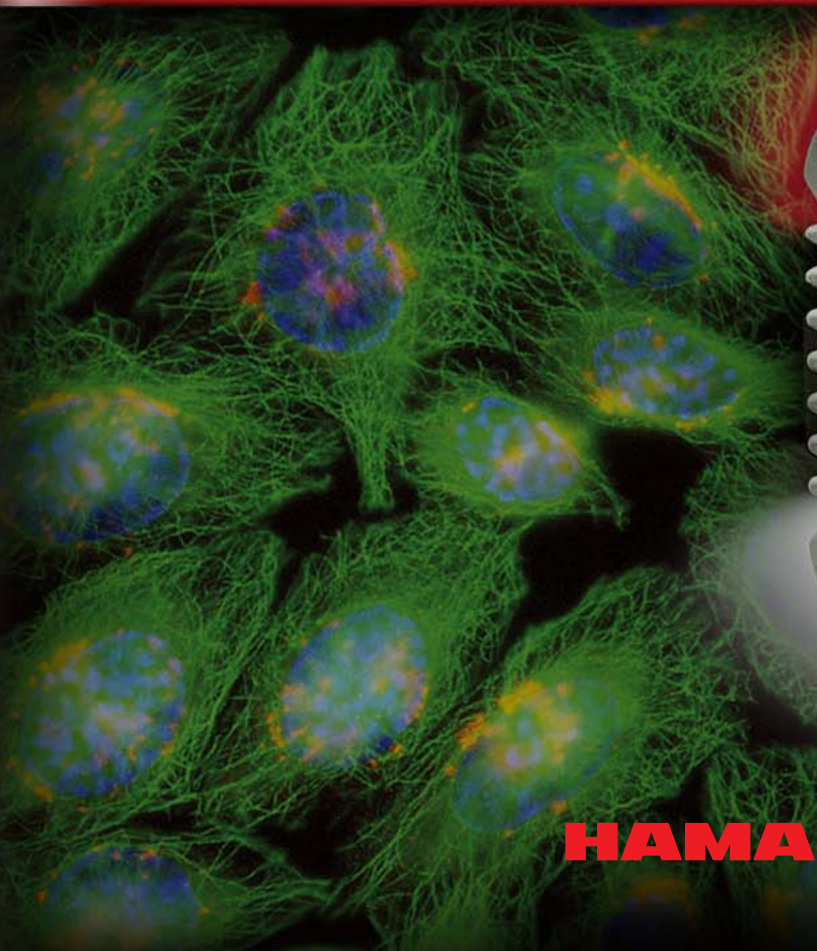




Digital CCD Cameras for Microscopy



HAMAMATSU

Fast frame rates and high sensitivity

EM-CCD (Electron multiplication CCD) cameras

High dynamic range

ImagEM
Enhanced

Ideal format for short exposures, fast frame rates and high dynamic range

- Back-thinned 512 x 512 frame transfer CCD with greater than 90 % QE
 - 16 μm pixels with large full well capacity
 - Optimized EM-CCD readout and stabilized dual mode cooling
-
- Short exposures and fast frame rates
 - Large dynamic range in both NORMAL-CCD and EM-CCD readout modes
 - Highly stabilized gain and minimal dark noise



High resolution

C9100-02

Front illuminated format for fast high resolution imaging

- High EM gain factor (2000 times)
 - 1000 x 1000 x 8 μm pixel format and 30 frames/s readout
 - -50 $^{\circ}\text{C}$ air cooling stabilized up to 40 $^{\circ}\text{C}$ ambient
-
- Great low signal detection
 - High spatial resolution well matched to high NA objectives
 - Consistent data regardless of ambient temperature



ImagEM-1K

Back-thinned format for high QE and high resolution

- Back-thinned 1024 X 1024 frame transfer CCD with greater than 90 % QE
 - 13 μm pixels and 11 MHz readout
 - Optimized EM-CCD readout and stabilized dual mode cooling
-
- Short exposures and high resolution
 - Well matched to high NA objectives and fast readout
 - Highly stabilized gain and minimal dark noise



Specifications

		High dynamic range	High resolution	
Model name		ImagEM Enhanced	C9100-02	ImagEM-1K
Type number		C9100-13	C9100-02	C9100-14
Camera head type		Hermetic vacuum-sealed air/water-cooled head ①	Hermetic vacuum-sealed air-cooled head ①	Hermetic vacuum-sealed air/water-cooled head ①
Window		Anti-reflection (AR) coatings on both sides, single window	Single window	Anti-reflection (AR) coatings on both sides, single window
AR mask		Yes	–	No ②
Imaging device		Electron multiplication back-thinned frame transfer CCD	Electron multiplication frame transfer CCD	Electron multiplication back-thinned frame transfer CCD
Effective number of pixels		512 (H) × 512 (V)	1000 (H) × 1000 (V)	1024 (H) × 1024 (V)
Cell size (square format)		16 μm (H) × 16 μm (V)	8 μm (H) × 8 μm (V)	13 μm (H) × 13 μm (V)
Effective area		8.19 mm (H) × 8.19 mm (V)	8.0 mm (H) × 8.0 mm (V)	13.3 mm (H) × 13.3 mm (V)
Pixel clock rate	EM-CCD readout	11 MHz, 2.75 MHz, 0.69 MHz	35 MHz/pixel	11 MHz, 2.75 MHz, 0.69 MHz
	NORMAL CCD readout	2.75 MHz, 0.69 MHz	–	2.75 MHz, 0.69 MHz
EM (electron multiplication) gain (typ.) ③		1x or 4x to 1200x	6x to 2000x	1x or 10x to 1200x
Ultra low light detection		Photon Imaging mode (1, 2, 3)	–	Photon Imaging mode (1, 2, 3)
Fastest readout speed (with binning, sub-array)		31.9 frames/s to 405 frames/s	30.1 frames/s to 520.8 frames/s	9.5 frames/s to 231 frames/s
		417 frames/s (Binning option)		
Readout noise (r.m.s.) (typ.)	EM-CCD readout	EM gain 4x (C9100-13)	10 electrons. (at 35 MHz)	10 electrons (at 11 MHz)
		6x (C9100-02)	–	8 electrons (at 2.75 MHz)
		10x (C9100-14)	–	3 electrons (at 0.69 MHz)
	NORMAL CCD readout	EM gain 1200x (C9100-13)	1 electron max. (at 35 MHz)	1 electron max. (at 11 MHz)
		2000x (C9100-02)	–	1 electron max. (at 2.75 MHz)
		1200x (C9100-14)	–	1 electron max. (at 0.69 MHz)
		17 electrons (at 2.75 MHz)	–	19 electrons (at 2.75 MHz)
		8 electrons (at 0.69 MHz)	–	10 electrons (at 0.69 MHz)
Full well capacity (typ.) ④		370 000 electrons (Max. 800 000 electrons)	70 000 electrons	400 000 electrons (Max. 730 000 electrons)
Analog gain		1/2 times to 5 times	–	1/2 times to 5 times
Cooling method / temperature ⑤	Forced-air cooled	-65 °C stabilized (0 °C to +30 °C)	-50 °C stabilized (0 °C to +40 °C)	-55 °C stabilized (0 °C to +30 °C)
		-75 °C (Room temperature : Stable at +20 °C)	–	-65 °C (Room temperature : Stable at +20 °C)
	Water cooled ⑥	-80 °C stabilized (Water temperature : +20 °C)	–	-70 °C stabilized (Water temperature : +20 °C)
		-90 °C (Water temperature : lower than +10 °C)	–	-80 °C (Water temperature : lower than +10 °C)
Temperature stability (typ.)	Forced-air cooled	±0.03 °C (Room temperature : Stable at +20 °C) (-65 °C stabilized)	–	±0.05 °C (Room temperature : Stable at +20 °C) (-55 °C stabilized)
	Water cooled	±0.01 °C (Water temperature : +20 °C [Operated with circulating water cooler] (-80 °C stabilized))	–	±0.01 °C (Water temperature : +20 °C [Operated with circulating water cooler] (-70 °C stabilized))
Dark current ⑦ (typ.)	Forced-air cooled	0.01 electron/pixel/s (-65 °C)	–	0.01 electron/pixel/s (-55 °C)
	Water cooled	0.001 electron/pixel/s (-80 °C)	–	0.001 electron/pixel/s (-70 °C)
Exposure time ⑧	Internal sync mode	30.5 ms to 2 h	100 μs to 10 s	103.3 ms to 2 h
	External trigger mode	10 μs to 2 h	100 μs to 10 s	10 μs to 2 h
A/D converter		16 bit	14 bit	16 bit
Output signal / External control		Camera Link		
Sub-array		Every 16 lines (horizontal, vertical) size, position can be set		
Binning		2 × 2, 4 × 4 (8 × 8, 16 × 16) ⑨	2 × 2, 4 × 4, 8 × 8, 16 × 16	2 × 2, 4 × 4 (8 × 8, 16 × 16) ⑨
External trigger mode ⑩		Edge trigger, Level trigger, Start trigger, Synchronous readout trigger	Edge trigger, Level trigger, Synchronous readout trigger	Edge trigger, Level trigger, Start trigger, Synchronous readout trigger
Trigger output ⑩		Exposure timing output, Programmable timing output (Delay and pulse length are variable)	Integ start out	Exposure timing output, Programmable timing output (Delay and pulse length are variable)
Image processing features (real-time)		Background subtraction, Shading correction, Recursive filter, Frame averaging, Spot noise reducer ⑪	–	Background subtraction, Shading correction, Recursive filter, Frame averaging, Spot noise reducer ⑪
EM gain protection		EM warning mode, EM protection mode	–	EM warning mode, EM protection mode
EM gain readjustment		Available	–	Available
Lens mount		C-mount		
Power requirements		AC 100 V to 240 V, 50 Hz / 60 Hz	DC + 12 V	AC 100 V to 240 V, 50 Hz / 60 Hz
Power consumption		Approx. 140 V·A	Approx. 60 V·A	Approx. 140 V·A
Ambient storage temperature		-10 °C to +50 °C		
Ambient operating temperature		0 °C to +40 °C		
Performance guaranteed temperature		0 °C to +30 °C	0 °C to +40 °C	0 °C to +30 °C
Ambient operating / storage humidity		70 % max. (with no condensation)		

① The hermetic sealed head maintains a high degree of vacuum 10⁻⁹ Torr, without re-evacuation.

② AR mask is not placed because the proportion of CCD area to the window is large therefore reflection is quite small.

③ Even with electron multiplication gain maximum, dark signal is kept low level at low light imaging.

④ Linearity is not assured when full well capacity is over 370 000 electrons (C9100-13) or 400 000 electrons (C9100-14), because of CCD performance.

⑤ The cooling temperature may not reach to this temperature depends on the operation condition.

⑥ Water volume 1.2 liter/min.

⑦ Typical thermal charge value (not guaranteed).

⑧ Image smearing may appear when the exposure time is short.

⑨ 8 × 8 and 16 × 16 binning are available on special order. Please consult with our sales office.

⑩ C-MOS 3.3 V with reversible polarity.

⑪ Recursive filter, frame averaging, spot noise reducer cannot be used simultaneously.

Low noise and Multipurpose versatility

Integrating cameras

High speed and high sensitivity

ORCA-R²

Maximum versatility

- 1.37 million pixel interline CCD with maximum QE over 70 %
 - 14 MHz and 28 MHz readout modes included
 - 12 bit and 16 bit digitizers are included and software selectable
 - Air and water cooling capabilities are standard
-
- High resolution and short exposure times combined
 - Choice of very low noise or very fast readout to suit applications
 - Choice of bit depth to suit data and precision needs
 - Long exposures with very low dark current and no vibration



ORCA II-ERG

Low noise and very long integration

- 1.37 million pixel interline CCD with maximum QE over 70 %
 - 12 bit and 14 bit digitizers are included and software selectable
 - Very low dark current (0.0045 electron/pixel/s) from -60 °C air cooling
 - Very low readout noise (4 electrons r.m.s.) in high precision mode
-
- High resolution and short exposure times combined
 - Choice of very low noise or very fast readout to suit applications
 - Exposure times of hours are possible
 - Even the dimmest signals are detectable without signal multiplication



ORCA-03G, ORCA-05G

Affordable price and low noise

- 1.37 million pixel interline CCD with maximum QE over 70 %
 - Compact head size with single cable and no controller
 - Wide spectral range from 400 nm to NIR region
 - 14.7 MHz readout at 12 bits
-
- High resolution and short exposure times combined
 - Fits into any laboratory space or setup
 - Good for both bright fluorescence and NIR-DIC
 - Fast frame rates and good precision
 - ORCA-03 model includes peltier cooling for extended exposures



Large format, High resolution

ORCA-HR

Large fields of view with excellent resolution

- Multi-megapixel interline CCD with 4000 x 2624 x 5.9 µm pixel format
 - Large format detector: 23.6 mm x 15.5 mm
 - Low readout noise even at 20 MHz readout
-
- Very high resolution images in micro and macro applications
 - Large field of view reduces tiling of images
 - High quality images from shadow to highlight areas



Speciality high QE, Low noise

ORCA II-BT-512G

Huge dynamic range and great sensitivity

- Back thinned 512 x 512 x 24 μm full frame CCD with over 90 % QE
- Large full well capacity
- Very low dark current (0.032 electron/pixel/s) with stabilized -75 °C cooling
- Very efficient light collection of dim signals
- Dynamic range of 32 875:1
- Suitable for fluorescence and luminescence



ORCA II-BT-1024G

High resolution, large dynamic range and great sensitivity

- Back thinned 1024 x 1024 x 13 μm pixel full frame CCD with over 90 % QE
- Wide spectral sensitivity from 200 nm to 1000 nm
- Very low dark current (0.0012 electron/pixel/s) with stabilized -75 °C cooling
- High resolution and fast exposure times for microscopy
- Broad range of applications including UV imaging
- Suitable for high resolution fluorescence and luminescence



Color

ORCA-3CCD

Simultaneous but independent exposures on R, G, and B channels

- Total 4.13 million pixels on 3 progressive scan interline CCD chips
- 36 bit color resolution
- Cooled R, G and B CCDs with independent exposure settings
- High spatial resolution images of multicolor specimens in brightfield and fluorescence
- Great color fidelity with superb backgrounds
- Tremendous dynamic range of separate fluorophores



High speed

C9300-221

High frame rates and high IR sensitivity

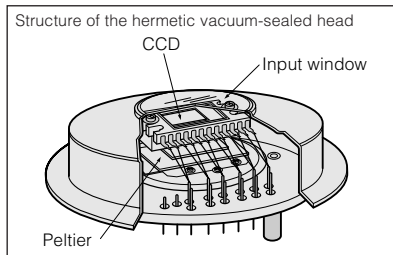
- High speed progressive scan VGA interline CCD
- Single or dual tap readout modes are software selectable
- 33 microsecond shutter capability
- High NIR sensitivity
- Good spatial resolution even at 694 frames/s
- Full frame readout of 82 frames/s or 150.2 frames/s
- Stop action imaging of fast moving specimens
- Good choice for moving fluorescence and NIR-DIC specimens



Specifications

		High speed and high sensitivity					
Model name		ORCA-R2	ORCA II-ERG	ORCA-03G	ORCA-05G		
Type number		C10600-10B	C4742-98-24ERG	C8484-03G02	C8484-05G02		
Camera head type		Hermetic vacuum-sealed air/water-cooled head ①	Hermetic vacuum-sealed air-cooled head ①		Passive air-cooled head		
Mechanical shutter		-					
Imaging device		ER-150 progressive scan interline CCD					
Effective number of pixels		1344 (H) x 1024 (V)					
Cell size (square format)		6.45 μm (H) x 6.45 μm (V)					
Effective area		8.67 mm (H) x 6.60 mm (V)					
Pixel clock rate	High speed readout	28.0 MHz/pixel	10 MHz/pixel	14.7 MHz/pixel			
	High precision readout	14.0 MHz/pixel	1.25 MHz/pixel	-			
Frame rate	High speed readout	1 x 1	16.2 frame/s	5.6 frame/s	8.9 frame/s		
		binning	2 x 2	28.4 frame/s	9.8 frame/s	16.3 frame/s	
			4 x 4	45.7 frame/s	15.6 frame/s	27.8 frame/s	
			8 x 8	64.3 frame/s	22.2 frame/s	43.0 frame/s	
	High precision readout	1 x 1	8.5 frame/s	0.83 frame/s	-		
		binning	2 x 2	15.6 frame/s	1.58 frame/s	-	
			4 x 4	26.7 frame/s	2.90 frame/s	-	
			8 x 8	40.6 frame/s	4.97 frame/s	-	
Readout noise (r.m.s.) typ.	High speed readout	10 electrons	8 electrons	6 to 8 electrons	10 electrons		
	High precision readout	6 electrons	4 electrons	-			
Full well capacity typ.	1 x 1	18 000 electrons	18 500 electrons	15 000 electrons			
	binning	36 000 electrons (at High dynamic range mode)	40 500 electrons	-			
Dynamic range typ. ③	High speed readout	-	2312 : 1	2142 : 1	1500 : 1		
	High precision readout	1 x 1	3000 : 1	4625 : 1	-		
		binning	-	10 125 : 1	-	-	
Cooling method		Forced air/water peltier cooling, with hermetic sealing	Forced air peltier cooling, with hermetic sealing		-		
Cooling temperature (at +20 °C ambient temperature)		-40 °C (absolute value) (Water cooled)	-60 °C (absolute value)	-10 °C (absolute value)	-		
Dark current		0.0005 electrons/pixel/s	0.0045 electrons/pixel/s	0.1 electrons/pixel/s	-		
A/D converter	High speed readout	12 bit or 16 bit	12 bit		-		
	High precision readout	12 bit or 16 bit	14 bit	-			
Interface / Output signal (digital output)		IEEE 1394b-2002	IEEE 1394-1995 / Non-compressed data (Mono 16)				
Exposure time		10 μs to 4200 s	30 μs to 7200 s	10 μs to 10 s	10 μs to 1 s		
External control		IIDC 1394-Based Digital Camera Specification Ver.1.31 **					
Sub-array		Yes					
External trigger		Yes					
Contrast enhancement	High speed readout	Analog gain (10 times max.) and offset function	1 to 6 times	High gain / Low gain	High gain / Low gain		
	High precision readout	Analog gain (10 times max.) and offset function	1, 2, 10 times	-	-		
Lens mount		C-mount					
Line voltage		AC 100 V to 240 V, 50 Hz / 60 Hz		DC +12 V 2A	DC +8 V to DC +30 V		
Power consumption		approx. 60 V-A	approx. 220 V-A	approx. 24 V-A	approx. 8 V-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)					

① The hermetic sealed head maintains a high degree of vacuum 10^{-8} Torr, without re-evacuation.



** "ORCA 3CCD Digital Color Camera w/front cable mount" for the C7780-10
 "ORCA 3CCD Digital Color Camera w/rear cable mount" for the C7780-20

** Hamamatsu is a member of 1394 Trade Association



② The resolution of outline scan is 664(H) x 422(V).

③ Calculated from the ratio of the full well capacity and average readout noise.

④ The hermetic vacuum-sealed air-cooled head is available. Please consult with our sales office.

⑤ The sub-array setting is available only with binning mode.

	Horizontal width	Horizontal offset	Vertical width	Vertical offset
2 x 2 binning	8 x n	8 x n	8 x n	8 x n
4 x 4 binning	8 x n	8 x n	8 x n	8 x n
n	$0 \leq n \leq 500$	$0 \leq n \leq 499$	$0 \leq n \leq 328$	$0 \leq n \leq 327$

Large format, High resolution	Speciality high QE, Low noise		Color	High speed
ORCA-HR	ORCA II-BT-512G	ORCA II-BT-1024G	ORCA-3CCD	C9300-221
C4742-95-12HR	C4742-98-26LWG2	C4742-98-26KWG2	C7780-10, C7780-20 *	C9300-221
Passive air-cooled head	Hermetic vacuum-sealed water-cooled head ①		Passive air-cooled head	Forced air-cooled head
-	Built-in (Control: Open / Close / Auto)		-	-
Large format interline CCD (HR-1000)	S7170 full-frame transfer CCD	CCD47-10 full-frame transfer CCD	ER-150 progressive scan interline CCD	Progressive scan interline CCD
4000 (H) x 2624 (V)	512 (H) x 512 (V)	1024 (H) x 1024 (V)	1344 (H) x 1024 (V)	640 (H) x 480 (V)
5.9 μm (H) x 5.9 μm (V)	24 μm (H) x 24 μm (V)	13 μm (H) x 13 μm (V)	6.45 μm (H) x 6.45 μm (V)	7.4 μm (H) x 7.4 μm (V)
23.6 mm (H) x 15.5 mm (V)	12.29 mm (H) x 12.29 mm (V)	13.3 mm (H) x 13.3 mm (V)	8.67 mm (H) x 6.60 mm (V)	4.74 mm (H) x 3.55 mm (V)
20 MHz/pixel	2.5 MHz/pixel	5 MHz/pixel	16.0 MHz/pixel	30 MHz/pixel
-	156 kHz/pixel	312.5 kHz/pixel	-	-
1.7 frame/s	6.34 frame/s	3.05 frame/s	9.1 frame/s	150 frame/s
3.4 frame/s	9.84 frame/s	4.58 frame/s	17.9 frame/s	274 frame/s
6.4 frame/s	13.6 frame/s	6.12 frame/s	31.5 frame/s	461 frame/s
Outline scan ② 8.9 frame/s	16.8 frame/s	7.36 frame/s	49.2 frame/s	694 frame/s
-	0.55 frame/s	0.28 frame/s	-	82 frame/s
-	1.07 frame/s	0.54 frame/s	-	155 frame/s
-	2.05 frame/s	1.01 frame/s	-	280 frame/s
-	3.75 frame/s	1.83 frame/s	-	465 frame/s
13 electrons	-	-	13 electrons	-
-	7 electrons	6 electrons	-	20 electrons
13 300 electrons	230 000 electrons	80 000 electrons	18 000 electrons	20 000 electrons
-	-	-	-	-
1000 : 1	-	-	1384 : 1	1000 : 1
-	32 875 : 1	13 333 : 1	-	-
-	-	-	-	-
Peltier cooling, air radiation system	Water-cooling and peltier cooling, with hermetic sealing ④		Peltier cooling, air radiation system	Forced air peltier cooling
+5 °C to +7 °C	-75 °C (absolute value) ④		0 °C (absolute value)	0 °C to +5 °C
0.5 electrons/pixel/s	0.032 electrons/pixel/s ④	0.0012 electrons/pixel/s ④	0.5 electrons/pixel/s	2 electrons/pixel/s
12 bit	12 bit		12 bit	
-	16 bit		-	12 bit
TIA/EIA-644(LVDS) parallel output 12 bit	IEEE1394-1995 / Non-compressed data (Mono 16)		12 bit, 10 bit and 8 bit x3 channels parallel output	Camera Link
330 μs to 10 s	20 ms to 7200 s		128 μs to 10 s	33.1 μs to 10 s
RS-232C	IIDC 1394-Based Digital Camera Specification Ver.1.30 **		RS-232C	Camera Link
Yes ⑤	Yes		-	-
-	Yes		-	-
Analog gain (10 times max.) and offset function	1 to 6 times		-	Analog gain (5 times max.)
Analog gain (10 times max.) and offset function	1, 4, 16 times	1, 4, 18 times	-	Analog gain (5 times max.)
F-mount	C-mount		2/3 inch bayonet mount (flange back 48 mm)	
AC 100 V to 240 V, 50 Hz / 60 Hz				
approx. 90 V·A	approx. 220 V·A		approx. 77 V·A	approx. 10 V·A
-10 °C to +50 °C				
0 °C to +40 °C				
70 % max. (no condensation)				

Advantages of an interline transfer CCD (ER-150 CCD)

New interline transfer CCDs like the Hamamatsu ER-150 CCD (Figure 1) used in the ORCA series of cameras, offer characteristics ideally suited to many scientific applications.

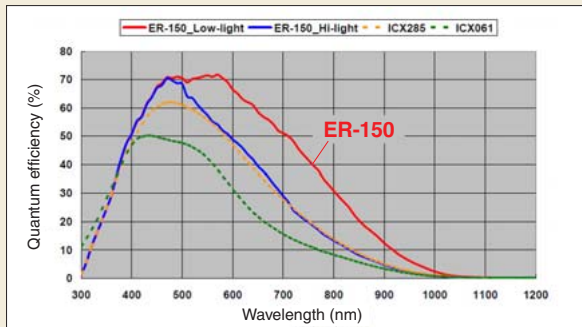
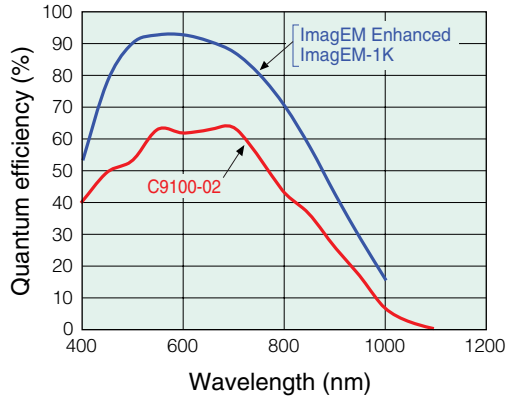


Fig. 1 QE of the ER-150 interline transfer CCD (See line in red.)

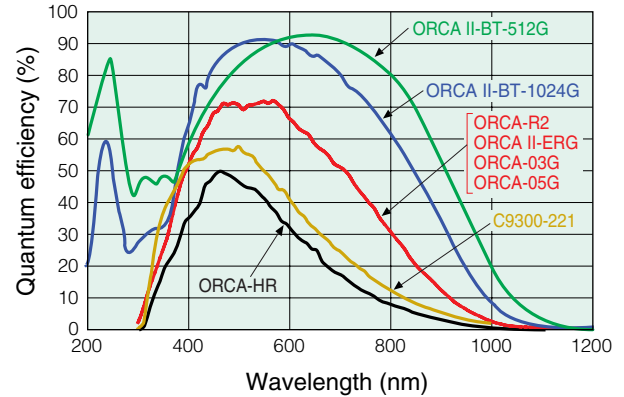
Spectral response characteristics

* These are typical, not guaranteed.

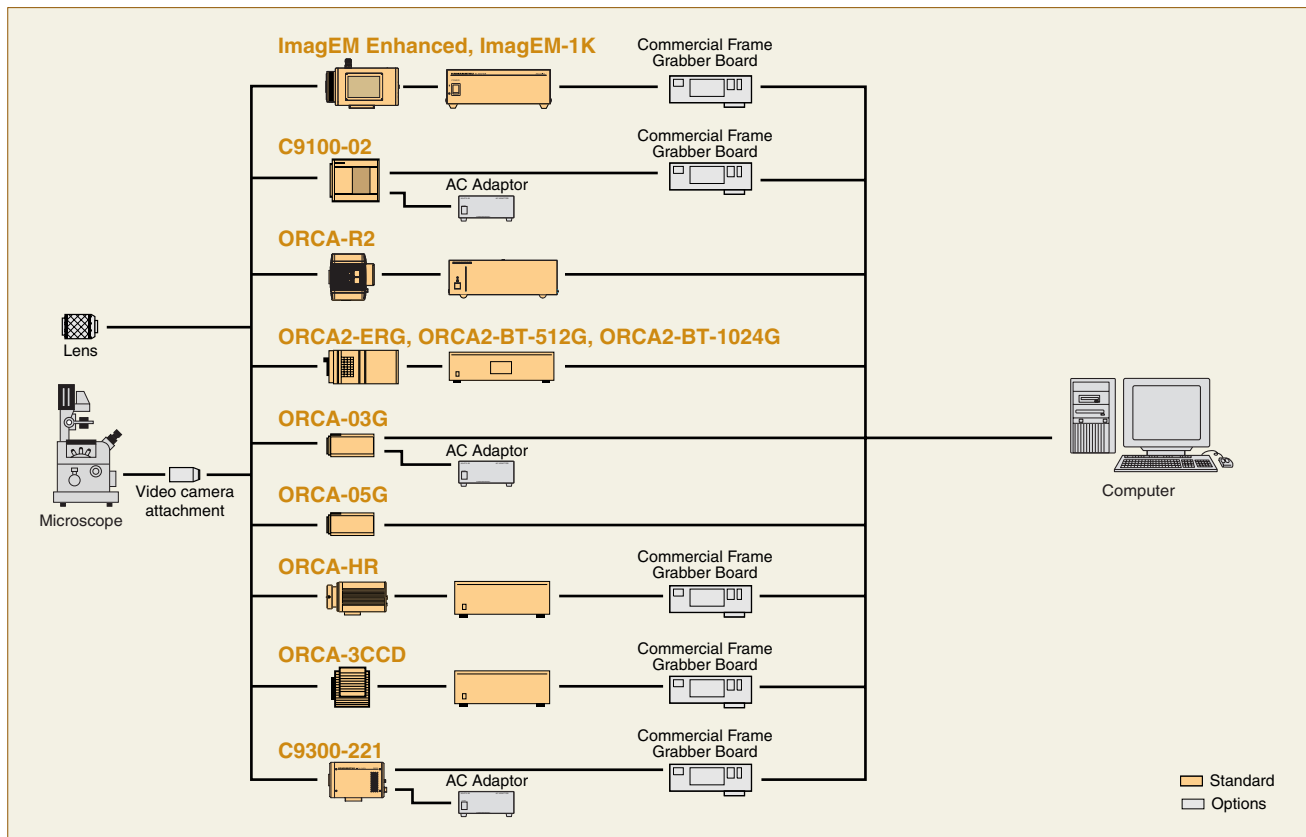
EM-CCD (Electron multiplication CCD) cameras



Integrating cameras



System configurations



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