.06 e^-/p/s @ 18 °C	< 0.06 e^-/p/s @ 18 °C	< 0.1 e^-/p/s @ 23 °C	< 0.1 e^-/p/s @ 23 °C	1.1 e^-/p/s @ 15 °C
Bit Depth	14 bit	14 bit	14 bit	14 bit	14 bit	14 bit
Exposure Time Range	250 µs – 60 s	250 µs – 60 s	250 µs – 60 s	250 µs – 60 s	250 µs – 60 s	100 µs – 60 s
Frame rate live image / time lapse recording	38 fps @ 1936 × 1460 (slow); 61 fps @ 968 × 728 (medium); 86 fps @ 640 × 484 (fast), 45 (ROI in HD format)	19 fps @ 2752 × 2208 (slow); 33 fps @ 917 × 733 (medium); 51 fps @ 550 × 440 (fast), 32 (ROI in HD format)	19 fps @ 2752 × 2208 (slow), 33 fps @ 1376 × 1104 (medium), 51 fps @ 912 × 736 (fast), 32 (ROI in HD format)	10 fps @ 4248 × 2832 (slow), 26 fps @ 1416 × 944 (medium), 35 fps @ 848 × 564 (fast), 22 fps with ROI in 1936 × 1080 HD format	10 fps @ 4248 × 2832 (slow), 26 fps @ 1416 × 944 (medium), 35 fps @ 848 × 564 (fast), 22 fps with ROI in 1936 × 1080 HD format	128 fps @ 1920 × 1216, 210 fps @ 1929 × 720, 288 fps @ 1920 × 512, 534 fps @ 1920 × 256, 1000 fps @ 1024 × 128
Cooling system	Delta-T 20 °C, sensor temperature 18 °C	Delta-T 20 °C, sensor temperature 18 °C	Delta-T 20 °C, sensor temperature 18 °C	Delta-T 15 °C, sensor temperature 23 °C	Delta-T 15 °C, sensor temperature 23 °C	Delta-T 23 °C, sensor temperature 15 °C
External trigger	Yes	Yes	Yes	Yes	Yes	Yes
Spectral Sensitivity	Approx. 350 nm – 1000 nm, coated protective glass	Approx. 400 nm – 720 nm, coated IR cut filter	Approx. 350 nm – 1000 nm, coated protective glass	Approx. 400 nm – 720 nm, coated IR cut filter	Approx. 350 nm – 1000 nm, coated protective glass	Approx. 350 nm – 1000 nm, coated protective glass
Interface	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;



Knowledge Base

Technical Data

	Axiocam ERc 5s	Axiocam 105 color	Axiocam ICc1	Axiocam ICm1	Axiocam 305 color	Axiocam 503 color
Power supply	5 W through 2× USB 2.0	1.7 W through USB 3.0	3.5 W through FireWire	3.5 W through FireWire	powered by 4 W through USB 3.0 – Bus from PC	powered by 7 W through USB 2.0 and USB 3.0-Bus from PC; For maximum performance connection to both USB 3.0 and USB 2.0 required
Operating system	Microsoft Windows 7 Ultimate, Professional	Microsoft Windows 7 ×64 Ultimate, Professional	Microsoft Windows 7 Ultimate, Professional	Microsoft Windows 7 Ultimate, Professional	Microsoft Windows 7 Ultimate, Professional	Microsoft Windows 7 ×64 Ultimate, Professional
Software	ZEN 2012 SP2; ZEN 2, ZEN Core	AxioVision SE64 4.9.1 SP1; ZEN 2012 SP2; ZEN 2, ZEN Core	AxioVision 4.8.2 SP3; AxioVision SE64 4.9.1 SP1; ZEN 2012 SP2; ZEN 2, ZEN Core	AxioVision 4.8.2 SP3; AxioVision SE64 4.9.1 SP1; ZEN 2012 SP2; ZEN 2, ZEN Core	ZEN 2, ZEN Core, AxioVision SE64	ZEN 2012 SP2; ZEN 2, ZEN Core
Dynamic range	–	–	–	Approx. 1 : 1000	Typical > 1:4800 (>73 dB)	Typical 1 : 2500 (68 dB)
Analog Gain	No	Yes	No	No	Yes	Yes

	Axiocam 503 mono	Axiocam 506 color	Axiocam 506 mono	Axiocam 512 color	Axiocam 512 mono	Axiocam 702 mono
Power supply	powered by 7 W through USB 2.0 and USB 3.0-Bus from PC; For maximum performance connection to both USB 3.0 and USB 2.0 required (dual connection cabling provided with camera)	powered by 7 W through USB 2.0 and USB 3.0-Bus from PC; For maximum performance connection to both USB 3.0 and USB 2.0 required (dual connection cabling provided with camera)	powered by 7 W through USB 2.0 and USB 3.0-Bus from PC; For maximum performance connection to both USB 3.0 and USB 2.0 required (dual connection cabling provided with camera)	powered by 7 W through USB 2.0 and USB 3.0-Bus from PC; For maximum performance connection to both USB 3.0 and USB 2.0 required (dual connection cabling provided with camera)	powered by 7 W through USB 2.0 and USB 3.0-Bus from PC; For maximum performance connection to both USB 3.0 and USB 2.0 required (dual connection cabling provided with camera)	powered by 7 W through USB 2.0 and USB 3.0-Bus from PC; For maximum performance connection to both USB 3.0 and USB 2.0 required (dual connection cabling provided with camera)
Operating system	Microsoft Windows 7 ×64 Ultimate, Professional	Microsoft Windows 7 ×64 Ultimate, Professional	Microsoft Windows 7 ×64 Ultimate, Professional	Microsoft Windows 7 ×64 Ultimate, Professional	Microsoft Windows 7 ×64 Ultimate, Professional	Microsoft Windows 7 ×64 Ultimate, Professional
Software	ZEN 2012 SP2; ZEN 2, ZEN Core	ZEN 2012 SP2; ZEN 2, ZEN Core	ZEN 2012 SP2; ZEN 2, ZEN Core	ZEN 2012 SP2; ZEN 2, ZEN Core	ZEN 2012 SP2; ZEN 2, ZEN Core	ZEN 2012 SP2; ZEN 2, ZEN Core
Dynamic range	Typical 1 : 2500 (68 dB)	Typical 1 : 2500 (68 dB)	Typical 1 : 2500 (68 dB)	Typical > 1380 : 1 (63dB)	Typical > 1380 : 1 (63dB)	Typical > 5000 : 1 @ gain 1×, HDR Mode 25.000 : 1
Analog Gain	Yes	Yes	Yes	Yes	Yes	Yes

	Axiocam ERc 5s	Axiocam 105 color	Axiocam ICc1	Axiocam ICm1	Axiocam 305 color	Axiocam 503 color
Histology / Pathology	++	++	++	+	+++	++++
Live Cell Imaging	+	+	+	+++	++	+++
Fluorescence Imaging	+	+	+	+++	++	++
Low Light Imaging for Dim Samples	+	+	++	+++	+++	++++
Semiconductor Inspection	++	++	+	+	+++	+++
Large Samples	+	+	+	+	+++	+++
Materials Research	++	+++	++	+	++++	++++
Quality Control	+++	+++	++	+	+++	+++
Teaching	++++	+++	+++	++	++	++
Clinical Routine	+++	++++	+++	+++	+++	++
Dynamic Range	+	+	++	++	+++	++++
Color Rendition	++	++	++	–	+++	++++

	Axiocam 503 mono	Axiocam 506 color	Axiocam 506 mono	Axiocam 512 color	Axiocam 512 mono	Axiocam 702 mono
Histology / Pathology	+	++++	+	++++	+	+
Live Cell Imaging	++++	+++	++++	++	++++	++++
Fluorescence Imaging	++++	++	++++	++	++++	++++
Low Light Imaging for Dim Samples	++++	++++	++++	+++	+++	++++
Semiconductor Inspection	++	++++	+++	++++	+	+
Large Samples	+++	++++	++++	++++	++++	+++
Materials Research	+	++++	+	++++	+	+
Quality Control	+	+++	+	++++	+	+
Teaching	+	+	+	+	+	+
Clinical Routine	+	+	+	++	+	+
Dynamic Range	++++	++++	++++	++	++	++++
Color Rendition	–	++++	–	++++	–	–

Service and Support
for Your ZEISS Microscope System

ZEISS Moments are about passion. The same passion that drives us to support and accompany you and your ZEISS microscope over its life cycle ensures that your work will lead systematically to success.

You work hard. We make sure your microscope keeps pace with you.
High imaging quality, reliable results and instrument availability are the parameters of your day-to-day working life. Your ZEISS microscope integrates seamlessly into this demanding workflow. It provides you with insights and results that you can trust: thorough, comprehensive and reproducible. With our Life Cycle Management we help you keep your microscope in optimum condition to get these optimum results.

Life Cycle Management comes with your microscope.
Life Cycle Management from ZEISS backs up our solutions throughout the working life of your ZEISS microscope system. From the procurement phase onward, you can count on our support with site surveys to optimize the location for your microscope system. Throughout the operational phase we will complement our service with support for relocations and upgrade opportunities that enhance or expand your possibilities. As soon as you think about replacing your long-serving microscope with a new one, we will take care of the disassembly and disposal of systems that are no longer needed. Rely on our service features: our employees analyze the status of your system and solve problems via remote maintenance or directly at your location.

From expert to expert
Never hesitate to ask our application specialists to support your specific tasks. Take advantage of our training sessions for any colleagues or employees who will be working with your ZEISS microscope.

Peace of mind and availability with regular maintenance
Your service plan is tailor-made for you. Make sure you take advantage of all the opportunities your ZEISS microscope system offers. Get optimized performance, instrument reliability and availability, all at predictable costs. Choose from different service levels of our Protect-Service Plans, ranging from Protect preventive, via Protect advanced, to Protect premium. We look forward to discussing your ideal Service Plan personally.

The moment you see something that has been hidden from you until now.
This is the moment we work for.

How will doctors treat their patients in the future? How far can we go with the miniaturization of semiconductor structures? What role will photographs and videos play in the way we communicate in years to come? These and many other questions are what drive us every day at ZEISS. Only those who ask will find the answers.

As pioneers in the industry and one of today's worldwide leaders in the field of optics and optoelectronics, we have always pushed the limits of the imagination at ZEISS.

The questions for medicine in the future are already being worked on by our people – with boldness, passion and innovation. From this impetus will come medical instruments that optimize the success of treatments and laboratory devices that will underpin medical advances.

The many challenges that industry faces also motivate us to continue setting new standards in technology. As we do, quality in all components is being safeguarded by ZEISS. Just as it will be in the smaller, higher-performance and low-priced microchip of the future.

ZEISS researchers and developers are working with equal determination to realize their quality standards for moving and fixed images. Whether in the largest planetarium in the world or in the smallest smartphone that has ever been built, it's going to happen and you will see it. This passion for topmost performance links all business areas at ZEISS. That's how we create advantages for our customers and inspire the world to look for things that have been hidden until now.

Carl Zeiss Microscopy GmbH
07745 Jena, Germany
microscopy@zeiss.com
www.zeiss.com/microscopy