

EM-CCD Camera C9100-02

Electron Multiplication CCD Digital Camera



The C9100-02 camera brings together all the advantages of the latest Electron Multiplication CCDs with Hamamatsu engineering. High gain, good signal to noise, resolution and speed are combined with a proprietary hermetic vacuum chamber evacuated to approx. 1.3×10^{-6} Pa (10^{-8} Torr). High vacuum, deep cooling and specially designed electronics combine to reduce camera noise before the gain multiplication process begins.

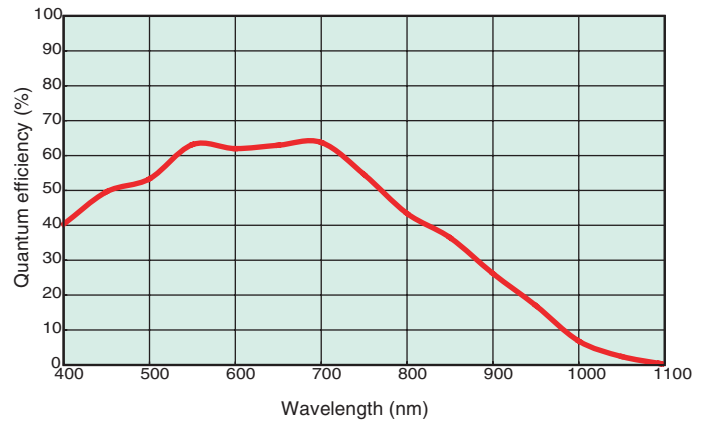
Using on-chip electron multiplication gain and deep cooling, the signal level can be greatly increased relative to the camera noise providing a relative read noise of less than one electron at high gain levels. 2000 time gain factor is possible while still operating at 30 frames per second at full spatial resolution and 14 bit digitization. Frame rates of 250 frames per second or greater are possible by using the binning and sub-array features.

Furthermore, the camera controls the stable cooling temperature at $-50\text{ }^{\circ}\text{C}$ even when the ambient temperature is fluctuated from $0\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$. The constant cooling temperature can work out the uniformed electron multiplication factor and low noise characteristic.

And kinds of external synchronization mode are available, in addition to the internal synchronization mode. Especially, the synchronous readout trigger mode can achieve the optimized frame rate and exposure time such as 30 frames per second with 32 millisecond exposure at C9100-02 (Patent pending).

The C9100-02 series is recommended for any application requiring, speed, signal to noise ratio, dynamic range and resolution at low light levels.

SPECTRAL RESPONSE



★ This is typical, not guaranteed.

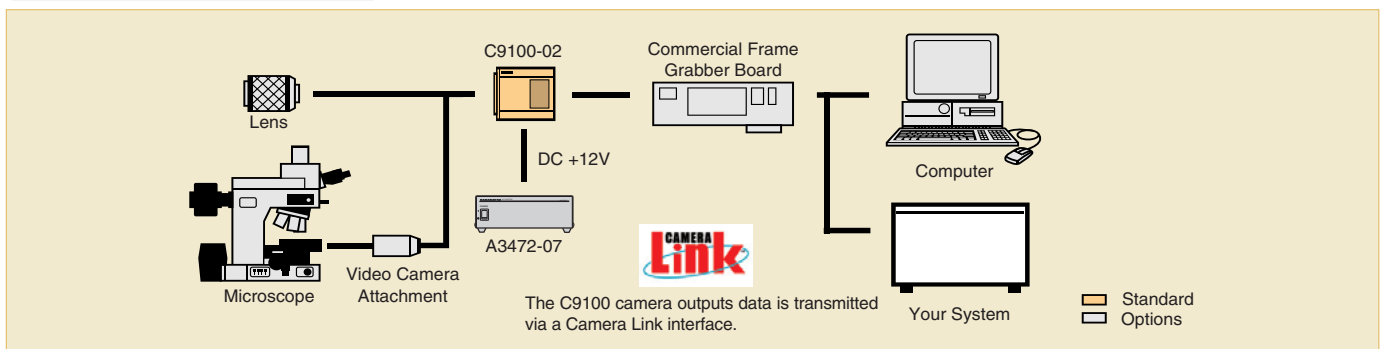
FEATURES

- High EM gain (2000 times)
- $-50\text{ }^{\circ}\text{C}$ cooling with hermetic sealed head
- Real time ($> 30\text{ Hz}$) readout with full resolution
 - 35 MHz clock (1000×1000)
- Stable cooling at $-50\text{ }^{\circ}\text{C}$ (at $0\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$ ambient temperature)
- Various kinds of external synchronization mode
- Synchronous readout trigger mode (Patent pending)

APPLICATIONS

- Real time imaging for low light imaging
- Real time confocal microscopy
- I.I. readout for single molecule fluorescence imaging
- TIRF microscope imaging

SYSTEM CONFIGURATION



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SPECIFICATIONS

Type number	C9100-02		
Camera head type	Hermetic vacuum-sealed air-cooled head		
Imaging device	Frame Transfer CCD		
Effective number of pixels	1000 (H) × 1000 (V)		
Cell size	8 μm (H) × 8 μm (V)		
Effective area	8.0 mm (H) × 8.0 mm (V)		
Pixel clock rate	35 MHz/pixel		
Frame rate***	binning	1 × 1	30.1 frame/s
		2 × 2	57.0 frame/s
		4 × 4	103.0 frame/s
		8 × 8	172.7 frame/s
		16 × 16	262.0 frame/s
Readout noise(r.m.s.) (typ.)	at EM-gain min.	10 electrons	
	at EM-gain max.	< 1 electrons	
Full well capacity (typ.)	70 000 electrons		
Electron multiplication gain max.	2000 times*		
Cooling method	Forced-air peltier cooling with hermetic sealing**		
Cooling temperature	Absolute and stabilized to -50 °C (at ambient room temperature 0 °C to +40 °C)		
Exposure time	Internal sync mode	100 μs to 10 s	
	External trigger mode	100 μs to 10 s	
A/D converter	14 bit		
Output signal / External control	Camera Link		
Electronic shutter	Yes		
Sub-array***	Yes		
External trigger	Yes		
Offset enhancement	Yes		
Lens mount	C-mount		
Power requirements	DC +12 V		
Power consumption	Approx. 60 W-A		
Ambient storage temperature	-10 °C to +50 °C		
Ambient operating temperature	0 °C to +40 °C		
Ambient operating/storage humidity	70 % max. (with no condensation)		

● Readout Speed

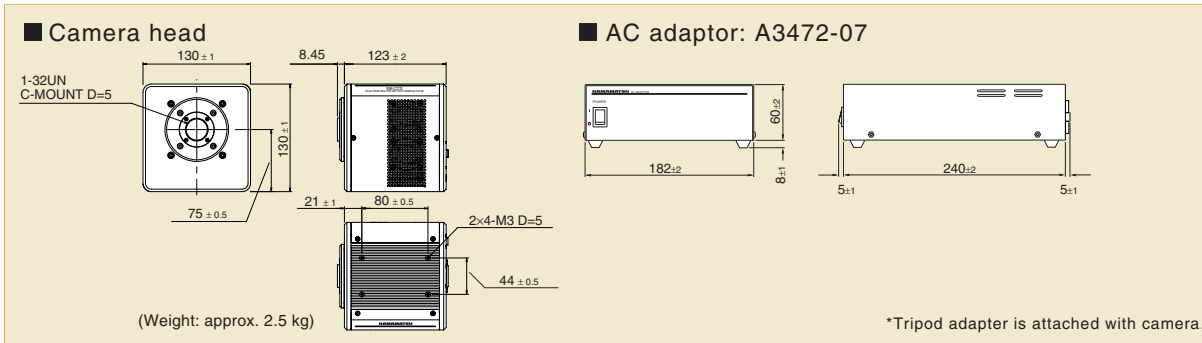
*** Frame rate of each binning and sub-array condition	Effective vertical width (Sub-array)								
		1000	512	256	128	64	32	16	
Frame rate (frame/s)	Binning	1 × 1	30.1	55.8	101.0	169.8	257.7	347.2	420.2
		2 × 2	57.0	101.0	169.8	257.7	347.2	420.2	469.5
		4 × 4	103.0	169.8	257.3	347.2	420.2	469.5	500.0
		8 × 8	172.7	257.7	347.2	420.2	469.5	500.0	515.5
		16 × 16	262.0	346.0	418.4	467.3	497.5	512.8	520.8

* Even with electron multiplication gain maximum, dark signal is kept low level for low light imaging.
 ** The hermetic sealed head maintains a high degree of vacuum approx. 1.3×10^{-6} Pa (10^{-8} Torr), without re-evacuation.

OPTIONS

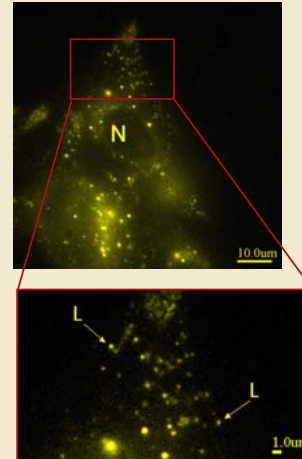
- **Camera cable: A9189-05** (5 m)
- **External trigger cable: A9967-05** (5 m)
- **AC adaptor: A3472-07**
 Line voltage: AC 100 V to AC 240 V input
 Output voltage: DC +12 V
 Dimension: 182 mm (W) × 240 mm (D) × 60 mm (H)

DIMENSIONAL OUTLINES (Unit : mm)



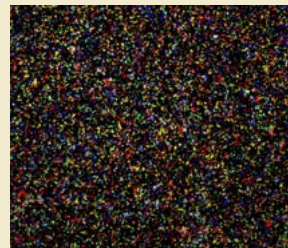
MEASUREMENT EXAMPLE

● High resolution observation of Lysosome trafficking



Observation of the intracellular behaviour of Lysosomes in a CHO cultured cell using Lyso Tracker™.
 Sampling rate : 33 ms (30 frame/s, 1000 × 1000 pixel)
 (Excitation light is attenuated by ND 10 % to reduce fading)
 N : Nucleus L : Lysosome

● False-color composite of fluorescence image data from one position on the Polony sequencing bead array (about 1/20000th of one cycle of data).



• Church, George M., Gregory J. Porreca, Richard C. Terry, and Maridel Lares. "High-Speed Imaging for DNA Sequencing." Biophotonics International June 2008: 34-36.

• Shendure, J, Porreca, GJ, Reppas, NB, Lin, X, McCutcheon, JP, Rosenbaum, AM, Wang, MD, Zhang, K, Mitra, RD, Church, GM (2005) Accurate Multiplex Polony Sequencing of an Evolved Bacterial Genome Science 309(5741):1728-32.

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