ZEISS Axiocam Family

Your Guide to Microscope Camera Technology from ZEISS.

zeiss.com/axiocam

Seeing beyond

Cameras for Teaching or Routine Applications

High End Color Cameras

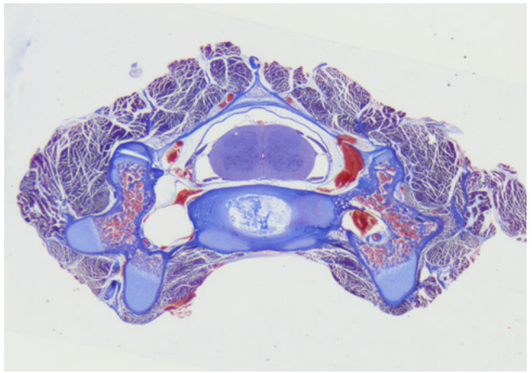
Polarization Camera

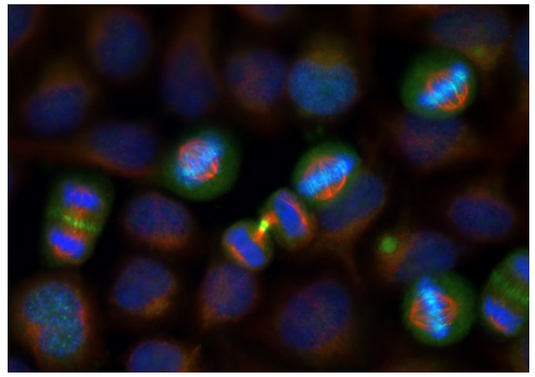
High End Fluorescence Cameras

Integrated Network Cameras

Visualization and Documentation

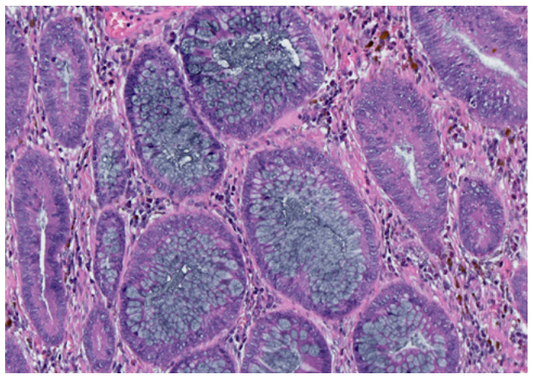
Camera technology as diverse as your imaging and documentation tasks.





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 USB, 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 which are used to describe them.



Select your ZEISS Axiocam to match your requirements.

Welcome to the fascinating world of microscope cameras. With this compendium, you'll get an overview about the whole portfolio of ZEISS Axiocams. Discover many exciting applications and use it as your guide to selecting the best camera for your imaging and documentation tasks.

Cameras for Teaching or Routine Applications

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. For polarized light applications a special camera provides meaningful color-coded visualization.

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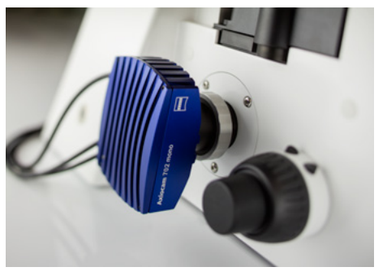

High End Fluorescence Cameras

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 36

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.

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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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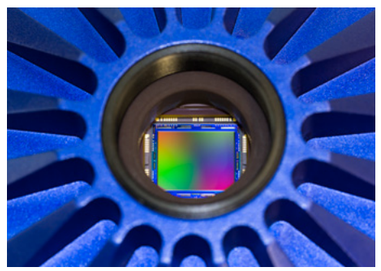
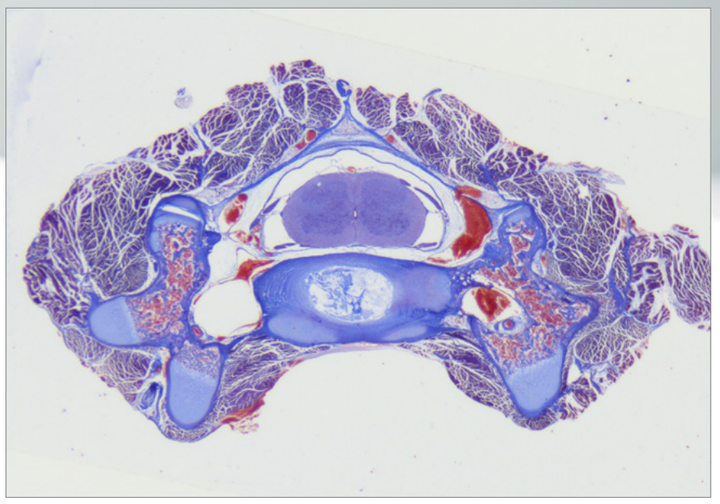


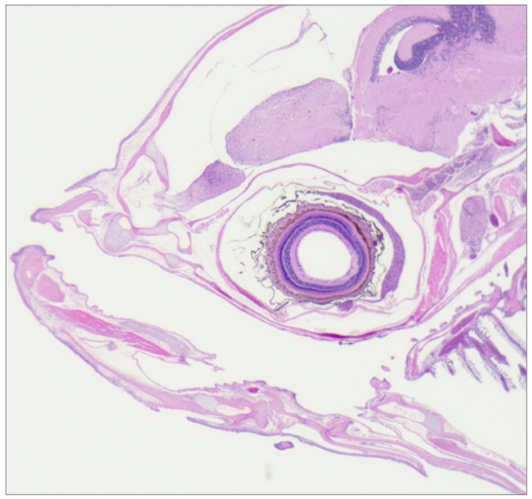
Cameras for Teaching or Routine Applications
Enjoy efficient, easy operation.



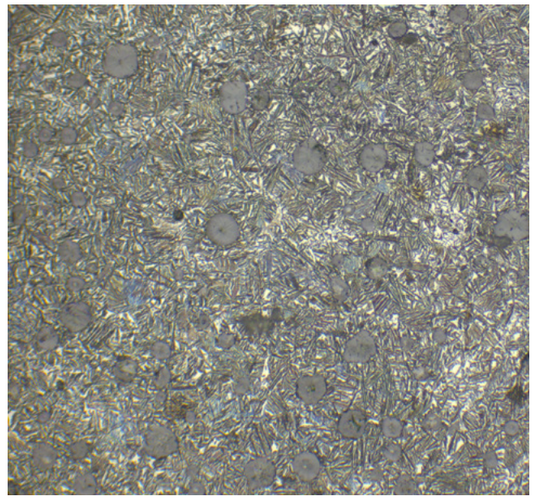
These cameras meet the needs for easy operation and efficiency.
You benefit from live images with exactly the right resolution and crisp contrast.

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×

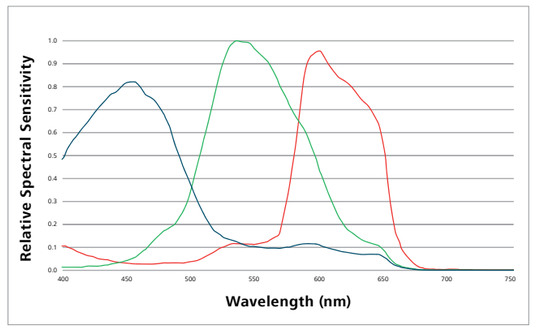
Axiocam 105 color is your small, no-frills microscope camera. With its compact design, it makes quick and efficient work of your daily documentation needs.
With its USB 3.0 connection, experience a high speed data transfer rate for handling your high resolution 5 megapixel color images. Offering an exposure 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

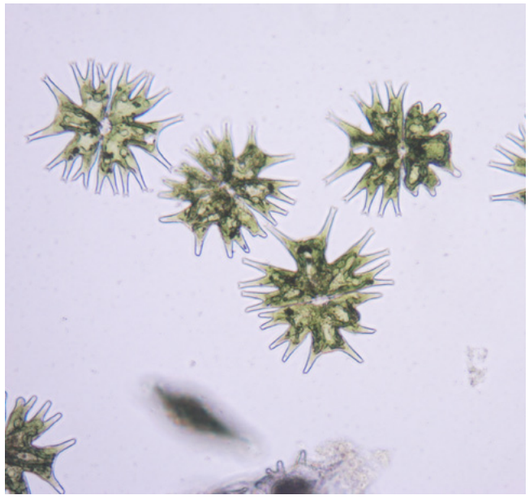
ZEISS Axiocam ERc 5s

Your 5 Megapixel Standalone Microscope Camera

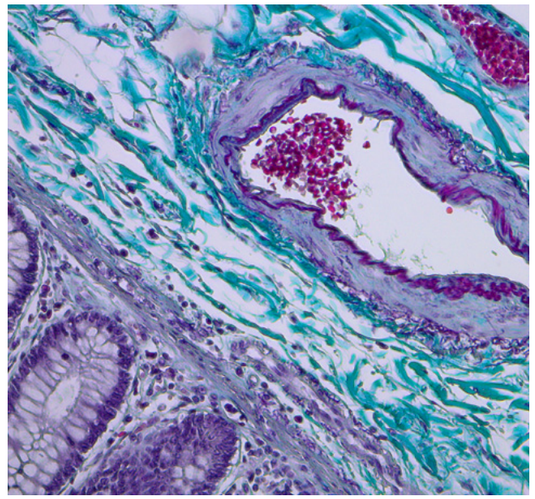
This 5 megapixel CMOS camera from ZEISS offers you flexible technology at an impressive price-performance ratio.
With Axiocam ERc 5s you capture the finest details of structures in your sample in high resolution. Connect your camera in a multitude of ways. Attach it to your PC to acquire crisp images with the easy-to-use imaging app Labscope or 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



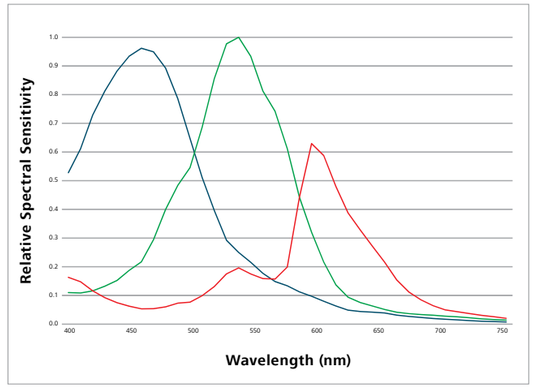
Micrasterias radiata *(algae), brightfield*



Pig gut, May-Grünwald-Giemsa staining

Simpler. More Intelligent. More Integrated.

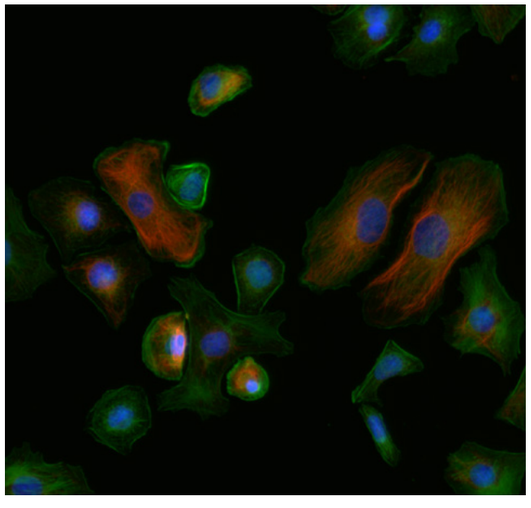
- 5 megapixel CMOS sensor
- 8 bit digitization
- High resolution with 2.2 µm pixel
- Color and black & white imaging modes
- Flexibility – use Axiocam ERc 5s as a stand-alone camera and acquire images / movies directly to an SD card.
  Or use it as digital video camera and stream HD (720p60 or 1080p30)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



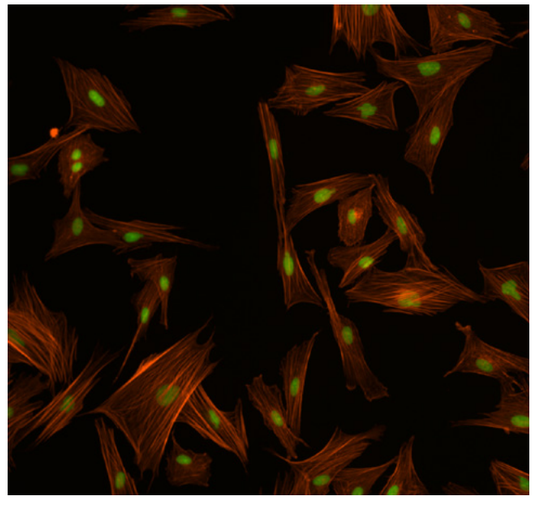
Relative spectral sensitivity

ZEISS Axiocam 202 mono

Your 2 Megapixel Stand-alone Microscope Camera for Routine Fluorescence Documentation



Mink endometrium cells, Vimentin (Ms) – Alexa Fluor 568, Phalloidin – Alexa Fluor 488, Hoechst 33342, acquired with ZEISS Axioscope 5, objective: Plan-APOCHROMAT 20×/0.8



Indian muntiac, deer epidermis fibroblasts, Tubulin (Ms) – Alexa Fluor 405, Phalloidin – Texas Red, SYTOX Green, acquired with ZEISS Axioscope 5, objective: Plan-NEOFLUAR 10×/0.3

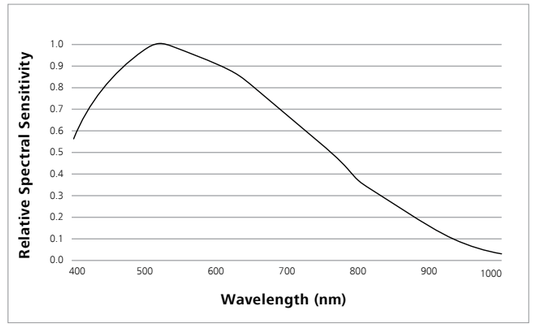
Axiocam 202 mono is your 2 megapixel monochrome microscope camera with automatic functions for routine fluorescence applications. With this CMOS sensor camera you can easily acquire monochrome images in stand-alone mode with no need of a PC. Since the camera automatically adjusts the exposure time you only need to press the snap button to capture and store your fluorescence images on a USB flash drive. If needed you can adjust parameters in the OSD (on screen display) menu before you acquire the image. In combination with the smart microscopes Axiolab 5 or Axioscope 5 you can even capture multichannel fluorescence images by simply pressing one button.

Recommended for

- Applications with bright fluorescence samples
- Documentation
- Education/Teaching
- Fluorescence imaging applications with live and fixed cells
- Documentation of fluorescent cell cultures
- Routine tasks in cell laboratories

Simpler. More Intelligent. More Integrated.

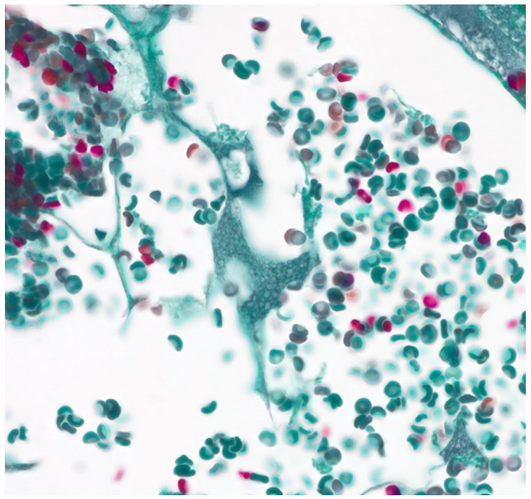
- 2 megapixel CMOS chip sensor with image diagonal of 13 mm and large pixel size for high sensitivity in fluorescence documentation
- Choose between 12 bit or 8 bit digitization
- Store images directly on USB flash drive in stand-alone mode
- Single button multichannel fluorescence acquisition when combined with Axiolab 5 or Axioscope 5 stands in stand-alone mode (with no PC)
- Automatic exposure and gain adjustment for easy fluorescence image capture
- Connect directly to a monitor by a HDMI cable for live image display for search and focussing and review of acquired images
- Perform secure image data transfer to TWAIN-compatible 3rd party software solutions with the TWAIN driver.



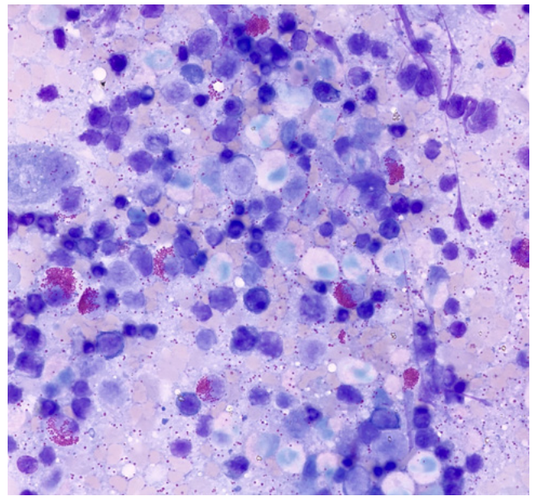
Relative spectral sensitivity

ZEISS Axiocam 208 color

Your Fast, 4K Microscope Camera for Smart Digital Documentation



Trichrome stained blood vessels in transmitted light brightfield, acquired with ZEISS Axiolab 5, objective: Plan-APOCHROMAT 40×/1.4



Red bone marrow in transmitted light brightfield, acquired with ZEISS Axiolab 5, objective: Plan-APOCHROMAT 40×/1.4

Axiocam 208 color is your smart versatile 8 megapixel color microscope camera suitable for education, documentation and routine applications. This CMOS camera delivers crisp, detail rich live images with high color fidelity at full 4k resolution in outstanding 30 fps. Choose between three modes of operation:

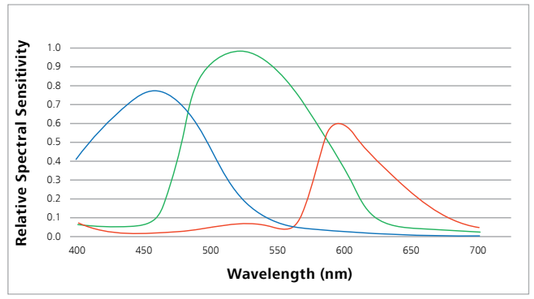
1. In stand-alone mode, you don't need a PC to acquire microscope images. The camera automatically adjusts brightness and white balance and offers live image enhancement functions like sharpening, denoising and HDR. Digital documentation of your specimen has never been easier.
2. Alternatively, connect the CMOS camera via USB or to a network and control it wirelessly with the easy-to-use imaging app Labscope. Since you can connect multiple cameras to the network, Axiocam 208 color is the ideal solution for digital classroom applications and for connected laboratories, too.
3. In addition, you can use the powerful imaging software ZEN with your Axiocam 208 color.

Recommended for

- Documentation
- Education/Teaching
- Routine tasks
- Materials research
- Quality assurance/Quality control
- Fast high resolution live image for co-observation

Simpler. More Intelligent. More Integrated.

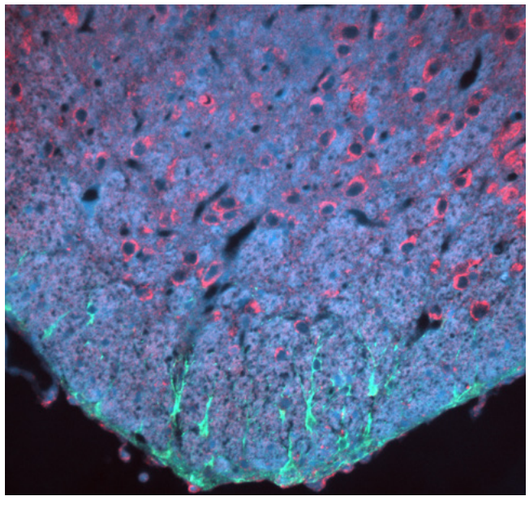
- Full 4K resolution in outstanding 30 fps
- Brilliant color rendering
- Live image enhancement functions like sharpening, denoising and HDR
- Use in stand-alone mode and save images on USB flash drive, use Labscope imaging app or ZEN imaging software
- Easy and effortless digital documentation – especially suitable for education, digital classroom and routine documentation
- Ethernet or USB 3.0 as digital data interface
- Use the optional WiFi stick and Labscope imaging app to control and transfer data wirelessly
- Document your samples as you see it in the eyepieces
- Stand-alone operation with camera control by intuitive On Screen Display via mouse and keyboard without a PC
- Connect directly to a monitor by a HDMI cable for live image display for search and focussing and review of acquired images
- Perform secure image data transfer to TWAIN-compatible 3rd party software solutions with the TWAIN driver.



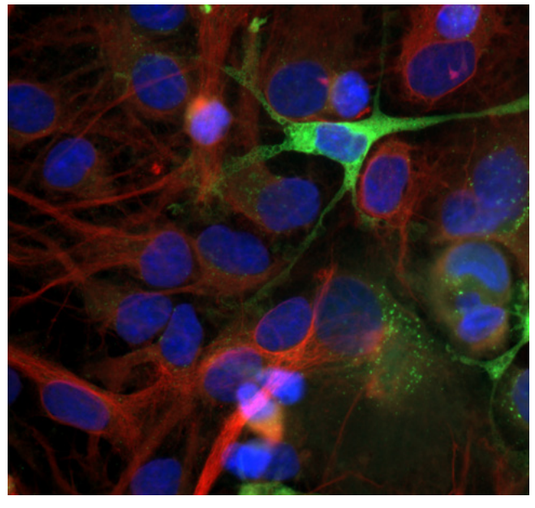
Relative spectral sensitivity

ZEISS Axiocam 305 mono

Your Fast 5 Megapixel Microscope Camera for Routine Fluorescence Applications



Antibody staining of mouse brain section. Cell nuclei (blue), astrocytes (green), cytokeratin (red), acquired with ZEISS Axio Imager, objective: EC Plan-NEOFLUAR 20× / 0.50



Astrocytes. Green: GFP, red: tubulin – Alexa 568, blue: Hoechst 33342, acquired with ZEISS Axio Imager.D2, objective: Plan APOCHROMAT 63×/ 1.4

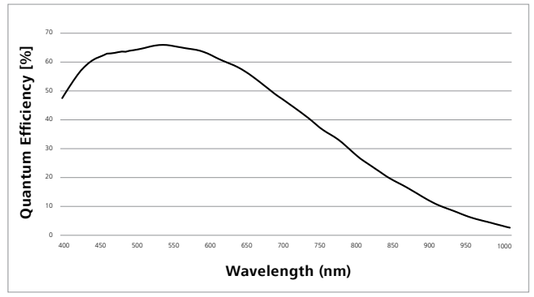
Axiocam 305 mono your 5 megapixel camera from ZEISS for fluorescence imaging for your routine lab and enables a range of applications for live cell observation. The state-of-the-art CMOS Global Shutter technology lets you follow and capture samples accurately. Thanks to its high dynamic range, you can acquire images with various high contrasts and intensities in a single image. A dark homogenous background helps you see even the finest structural details. And it's a really fast camera, acquiring up to 36 frames per second at full 5 megapixel resolution. Highly sensitive sensor technology and sophisticated camera engineering means your Axiocam 305 mono will deliver reproducible results every time. The sensor is temperature-stabilized, resulting in reproducible quality and reduced background noise. Easy to use ZEN imaging software fully supports the robust camera performance by an intuitive user interface through a simple and fast USB 3.0 connection.

Recommended for

- Fluorescence imaging applications with live and fixed cells
- Documentation of fluorescent cell cultures
- Routine tasks in cell laboratories
- Materials research in near infrared wavelengths
- Time lapse recording
- Multi channel imaging without the need for hardware trigger synchronization

Simpler. More Intelligent. More Integrated.

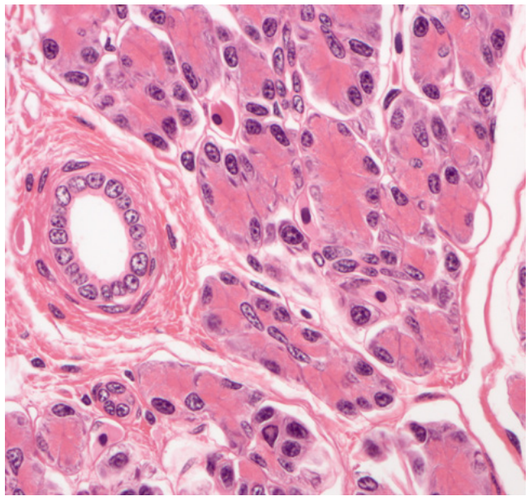
- 5 megapixel CMOS global shutter sensor
- 11.1 mm image diagonal
- Fast readout with 36 images per second in full color resolution
- 12 bit digitization finer gradation in signal
- Small 3.45 micron pixels for better sampling at low magnifications
- Global shutter architecture for distortion-free images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



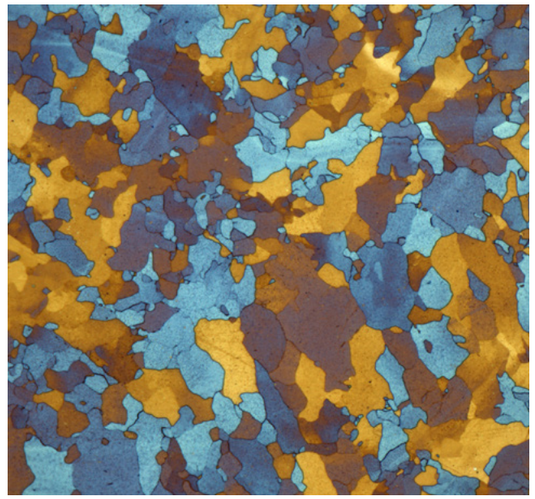
Spectral sensitivity

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

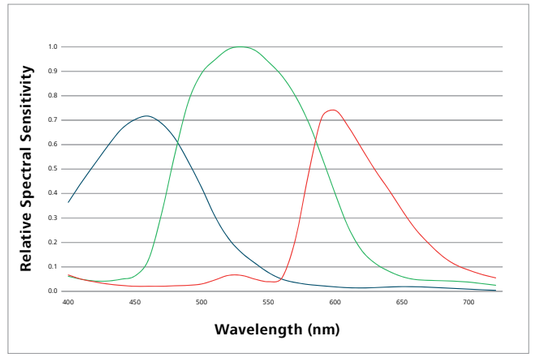
Axiocam 305 color is your 5 megapixel camera for high resolution imaging at fast speeds. With state-of-the-art CMOS global shutter technology, you can follow and capture samples distortion-free and with great accuracy. Thanks to this highly sensitive sensor technology and precise camera engineering, 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

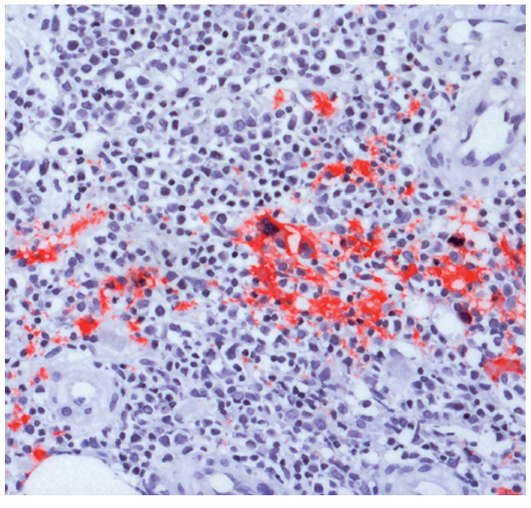
Simpler. More Intelligent. More Integrated.

- 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 for 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

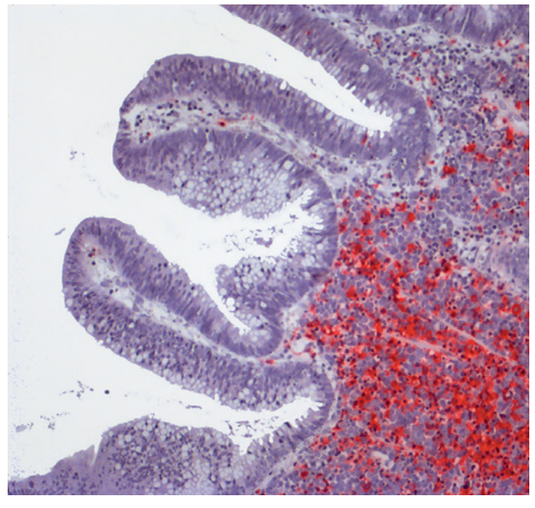


Relative spectral sensitivity

Pathology & Histology



Histological section; red: CD61, blue: nuclear counterstaining, objective: EC Plan-NEOFLUAR 20× / 0.5



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.

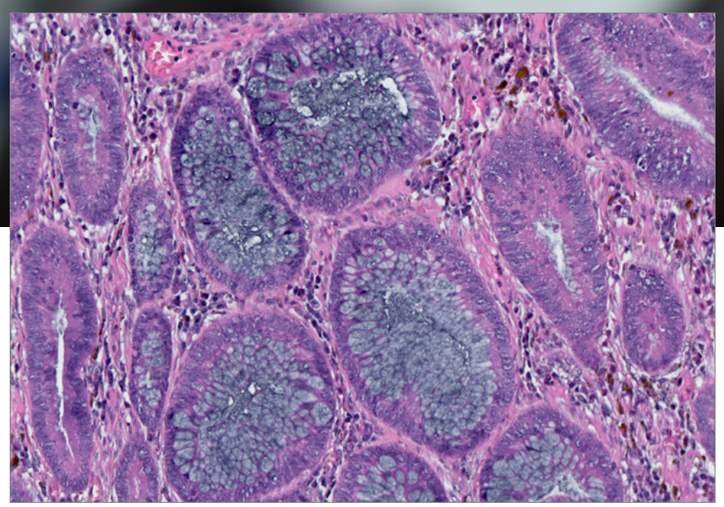
But nowadays it's not just color stainings for transmitted light illumination that are used. You also employ fluorescent dyes to label and identify different kinds of cells and structures. This helps you to get more specific information and, by multiplexing with many dyes, allows to extract a lot more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

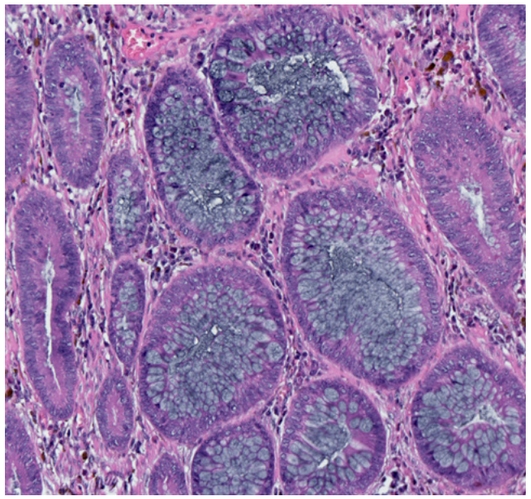
Get True Color Images in High Resolution



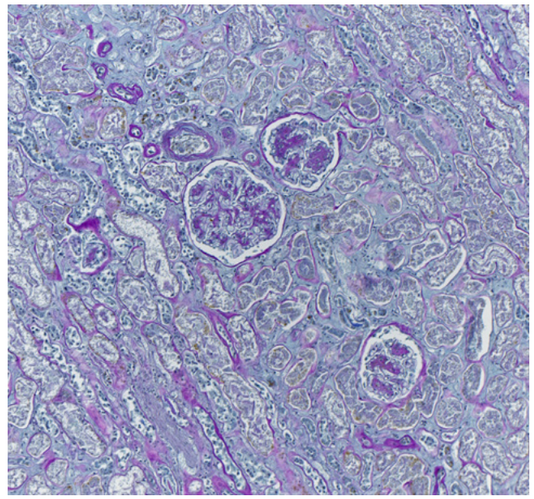
These cameras all deliver outstanding true color images in high resolution. Their high dynamic range and high frame rates meet the needs of even the most demanding pathology or histology imaging. Large sensor areas offer best coverage of your microscope field of view.

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

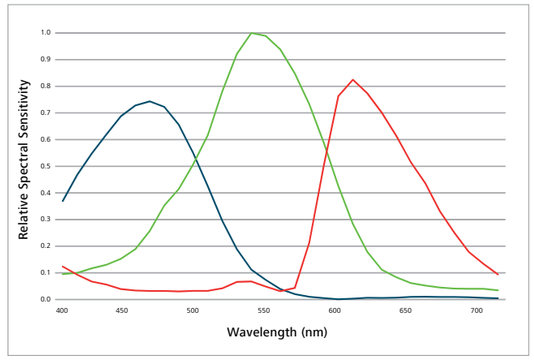
This high quality 6 megapixel color camera offers you an amazingly fast live image and acquisition speed despite its large pixel count and the very large 16 mm diagonal field of view.
This makes it the camera of choice whenever large sample areas have to be screened and recorded by taking many image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

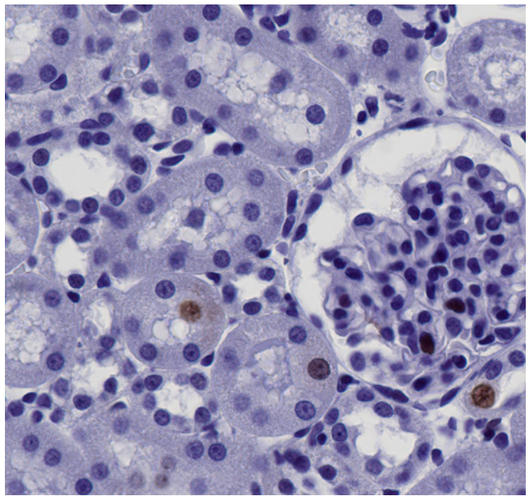
- 6 megapixel CCD sensor with 16 mm image diagonal
- 19 full resolution color images per second
- High image contrast with 14 bit signal conversion
- Small 4.54 micron pixels for optimal resolution
- Fast quad-port read-out with global shutter architecture for distortion-free images
- Black & white imaging 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



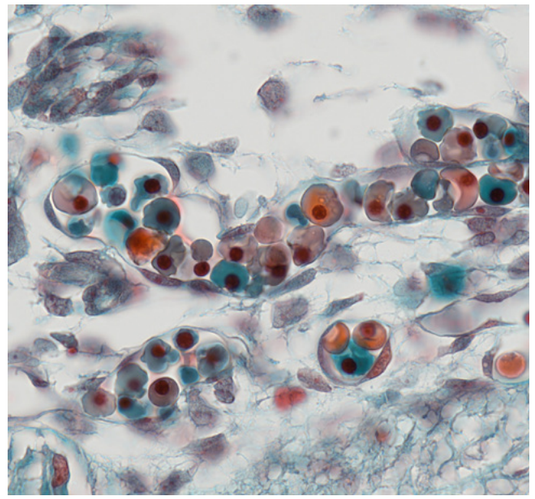
Relative spectral sensitivity

ZEISS Axiocam 705 color

Your Fast 5 Megapixel Microscope Camera
for True Color Image Acquisition in High Resolution



Rat kidney section, objective: Plan-APOCHROMAT 40×/1.4 oil



Rat embryonic tissue section, objective: Plan-APOCHROMAT 63×/1.4 oil

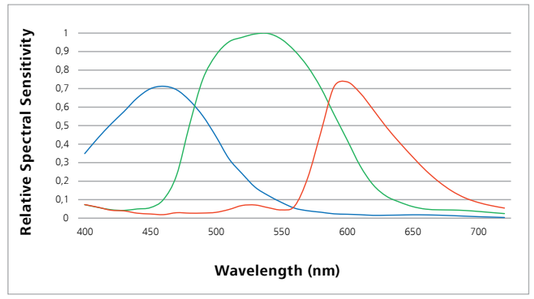
This flexible 5 megapixel scientific color camera strikes the perfect balance of speed and resolution. Delivering more than 60 frames per second at full 5 megapixel resolution, this camera captures even the most dynamic processes without compromising image resolution. Subsampling or sub-region readout accelerate your acquisition speed to hundreds of frames per second.

Recommended for

- High-resolution microscopy
- High-framerate imaging
- Research
- Documentation
- Industrial applications
- Materials research
- Quality control
- Medical microscopy
- Pathology
- Cytology

Simpler. More Intelligent. More Integrated.

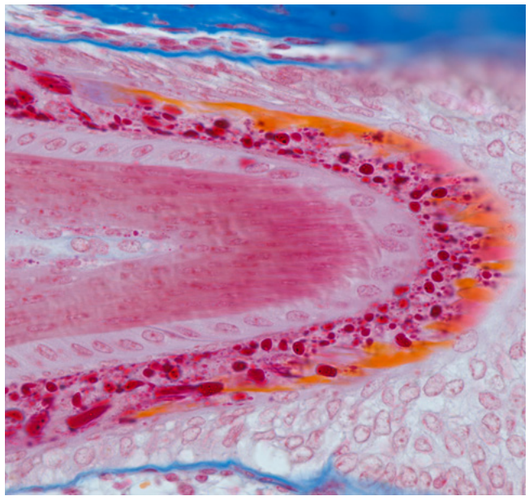
- 5 megapixel cooled color CMOS sensor with 11 mm diagonal
- 62 frames per second in full 5 megapixel resolution
- Best-in-class color rendition
- Color and monochrome imaging modes
- Exclusive noise inhibition technology for low-light imaging
- Dynamic range of 1:25,000 in high-dynamic range (HDR) mode
- Combined analogue and digital pixel binning
- Small 3.45 µm pixels for high-resolution imaging
- Hardware triggering



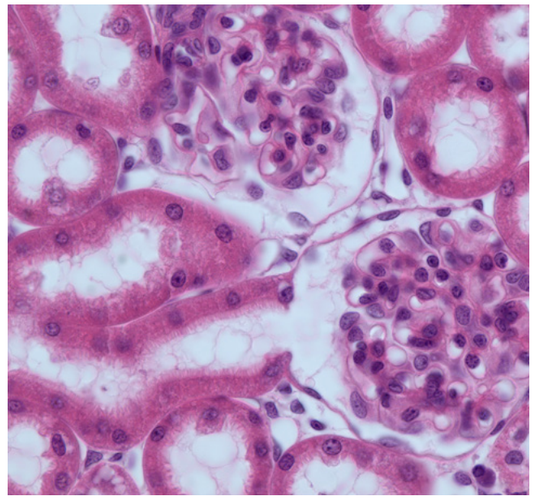
Relative spectral sensitivity

ZEISS Axiocam 712 color

Your All-round 12 Megapixel Microscope Camera for True Color Acquisition of Large Specimen Areas in High Resolution



Mouth region of a mouse embryo section, objective: Plan-APOCHROMAT 63×/1.4 oil



Rat kidney section, objective: Plan-APOCHROMAT 63×/1.4 oil

This 12 megapixel scientific grade camera combines a large image sensor, small pixel size, precise color rendition and fast imaging speed. The CMOS sensor delivers more than 20 frames per second with a 17.5 mm diagonal large field of view. You can now acquire large specimen regions quickly and with uncompromised image quality. The large field of view reduces the number of tiles required to image largest samples, and so drastically accelerates tiling experiments.

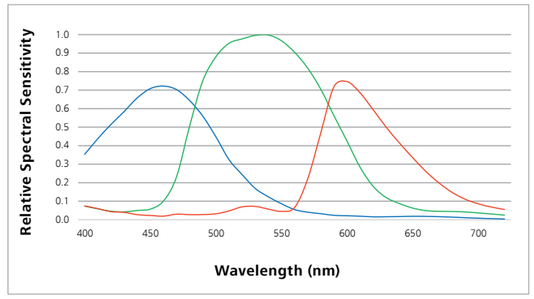
Axiocam 712 color is a highly evolved digital color camera addressing the needs of scientific microscopy, including documentation, reporting and analysis. Fast and artifact-free imaging with optimized color reproduction makes your work comfortable and efficient. In addition, exploring your sample on the screen, instead through the oculars, becomes a true and very convenient alternative.

Recommended for

- High-resolution microscopy
- Large region imaging
- Medical imaging
- Material science research
- Macroscopic imaging
- Pathology

Simpler. More Intelligent. More Integrated.

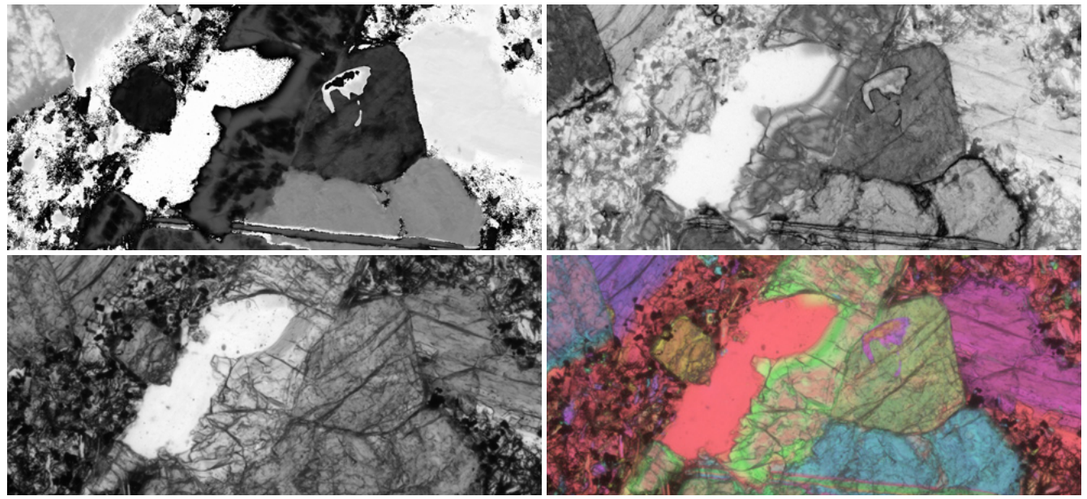
- 12 megapixel cooled color CMOS sensor
- Large sensor with 17.5 mm diagonal for extended field of view
- Best-in-class color rendition
- Color and monochrome imaging modes
- 20 frames per second in full 12 megapixel resolution
- 30 frames per second of the entire field of view in live image mode
- Exclusive noise inhibition technology for lowlight imaging
- Dynamic range of 1:25,000 in high-dynamic range (HDR) mode



Relative spectral sensitivity

ZEISS Axiocam 705 pol

Your Scientific 5 Megapixel Microscope Camera for Single-shot Polarization Imaging



Basalt thin section, Axiocam 705 pol, 4 channels

Axiocam 705 pol is your scientific 5 megapixel camera with a polarization filter mask enhanced sensor. A single image is sufficient to capture different polarization parameters such as angle of polarization, degree of polarization together with the image content. No special accessories such as an analyzer in your microscope are required. You simultaneously acquire polarization effects with one single exposure over the field of view which speeds up your imaging as no analyzer needs to be adjusted.

Recommended for

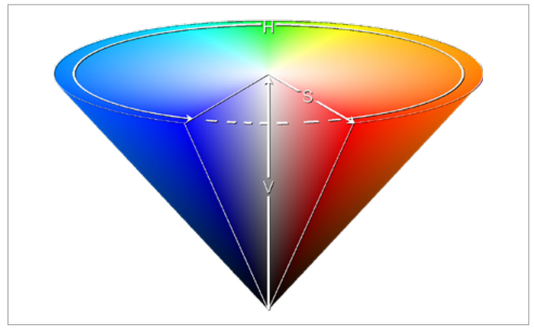
- Material discrimination
- Kerr microscopy
- Mineralogy
- Glass and transparent materials
- Materials research
- Live cell imaging

Simpler. More Intelligent. More Integrated.

- 5-megapixel cooled polarization sensitive CMOS sensor
- Meaningful methods for visualization of multiple polarization parameters
- Low readout noise and analogue signal amplification
- Dynamic range of 1:25,000 in high-dynamic range (HDR) mode
- Small 6.9 µm per polarization pixel unit for high-resolution imaging
- Hardware triggering

Representation of the acquired image information with Axiocam 705 pol

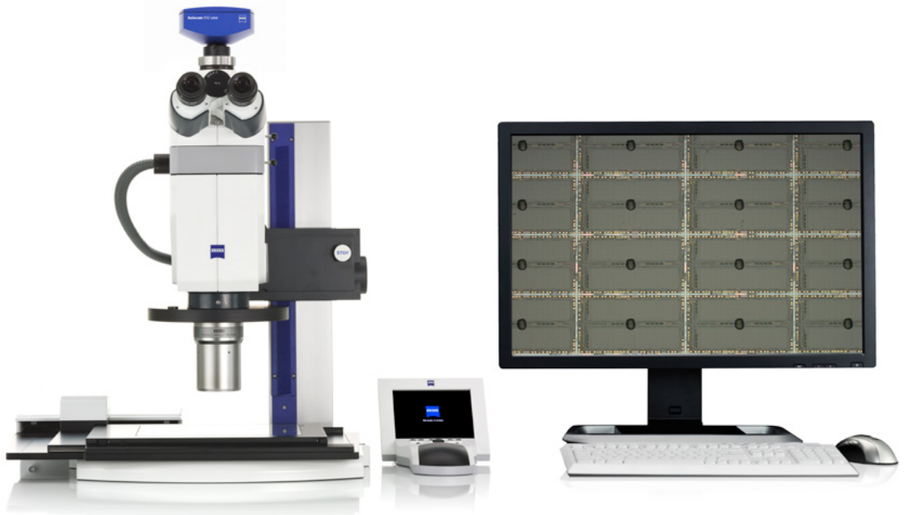
- Encoded Pseudo Color 4 Channel Image
- Channel 1 = Angle of Polarization
- Channel 2 = Degree of linear Polarization
- Channel 3 = Intensity
- Channel 4 = Color encoded information derived from above channels



- Method of color encoding in HSV color space
  - Hue = Angle of polarization
  - Saturation = Degree of linear Polarization
  - Value = Intensitiy
  - I = Intensity

https://de.wikipedia.org/wiki/HSV-Farbraum

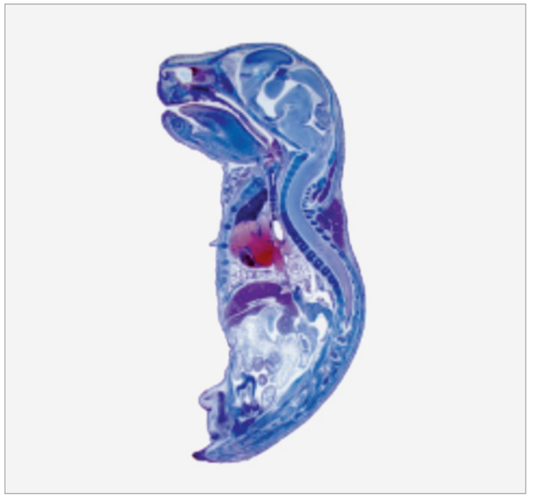
Large Area Imaging



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.



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

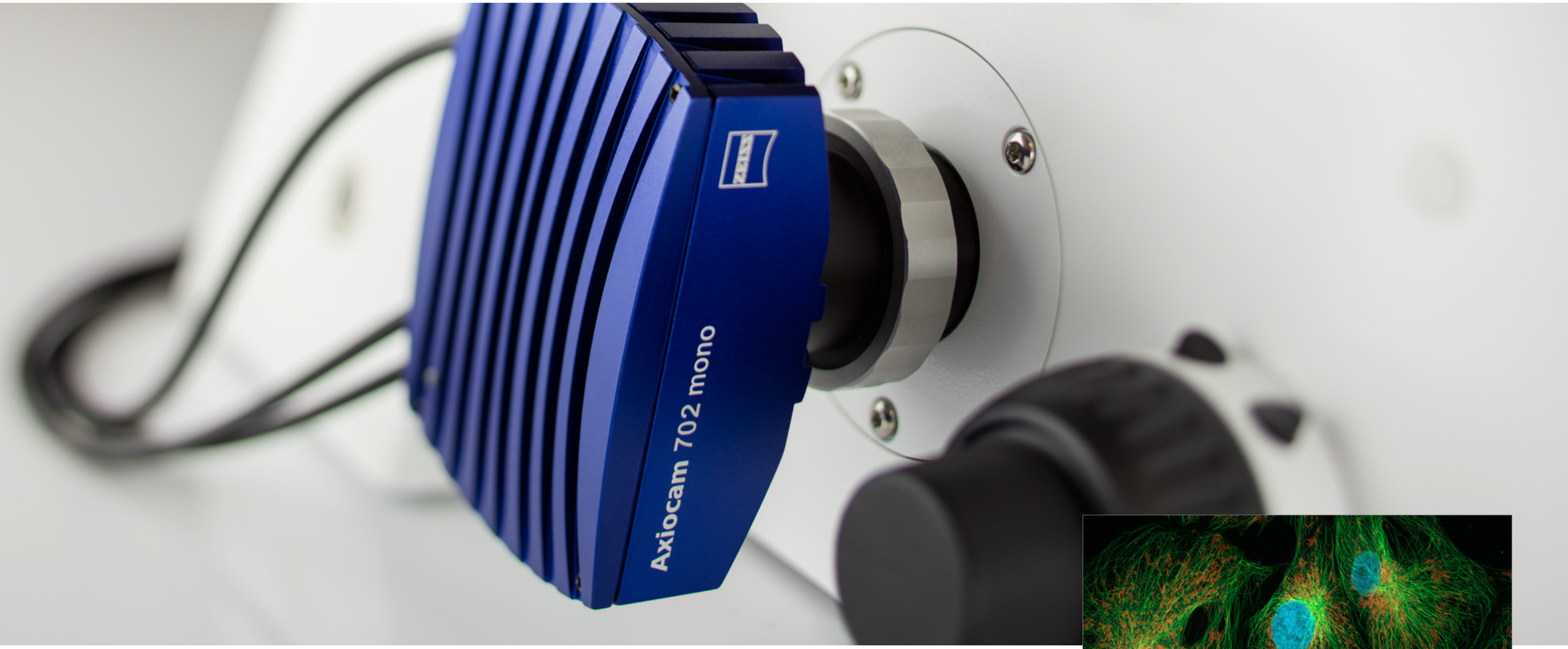
While this procedure has commonly been used for many years, the current generation of ZEISS Axiocams is able to speed things up greatly and at the same time generate higher quality data. When using lower magnifications, you need cameras with small pixels, large sensor diameter and high pixel counts to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

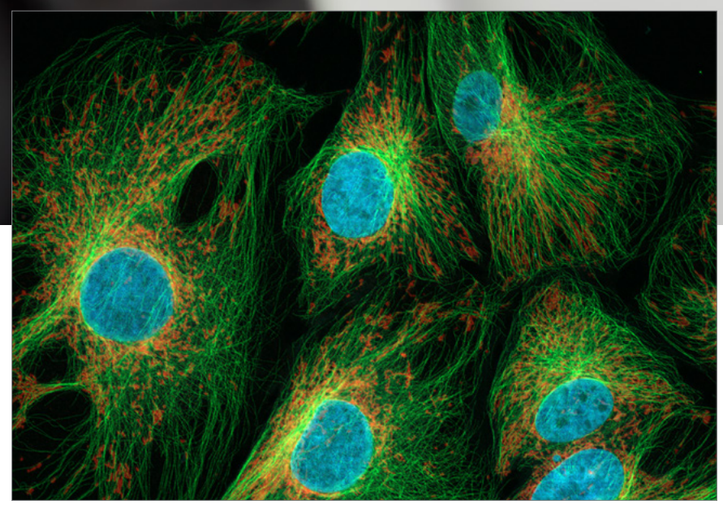
In addition, since 2014 the scientific community explores a new technique called ‘expansion microscopy’. This involves physically inflating biological tissues, which means that even small biological specimens such as single cells can get quite large and, consequently, the imaging procedure may take several 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

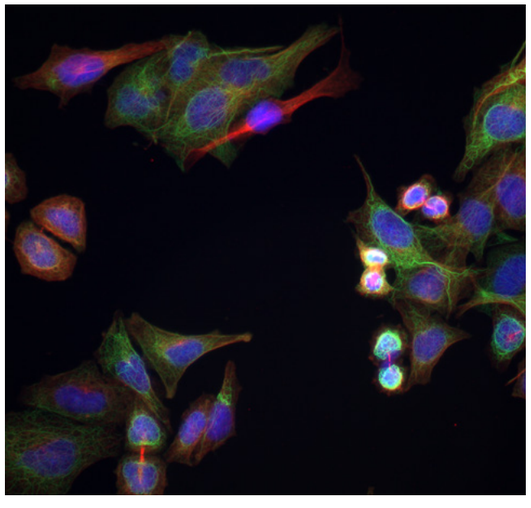




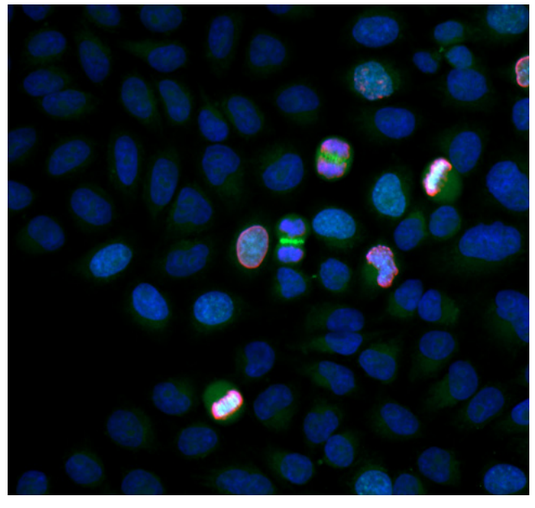
These sensitive monochrome cameras are dedicated to capture even faint signals from your living samples. Each Axiocam contributes a unique combination of resolution, sensitivity and speed to your most demanding live cell imaging experiments.

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

Recommended for

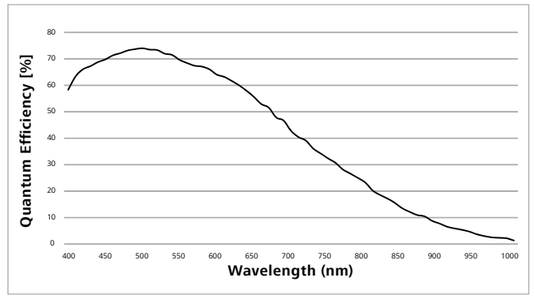
- Live cell imaging
- High-resolution fluorescence imaging
- Fluorescence scanning applications
- Near Infrared fluorescence dyes
- Near Infrared observation in materials applications

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. Optional synchronization of other components by hardware trigger signals assures reproducible imaging precision.

Simpler. More Intelligent. More Integrated.

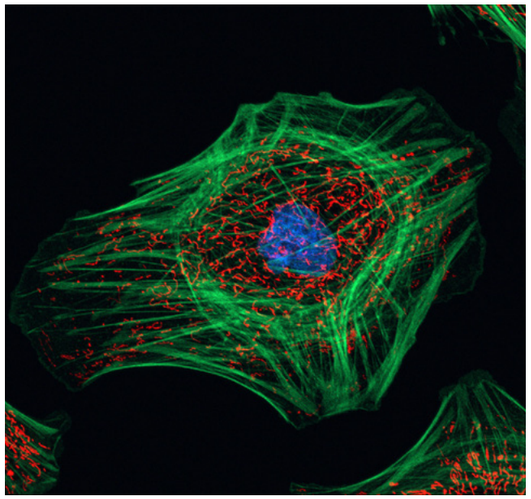
- 6 megapixel CCD sensor
- Excellent coverage of the microscopic field of view and sample overview, thanks to the 1" sensor – twice the field of view compared to ⅔" cameras
- USB 3.0 interface technology with fast 5 gigabit data transfer rate and qad-port, high-end CCD sensor technology for rapid frame 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
- Optional hardware trigger synchronization



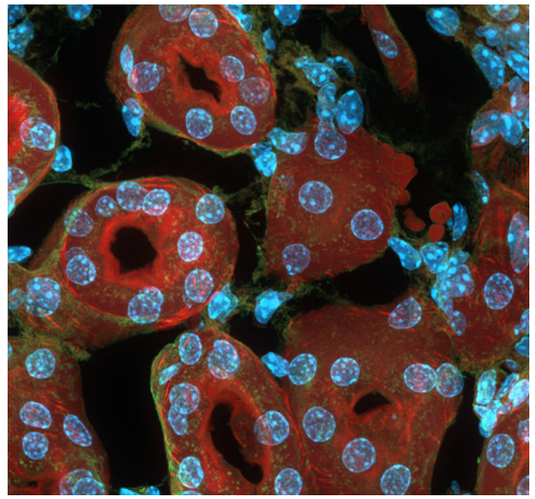
Spectral sensitivity

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: M. Davidson, Florida State University, USA



Mouse kidney section.
Sample courtesy of: M. Davidson, Florida State University, USA

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 CMOS imaging solution that is very sensitive and affordable. If provides also distortion free high 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.

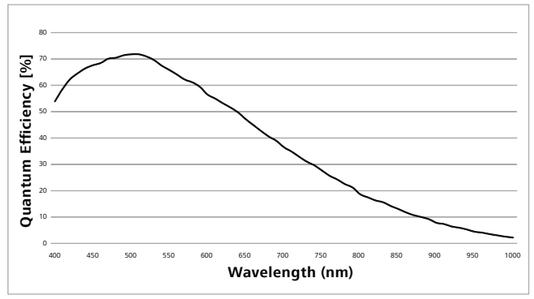
Highest light sensitivity combined with low noise and high frame rates give you the temporal resolution that you always longed for in live cell imaging.

Recommended for

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

Simpler. More Intelligent. More Integrated.

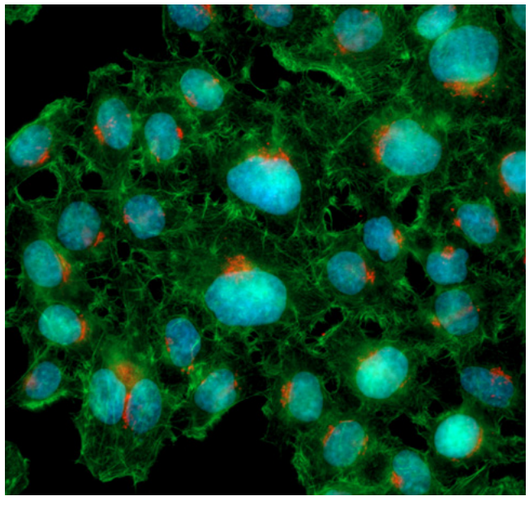
- Monochrome CMOS microscope camera with 2.3 megapixels
- Sensor size of 1/1.2" (diagonal 13.3 mm) and 1920 × 1216 pixels
- Pixel size of 5.86 µm
- Up to 128 fps at full resolution and up to 1000 fps @ 1024 × 128 pixels
- Dynamic range > 5000:1 (>74 dB) at typical < 6e read noise
- Thermo electrical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



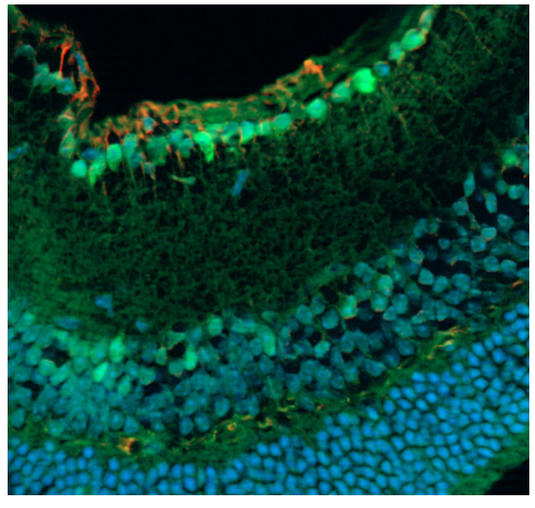
Spectral sensitivity

ZEISS Axiocam 705 mono

Your Fast 5 Megapixel Microscope Camera for High Resolution Imaging at High Speed



Fixed cultured HeLa cells



Fixed mouse retina section, acquired with ZEISS Apotome.2. Specimen courtesy of S. Nan and P. Heiduschka, Department of Ophthalmology, University Medical Center Münster, Germany.

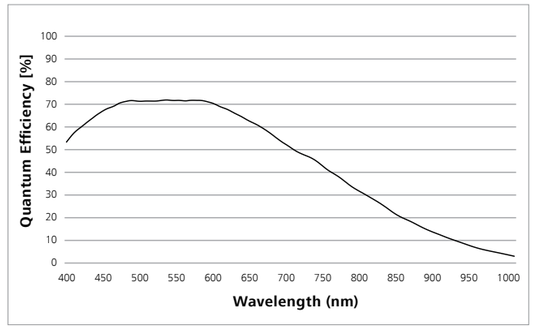
This 5 megapixel monochrome CMOS camera lets you capture time lapse sequences of the most dynamic processes in your Sample. You can achieve more than 60 frames per second with full 5 megapixels. Or, you simply reduce the pixel count to accelerate your imaging even more – up to hundreds of frames per second. Hardware triggering delivers precise timing and enables extremely fast multidimensional imaging experiments. Active sensor cooling and low sensor readout noise make this microscope camera your ideal choice for fluorescence microscopy of dim and delicate specimens. Your Axiocam 705 mono employs analog pixel binning and amplification of signal to boost sensitivity. With high peak quantum efficiency of up to 72 % and a broad spectral sensitivity ranging from UV to near-IR light, you can tackle even the most challenging fluorescence imaging applications.

Recommended for

- High-resolution fluorescence microscopy
- High-framerate imaging
- Research
- Documentation
- Live cell imaging
- Low light microscopy

Simpler. More Intelligent. More Integrated.

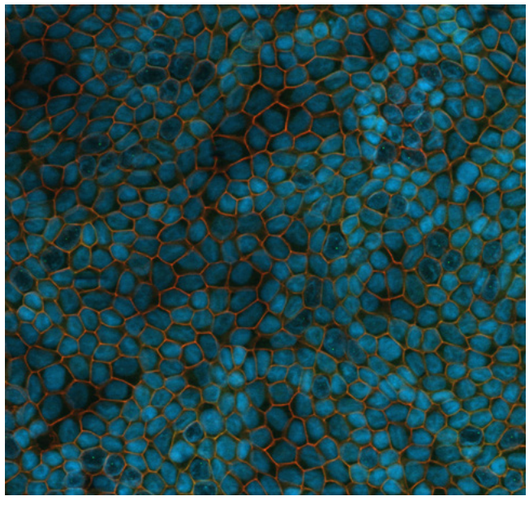
- 5 megapixel cooled global-shutter CMOS sensor
- 62 frames per second in full 5 megapixel resolution
- Wide sensitivity spectrum 350 nm – 1000 nm
- Exclusive noise inhibition technology for lowlight imaging
- Low readout noise and analogue signal amplification
- Dynamic range of 1:25,000 in high-dynamic range (HDR) mode
- Analogue pixel binning
- Small 3.45 µm pixels for high-resolution imaging
- Hardware triggering



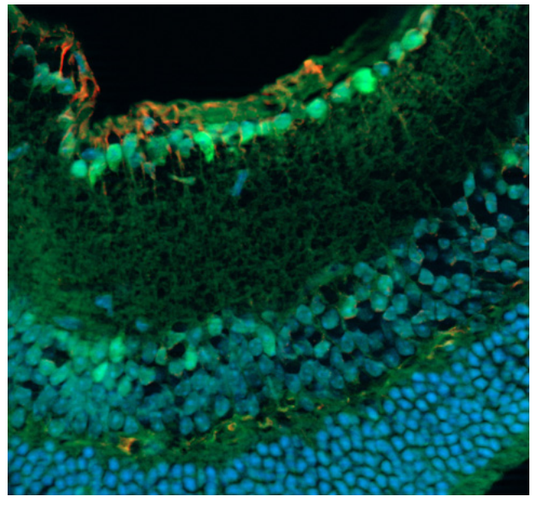
Spectral sensitivity

ZEISS Axiocam 712 mono

Your Flexible 12 Megapixel Microscope Camera for Fast High Resolution Imaging of Large Specimen Areas



Polarized CACO-2 cells, filter-grown for two weeks. Specimen courtesy of C. Hartmann and K. Ebnet, Center for Molecular Biology of Inflammation, Institute of Medical Biochemistry, WWU Münster, Germany



Fixed mouse retina section, acquired with ZEISS Apotome.2. Specimen courtesy of S. Nan and P. Heiduschka, Department of Ophthalmology, University Medical Center Münster, Germany.

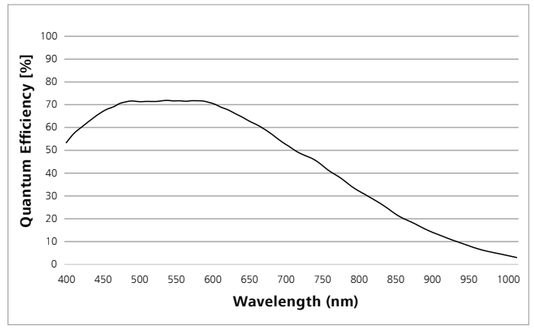
This camera brings lowest noise and high quantum efficiency for those applications that require highest sensitivity. Combining a large sensor with an abundance of small and sensitive pixels makes your Axiocam 712 mono a very flexible camera, suitable for countless different applications. The actively cooled CMOS sensor offers lowest readout noise and stable operation over long periods of time. Exposure times can range from 100 µs for the most dynamic specimens up to 60 s for detection of the dimmest signals. This camera delivers more than 20 frames per second at full pixel count and goes up to more than 100 frames per second with a reduced pixel count. Peak quantum efficiency of over 72 %, a broad detection spectrum and a high near-IR sensitivity complete the camera's set of excellent features. That makes Axiocam 712 mono your all-in-one tool for monochrome imaging applications, ranging from imaging of large sample regions and dynamic specimens to high-sensitivity microscopy of fragile fluorescent specimens.

Recommended for

- High-resolution fluorescence microscopy
- Large region imaging
- Research
- Live cell imaging
- Macroscopic imaging

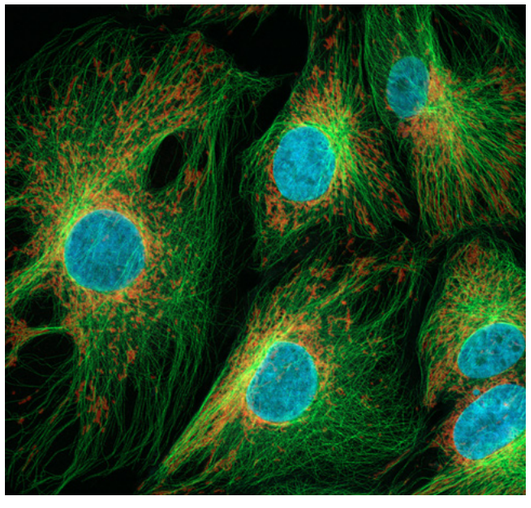
Simpler. More Intelligent. More Integrated.

- 12 megapixel cooled global-shutter CMOS sensor
- Large sensor for extended field of view
- Wide sensitivity spectrum 350 nm – 1000 nm
- 20 frames per second in full 12 megapixel resolution
- 30 frames per second of the entire field of view in live image mode
- Low readout noise and analogue signal amplification
- Exclusive noise inhibition technology for lowlight imaging
- Dynamic range of 1:25,000 in high-dynamic range (HDR) mode
- Small 3.45 µm pixels for high-resolution imaging
- Hardware triggering

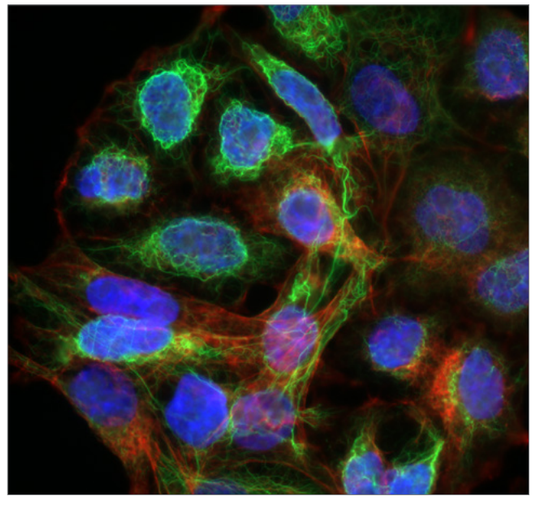


Spectral sensitivity

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 Lightsheet 7. 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. 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.

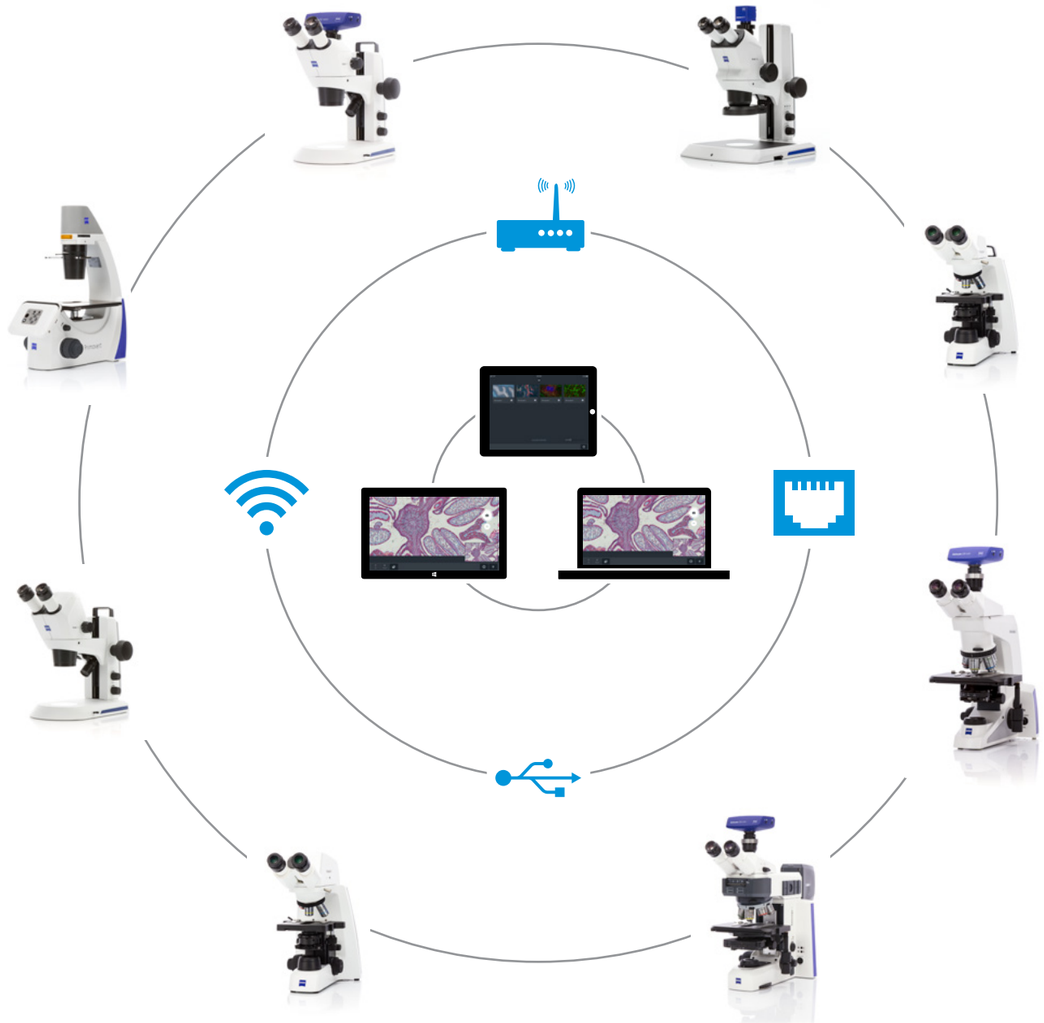
In addition, your Axiocam is always precisely controlled by the imaging software from ZEISS and ideally matched to the optical properties of our imaging stands and systems. That lets you exploit the possibilities of the newest sensor technology to the maximum.

Integrated Network Cameras
Connect Your Microscopes and Your Students

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.

Your Digital Classroom

Windows 10 | Download on the App Store



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.

- Connect Labscope to your microscope to start with digital microscopy work.
- Connect Labscope to multiple microscopes to fulfill your microscopy works on different microscopes.
- Connect your microscope to multiple tablets to do the microscopy work by different users at same time.
- Connect multiple microscopes to multiple devices to enable a fully connected lab or classroom.

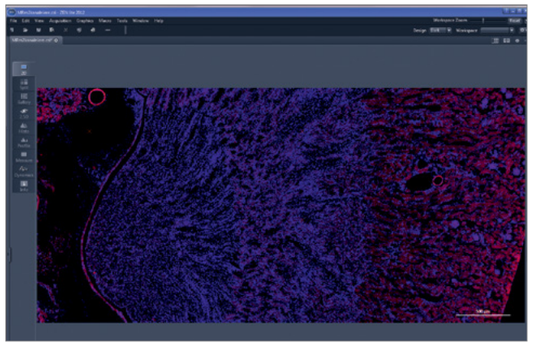
Software

Use ZEISS Imaging Software to Make Most of Your Axiocam

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.

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

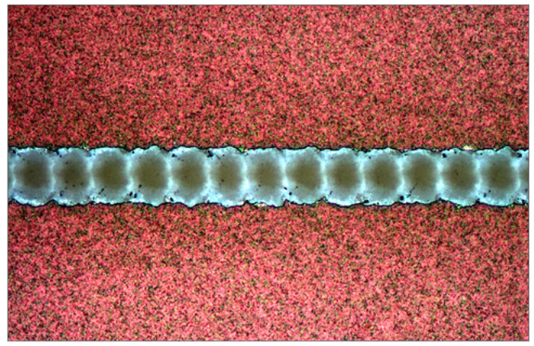
Your Microscope Software for Applications in Life Sciences

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 starter

Your Microscope Software for Industrial Applications

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

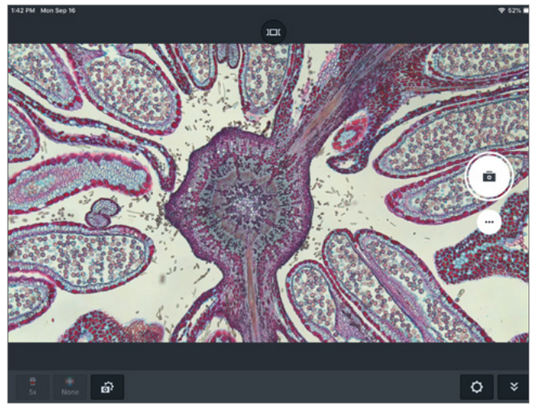
- Control ZEISS Axiocam microscope cameras
- Use customizable workbenches
- Create, manage and export manually-scaled microscope images and record videos
- Use the manual focus of your microscope to create extended depth-of-focus images
- Stitch images on-the-fly using the automated panorama functionality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

Upgrade ZEN 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 App for Digital Classrooms and Routine Laboratory Work



Labscope is your easy-to-use imaging app 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. You can easily create digital classrooms or digital labs – just connect your ZEISS microscopes into a network. Explore the advantages of an inter active 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. Control your cell laboratory microscopes with a connected iPad 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. Whether you use a Windows PC, iPad or iPhone you will enjoy the same consistent GUI, with the same look, feel and user experience: no training required. It's never been so simple and efficient until now.

Configured to Your Requirements

Microscopes
All microscopes with a camera interface
Primostar 3 HD
Primovert HDcam
Stemi 305 cam

Camera
Axiocam ERc 5s
Axiocam 202 mono
Axiocam 208 color

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

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

Simpler. More Intelligent. More Integrated.

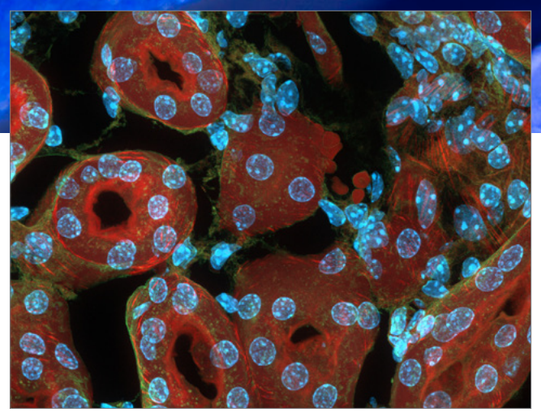
- Take your choice: HDMI, USB, and LAN interfaces offer you many options
- Use the HDMI interface to view directly on a screen without a PC
- Connect the camera to your WiFi stick or via Router to your WiFi network and enjoy the benefits of the imaging software Labscope
- Use the integrated pointer to 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 or Windows PC
- Network your classroom and move around freely while teaching

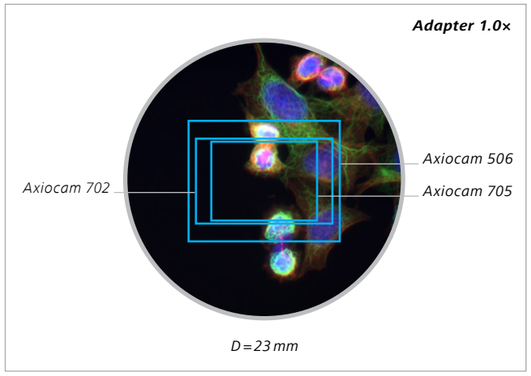
Knowledge Base

Your Resource for Camera Terminology



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.

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.

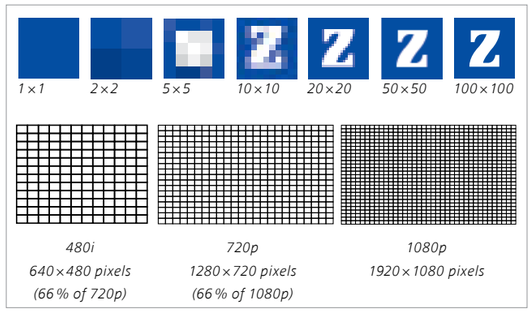
Typical image sensor diameters are 7.9 mm (½" format), 11 mm (⅔" format) or 16 mm (1" format).

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).

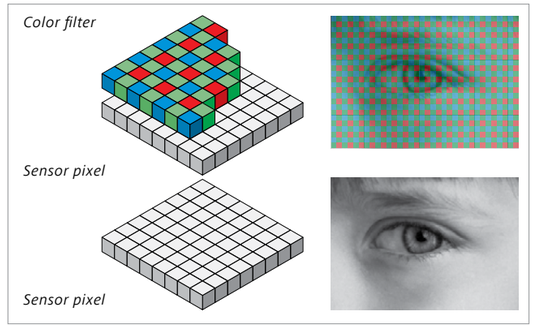
Effects of pixel size:
Smaller pixels are

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

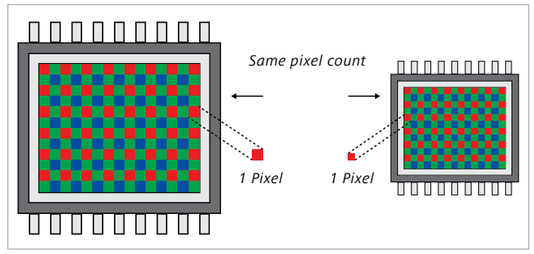
Larger pixels are:

- 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.



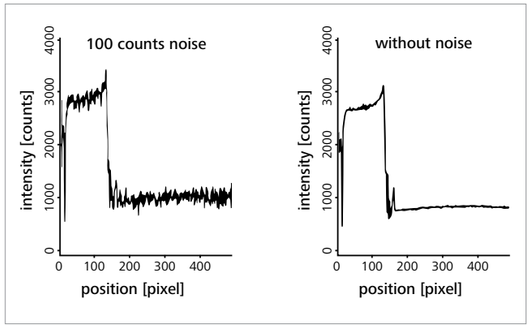
Monochrome and color sensors – a comparison.

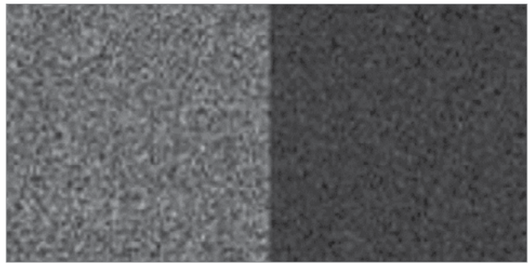


Even when the pixel count is the same, the image taken with the larger-sized pixels is less noisy because the CCD sensor is larger.

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 of Analog to Digital Converters	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

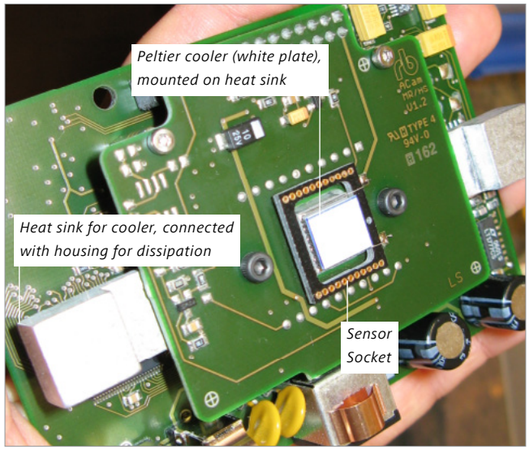
Noise in a digital camera is a random fluctuation of the image signal which causes a detection error. Noise can come from various physical sources and it limits the detection capability of a given camera. Post-processing algorithms can be used to minimize noise, but this sacrifices other image factors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

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



Thermo electrical cooling helps to minimize dark current effects of CCD and CMOS image sensors.

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.

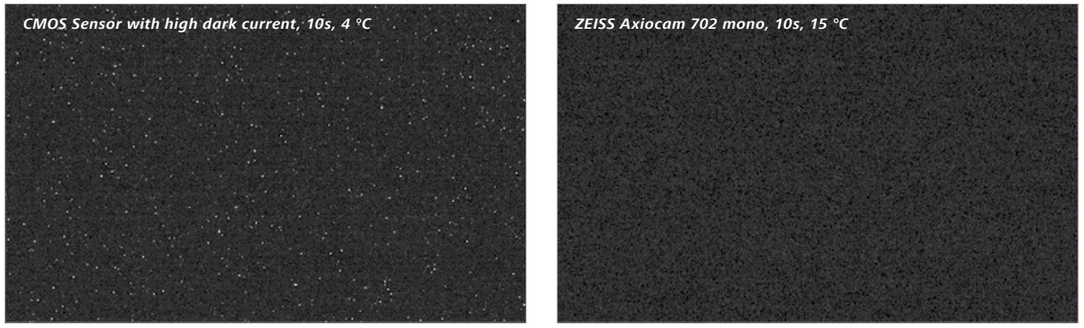
Binning

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.

Frame Rate

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

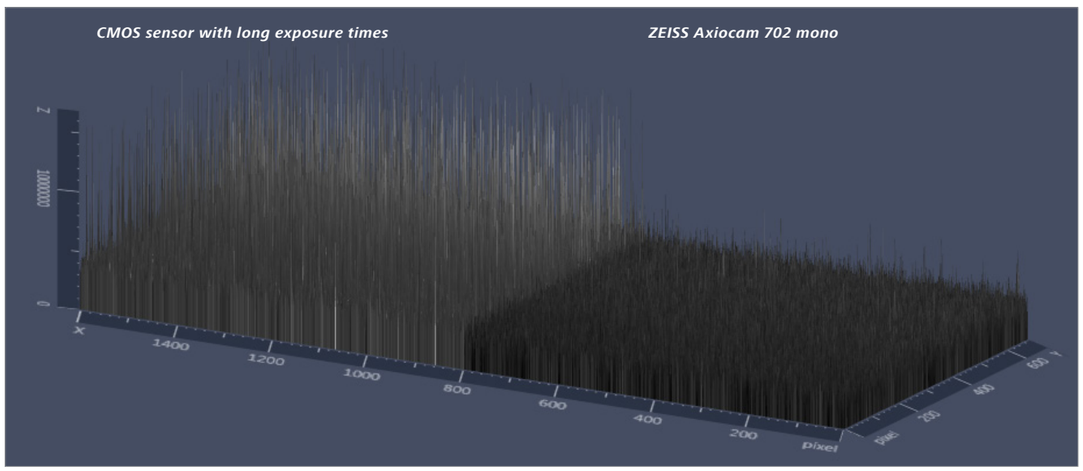
Hot Pixel

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.

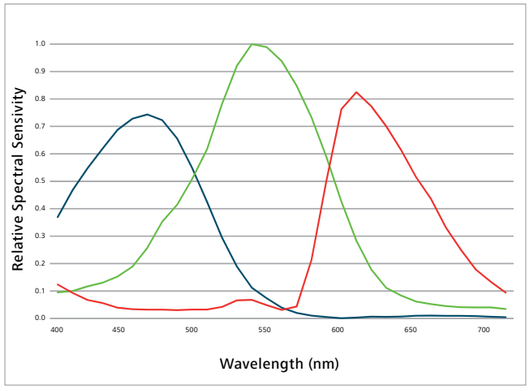
Spectral Sensitivity/Quantum efficiency

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.



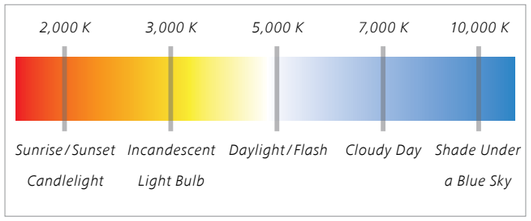
Left: Dark background, non uniformity from common CMOS sensor at 10s,
Right: ZEISS Axiocam 702 mono with modern CMOS sensor at 10s with very dark background, low non uniformity



Relative spectral sensitivity ZEISS Axiocam 506 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.

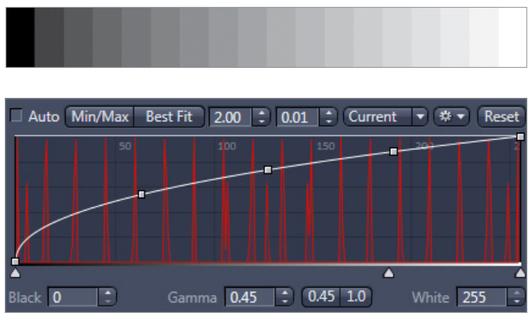
White Balance

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.

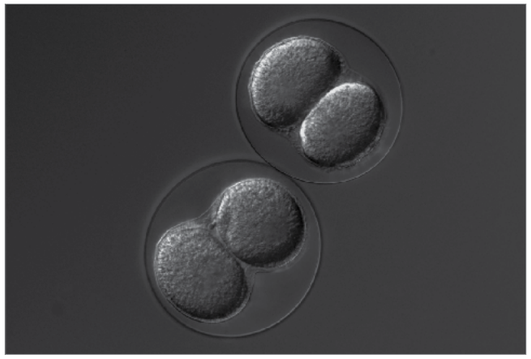
Display Curve

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

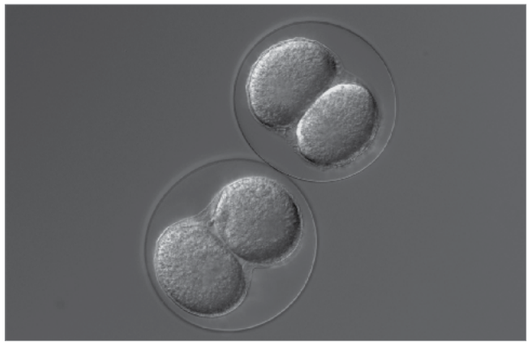


Gamma Adjustment – Gamma 0.45



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	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
Color Cameras

	Axiocam ERc 5s	Axiocam 105 color	Axiocam 208 color	Axiocam 305 color
Sensor type	CMOS, Rolling Shutter	CMOS, Rolling Shutter	CMOS, Rolling Shutter	CMOS, Global Shutter
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	7.1 mm × 4.0 mm equivalent to 1/2,1" diagonal 8,1 mm	8.5 mm × 7.1 mm equivalent ⅔" diagonal 11.1 mm
Pixel Count	5.0 megapixel: 2560 (H) × 1920 (V)	5.0 megapixel: 2560 (H) × 1920 (V)	8.3 megapixel: 3840 (H) × 2160 (V)	5.07 megapixel: 2464 (H) × 2056 (V)
Subsampling	–	–	–	1×1, 2×2
Pixel size	2.2 µm × 2.2 µm	2.2 µm × 2.2 µm	1.85 µm × 1.85 µm	3.45 µm × 3.45 µm
Full Well Capacity	–	–	–	10,500 e⁻
Sensor Filter Mask	RGB Bayer Filter	RGB Bayer Filter	RGB Bayer Filter	RGB Bayer Filter
Spectral Sensitivity	Approx. 400 nm – 700 nm, IR filter	Approx. 400 nm – 670 nm, IR filter	Approx. 400 nm – 700 nm, IR filter	Approx. 380 nm – 720 nm, coated IR cut filter
Binning	Digital binning	Digital binning 1×, 2×, 4×	No	Digital binning 1×, 2×, 3×, 4×, 5×
ROI (Region of Interest)	Yes (adjustable)	Yes (adjustable)	Fixed frame 1080p mode	Yes (adjustable)
Readout Noise	–	–	–	Typ. 2.2 e⁻ @ gain 1×
Dark current	–	–	–	Typ. < 1.0 e⁻/p/s @ 25°C
Dynamic range	–	–	–	Typ. 1:4800
Digitization Bit Depth	8 bit	8 bit	8 bit	12 bit / 8 bit
Exposure Time Range	10 µs – 2 s	100 µs – 2 s	61 µs – 1 s	100 µs – 4 s
Analog Gain	No	Yes	1× – 22× adjustable	1×, 2×, 4×, 8×, 16×
Frame rate live image/Time Lapse Recording	Live 20 fps at 800 × 600, Not recommended for time lapse imaging	Live 15 fps at 5 MP 33 fps at 1920 × 1080 (ROI in HD format) 62 fps at 1280 × 720 (ROI in HD format)	Live Ethernet: 30 fps at 4K/1080p (H.264) USB 3.0: 30 fps at 4K/1080p (MJPEG) HDMI: 30 fps at 4K/1080p Not recommended for timelapse imaging in ZEN	Live 30 fps at 5 MP 67 fps at 1920 × 1080 (ROI in HD format) 136 fps at 512 × 512 (ROI)
Sensor cooling	No	No	No	stabilized at 25°C
External trigger	No	No	No	No
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)	USB 3.0 Type C, Ethernet, HDMI, power	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 240 MB/s; USB 2.0 optional, with lower speed;
Power consumption and supply	5 W through 2× USB 2.0	1.7 W through USB 3.0	9 W, external power supply	4W, powered by USB 3.0-Bus from PC
Software	ZEN blue, ZEN core, Labscope	ZEN blue, ZEN core	ZEN blue, ZEN core, Labscope	ZEN blue, ZEN core

	Axiocam 506 color	Axiocam 705 color	Axiocam 712 color	Axiocam 705 pol
Sensor type	CCD, Quad Port Progressive Scan	CMOS, Global Shutter	CMOS, Global Shutter	CMOS, Global Shutter
Sensor size	12.2 mm × 9,8 mm equivalent to 1" diagonal 16 mm	8.5 mm × 7.1 mm equivalent to ⅔" diagonal 11.1 mm	14.1 mm × 10.4 mm equivalent to 1" diagonal 17.5 mm	8.5 mm × 7.1 mm equivalent to ⅔" diagonal 11.1 mm
Pixel Count	6 megapixel: 2752 (H) × 2208 (V)	5.07 megapixel: 2464 (H) × 2056 (V)	12 megapixel: 4096 (H) × 3008 (V)	5.07 megapixel: 2464 (H) × 2056 (V)
Subsampling	–	1×1, 2×2	1×1, 2×2	1 × 1
Pixel size	4.54 µm × 4.54 µm	3.45 µm × 3.45 µm	3.45 µm × 3.45 µm	3.45 µm × 3.45 µm, 6.9 µm effective pixel size based on polarization filter cell size
Full Well Capacity	15,000 e⁻	11,000 e⁻	11,000 e⁻	11,000 e⁻
Sensor Filter Mask	RGB Bayer Filter	RGB Bayer Filter	RGB Bayer Filter	Polarization Filter (0°, 45°, 90°, 135°)
Spectral Sensitivity	Approx. 400 nm – 720 nm, coated IR cut filter	Approx. 400 nm – 720 nm, coated IR cut filter	Approx. 400 nm – 720 nm, coated IR cut filter	Approx. 350 nm – 1,000 nm, coated protective glass
Binning	Charge binning 1×1, 2×2, 3×3, 4×4, 5×5	Digital binning 1×, 2×, 3×, 4×, 5×	Digital binning 1×1, 2×2, 3×3, 4×4, 5×5	Digital binning 1×1
ROI (Region of Interest)	Yes (adjustable)	Yes (adjustable)	Yes (adjustable)	Yes (adjustable)
Readout Noise	Typ. < 6.5 e⁻ (39 Mhz), Typ. 6 e⁻ (13 Mhz)	Typ. 2,2 e⁻ @ gain 1×, Typ. 1,15 e⁻ @ gain 16×	Typ. 2,2 e⁻ @ gain1×, Typ. 1,15 e⁻ @ gain 16×	Typ. 2.2 e⁻ @ gain 1× Typ. 1.15 e⁻ @ gain 16×
Dark current	Typ. < 0,06 e⁻/p/s at 18 °C	Typ. < 0.5 e⁻/p/s @ 18 °C	Typ. < 0.5 e⁻/p/s @ 18 °C	Typ. < 0.5 e⁻/p/s @ 18°C
Dynamic range	Typ. 1:2500	Typ. 1:5000 at gain 1×, 1:25,000 at HDR mode	Typ. 1:5000 at gain 1×, 1:25,000 at HDR mode	Typ. 1:5,000 at gain 1×, 1:25,000 at HDR mode
Digitization Bit Depth	3× 14 bit / 12 bit / 8 bit	14 bit / 12 bit / 8 bit	3× 14 bit / 12 bit / 8 bit	14 bit / 12 bit / 8 Bit
Exposure Time Range	250 µs – 60 s	100 µs to 60 s	100 µs to 60 s	100 µs – 60 s
Analog Gain	1×, 2×, 3×	1×, 2×, 4×, 8×, 16×	1×, 2×, 4×, 8×, 16×	1×, 2×, 4×, 8×, 16×
Frame rate live image/Time Lapse Recording	Live at 19 fps at 6 MP 19 fps at 2752 × 2208; 32 (ROI in HD format) 33 fps at 917 × 733; 51 fps at 550 × 440	Live 30 fps 5 MP 60 fps at 2464 × 2056 (5MP) 115 fps at 1920 × 1080 (HDTV format) 436 fps at 1920 × 256	Live 30 fps at 2048 × 1504, Live 20 fps at full frame 23 fps full frame 63 fps at 1920 × 1080 (HDTV) up to 430 fps at 1020 × 120	Live 25 fps 5 MP (values only for monochrome or fast color modes), Live 30 fps at 1920 × 1080 60 fps at 2464 × 2056 (5MP) 115 fps at 1920 × 1080 (HDTV format) 436 fps at 1920 × 256
Sensor cooling	stabilized at 18°C	stabilized at 18°C	stabilized at 18°C	stabilized at 18 °C
External trigger	Yes	Yes	Yes	Yes
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. 330 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 330 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 330 MB/s; USB 2.0 optional, with lower speed;
Power consumption and supply	7W, powered by USB 2.0 and USB 3.0-Bus from PC;	7W, powered by USB 2.0 and USB 3.0-Bus from PC;	7W, powered by USB 2.0 and USB 3.0-Bus from PC;	7W, powered by USB 2.0 and USB 3.0-Bus from PC;
Software	ZEN blue, ZEN core	ZEN blue, ZEN core	ZEN blue, ZEN core	ZEN blue, ZEN core

Technical Data

Monochrome Cameras

	Axiocam 202 mono	Axiocam 305 mono	Axiocam 506 mono
Sensor type	CMOS, Global Shutter	CMOS, Global Shutter	CCD, Quad Port Progressive Scan
Sensor size	11.25 mm × 6.33 mm equivalent to 1/1.2" diagonal 13.4 mm	8.5 mm × 7.1 mm equivalent ⅔" diagonal 11.1 mm	12.2 mm × 9,8 mm equivalent to 1" diagonal 16 mm
Pixel Count	2 megapixel: 1920 (H) × 1080 (V)	5.07 megapixel 2464 (H) × 2056 (V)	6 megapixel: 2752 (H) × 2208 (V)
Subsampling	–	1 × 1, 2 × 2	
Pixel size	5.86 µm × 5.86 µm	3.45 µm × 3.45 µm	4.54 µm × 4.54 µm
Full Well Capacity	–	10,500 e^-	15,000 e^-
Quantum Efficiency	–	69% @ 525 nm	74% @ 500nm
Spectral Sensitivity	Approx. 350 nm – 1000 nm, coated protective glass	Approx. 380 nm – 1000 nm, coated protective glass	Approx. 350 nm – 1000 nm, coated protective glass
Binning	No	Digital binning 1×, 2×, 3×, 4×, 5×	Charge binning 1 × 1, 2 × 2, 3 × 3, 4 × 4, 5 × 5
ROI (Region of Interest)	Fixed frame 1080p mode	Yes (adjustable)	Yes (adjustable)
Readout Noise	–	Typ. 2.2 e^- @ gain 1×	Typ. < 6.5 e^- (39 Mhz), Typ. 6 e^- (13 Mhz)
Dark current	–	Typ. < 1.0 e/p/s @ 25°C	Typ. < 0.06 e^-/p/s at 18°C
Dynamic range	–	Typ. 1:4,800	Typ. 1:2,500
Digitization Bit Depth	8 and 12 bit	12 bit / 8 bit	14 bit / 12 bit / 8 bit
Exposure Time Range	61 µs – 2 s	100 µs – 4 s	250 µs – 60 s
Analog Gain	1× – 16× adjustable	1×, 2×, 4×, 8×, 16×	1×, 2×, 3×
Frame rate live image/Time Lapse Recording	Live Ethernet: 30 fps at 1080p (H.264) USB 3.0: 30 fps at 1080p (MJPEG) HDMI: 30 fps at 1080p Not recommended for Timelapse imaging in ZEN	Live 30 fps at 5 MP 67 fps at 1920 × 1080 (ROI in HD format) 136 fps at 512 × 512 (ROI)	Live 19 fps at 6 MP 19 fps at 2752 × 2208; 32 (ROI in HD format) 33 fps at 917 × 733; 51 fps at 550 × 440
Sensor cooling	No	stabilized at 25 °C	stabilized at 18°C
External trigger	No	No	Yes
Interface	USB 3.0 Type C, Ethernet, HDMI, power	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;
Power consumption and supply	9W, external power supply	4W, powered by USB 3.0-Bus from PC	7W, powered by USB 2.0 and USB 3.0-Bus from PC;
Software	ZEN blue, ZEN core, Labscope	ZEN blue, ZEN core	ZEN blue, ZEN core

Axiocam 702 mono	Axiocam 705 mono	Axiocam 712 mono
CMOS, Global Shutter	CMOS, Global Shutter	CMOS, Global Shutter
11,3 mm × 7.1 mm equivalent to 1/1.2" diagonal 13,3 mm	8.5 mm × 7.1 mm equivalent to ⅔" diagonal 11.1 mm	14.1 mm × 10.4 mm equivalent to 1" diagonal 17.5 mm
2.4 megapixel: 1920 (H) × 1216 (V)	5.07 megapixel: 2464 (H) × 2056 (V)	12 megapixel: 4096 (H) × 3008 (V)
	1 × 1, 2 × 2	1 × 1, 2 × 2
5.86 µm × 5.86 µm	3.45 µm × 3.45 µm	3.45 µm × 3.45 µm
32,000 e^-	11,000 e^-	11,000 e^-
78% @ 525 nm	72% @ 550 nm	74% @ 500 nm
Approx. 350 nm – 1,000 nm, coated protective glass	Approx. 350 nm – 1,000 nm, coated protective glass	Approx. 350 nm – 1,000 nm, coated protective glass
Digital binning 1 × 1, 2 × 2, 3 × 3, 4 × 4, 5 × 5	Digital binning 1×, 2×, 3×, 4×, 5×	Digital binning 1 × 1, 2 × 2, 3 × 3, 4 × 4, 5 × 5
Yes (adjustable)	Yes (adjustable)	Yes (adjustable)
Typ. 6 e^- @ gain 1× Typ. 3.75 e^- @ gain 16×	Typ. 2.2 e^- @ gain 1× Typ. 1.15 e^- @ gain 16×	Typ. 2.2 e^- @ gain 1× Typ. 1.15 e^- @ gain 16×
1.1 e^-/p/s at 18 °C	Typ. < 0.5 e^-/p/s @ 18°C	Typ. < 0.5 e^-/p/s @ 18°C
Typ.> 1:5,000 at gain 1× HDR Mode 25,000:1	Typ. 1:5,000 at gain 1×, 1:25,000 at HDR mode	Typ. 1:5,000 at gain 1×, 1:25,000 at HDR mode
14 bit / 12 bit / 8 bit	14 bit / 12 bit / 8 Bit	14 bit / 12 bit / 8 bit adjustable
100 µs – 60 s	100 µs – 60 s	100 µs to 60 s
1×, 2×, 4×, 8×, 16×	1×, 2×, 4×, 8×, 16×	1x, 2x, 4x, 8x, 16x
Live 30 fps at 2.4 MP time lapse: 128 fps at 1920 × 1216 210 fps at 1929 × 720 534 fps at 1920 × 128 1,000 fps at 1024 × 128	Live 30 fps 5 MP 60 fps at 2464 × 2056 (5MP) 115 fps at 1920 × 1080 (HDTV format) 436 fps at 1920 × 256	Live 30 fps at 2048 × 1504, Live 20 fps at full frame 23 fps full frame 63 fps at 1920 × 1080 (HDTV) up to 430 fps at 1020 × 120
stabilized at 18°C	stabilized at 18 °C	stabilized at 18 °C
Yes	Yes	Yes
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. 330 MB/s; USB 2.0 optional, with lower speed;	USB 3.0 SuperSpeed (5 Gbit/s); Bandwidth max. 330 MB/s; USB 2.0 optional, with lower speed;
7W, powered by USB 2.0 and USB 3.0-Bus from PC;	7W, powered by USB 2.0 and USB 3.0-Bus from PC;	7W, powered by USB 2.0 and USB 3.0-Bus from PC;
ZEN blue, ZEN core	ZEN blue, ZEN core	ZEN blue, ZEN core

Applications

Color Cameras

	Axiocam ERc 5s	Axiocam 105 color	Axiocam 208 color	Axiocam 305 color	Axiocam 506 color	Axiocam 705 color	Axiocam 712 color	Axiocam 705 pol
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	++	+++	++++	++++	++++	++++	++++	
Polarized Light Applications	+	+	++	+++	++++	++++	++++	++++

Monochrome Cameras

	Axiocam 202 mono	Axiocam 305 mono	Axiocam 506 mono	Axiocam 702 mono	Axiocam 705 mono	Axiocam 712 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	+++	++++	++++	++++	++++	++++

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Carl Zeiss Microscopy GmbH
Carl-Zeiss-Promenade 10
07745 Jena, Germany

Email: microscopy@zeiss.com
zeiss.com/axiocam