Cooled CCD Camera Technology Terminology
What is important?

Sensitivity and performance with any CCD digital imaging system can be significantly affected by several key technology specifications. When looking for a CCD imaging system with high sensitivity for fluorescence and other low light applications such as chemiluminescence, these critical technology features should be extensively evaluated for highest sensitivity, throughput, minimal exposure times, and image quality.

Quantum efficiency

CCD sensors have different Q/E curves based on the design, silicon materials, architecture, anti-reflective (A/R) coatings, and gating structure. All CCD sensors have quantum efficiency curves that affect the relative effectiveness in detecting photons (light) at various wavelengths of the visible spectrum. For example, if a CCD sensor has a 25% Q/E at 500nm, then only 1 out of 4 photons that strike the CCD sensor will be detected and measured.

Syngene utilises CCD sensors that have the highest quantum efficiencies available compared to competitive CCD sensors. This is particularly relevant at low light imaging application wavelengths of 425- 500nm, typical of most chemiluminescence reagent kits.

At 540nm G:BOX iChemi XR offers a high Q/E of 67%.

Well capacity and pixel size

CCD sensors are made up of pixels and are available in a variety of formats ranging from 1/3inch to greater than 1inch size formats. Correspondingly, based on the sensor array resolution the pixels of the CCD sensor have a pixel size dimension, usually expressed in the micron unit of measurement.

Many imaging systems offering approximately 1392 x 1040 pixel resolution utilise 1/2” CCD sensor formats with small 4.65 x 4.65 micron pixels. Larger pixels increase the light gathering ability and significantly increase the sensitivity over 1/2” CCD sensors of similar resolution.

The G:BOX iChemi XR utilises a 2/3” format sensor and is able to produce images up to 5.5m pixels with a size of 6.45 x 6.45 microns. This can be greatly extended by on-chip binning for ultra high sensitivity up to 52 x 52 microns. This format provides the best of both worlds for image resolution and sensitivity.

Larger sensors could provide bigger pixels, however, using sensors larger than a 2/3” format requires F-mount optics. This is because standard C-mount optics produce an image distortion called “vignetting” (dark corners of the image). F-Mount optics significantly reduces the sensitivity of a system due to the very low aperture ratings that have to be used.

Pixel resolution

Each CCD sensor has a vertical and horizontal array of pixels that determine the overall resolution that the CCD can produce. Fundamentally, increasing pixel resolution results in higher image resolution and larger chip formats, unless the pixel size is reduced. However, decreasing pixel size can reduce the well capacity of a pixel and hence the dynamic range of a sensor. This leads to a requirement on most competitive systems to “bin” pixels, i.e. combine pixels, to increase the well capacity.

The G:BOX iChemi XR can be configured to produce images up to 5.5m pixels giving very high resolution without compromising the well capacity.

Dynamic range

Dynamic Range is also called Signal to Noise Ratio (SNR). The range of intensities that a sensor is capable of discriminating i.e. the difference in 2 pixel signals is more than the noise and so we can tell the two values apart.

Bits are also used to determine dynamic range i.e. 8 bit camera 2*8 = 256 grey shades = 0-2.5 orders of available dynamic range. Thus a 16 bit camera = 64,000 grey shades which is 0-4.8 orders of available dynamic range.

The linear dynamic range of an imaging system will directly impact the range of linear data you can generate when performing densitometry, quantitative analysis and quantitative PCR. Based on your requirements and your budget, Syngene can provide 8 bit CCD sensors, 12 bit CCD sensors and true 16 bit CCD technology. In addition EDR (Extended Dynamic Range) patented proprietary technology is available with Syngene image capture systems. This produces true 16 bit images within GeneSnap software, further extending the dynamic range of the system.

The GBOX iChemi XR is a true 16 bit camera and does not require the use of EDR.

Cooling temperature

A CCD cannot distinguish between electrons generated from photons or those generated by heat (Dark Current). Long exposures required for low light imaging mean more heat and consequently more of these electrons captured in the pixel well. Other noise is also created within the system and so deep cooling of the CCD sensor is required to minimise the build up of these “unwanted” electrons.

Syngene G:BOX iChemi XR is cooled for maximum dark current reduction, extending dynamic range and sensitivity cooling to -28C absolute/regulated. Many other competitive imaging systems only cool by 10 or 20C.

Optic aperture/F-stop

The speed of the optics utilised in any CCD based imaging system has a major impact on the overall sample sensitivity. Particularly for low light imaging applications, the speed of the optics can have a major impact on the required exposure time and hence throughput.

Syngene systems utilise optics that range from a wide angle at F0.85 and a zoom lens rated at F1.2. Faster C-mount optics are available, but most are configured for small format CCD sensors and thus have significant image vignetting, altering quantitative properties and image integrity. Many competitive systems offer optics with F-stop ratings ranging from F1.6 up to F2.4. Sensitivity comparisons between these are significant, for example an F1.2 lens is 77% more sensitive than a F1.6 lens and 235% more sensitive than a F2.2 lens.

Spatial resolution

The CCD sensor resolution and optical path field of imaging view determine the overall spatial resolution that an imaging system can achieve. Spatial resolution is important for resolving fine image details such as closely separated bands or doublets or triplets on an electrophoresis gel. The G:BOX iChemi XR with its megapixel resolution provides a spatial resolution of at least 40 microns.

Frame rate – is it "real time" imaging?

The speed at which images are captured by an imaging system is called the frame rate and is designated as the number of frames per second (FPS). In order to effectively and easily use a CCD imaging system, it must have a fast frame readout rate to allow for easy sample positioning, focusing, and zoom settings.

Syngene image capture systems all have fast frame rates of up to 30 frames per second. The G:BOX iChemi XR is one of the only "Real Time" chemiluminescence imaging systems on the market today. Most competitive systems provide a frame refresh rate at one frame every 1-30 seconds, which significantly diminishes the ease of use.

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Syngene reserves the right to amend or change specifications without prior notice. This Application note supersedes all earlier versions.

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