

# Finger Lakes Instrumentation

## AIC 2019: Full Speed Ahead in Astronomy

### What's New

What a year for FLI! With Gary Walker's ground-breaking work in milli-mag photometry using the Kepler KL400, and Tolga's APOD with the KL4040, our new Kepler cameras are finding their niches in astronomy. We've also released the deep cooled DC23084 (4K x 4K back-illuminated CCD with 15 micron pixels) and, by the time of AIC, we plan to have released the DC4320 (2K x 2K, 24 micron) and the DC23042 (2K x 2K, 15 micron), as well the initial release of the new 6K x 6K, 10 micron CMOS camera, the KL6060 (see pages 6 and 7). To say that our engineering team has been busy is a huge understatement.

To answer your questions: CCDs are not going away, FLI is not moving away from CCDs, and CMOS is not the answer to everything! But it is an extraordinarily exciting new tool offering fresh solutions to old problems, as well as opening up the way to completely new applications.



IC1396. Kepler KL4040. Courtesy Tolga Gumusayak.

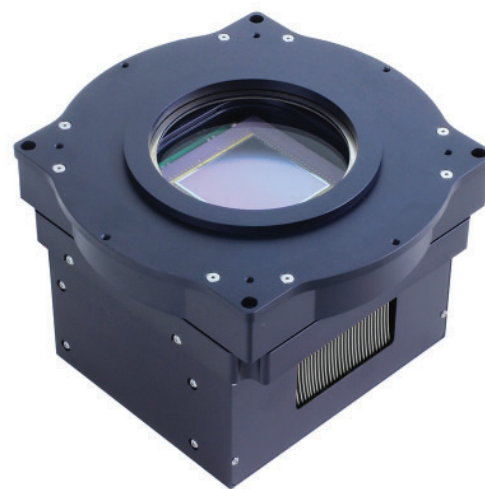
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Kepler KL400  
Back-illuminated CMOS



Kepler KL4040  
Front-illuminated CMOS



Kepler DC4320  
Front-illuminated CCD

# Kepler Cooled CMOS Cameras

## One Giant Leap Forward

### Higher Speeds, More Channels, New Sensors

Kepler is FLI's new series of cooled cameras, providing higher throughput, more channels, and scientific CMOS sensors.

#### Keplers Released in 2018

FLI began shipping the Kepler KL400 and KL4040 cameras in 2018. Both models feature a high QE, low-noise, high frame-rate cooled sCMOS sensor. The KL400 is one of the most sensitive cameras in existence (1.5 e- read noise, 95% QE). The KL4040 is a high QE front illuminated camera with a generous 52mm imaging diagonal.

#### Coming in 2019

The next model scheduled for release is the KL6060 camera, which features a 38 megapixel, 87mm diagonal sensor, available with front (2019) or back illuminated (2020) sensor.

#### Other Potential Candidates for the Kepler Platform

The extremely high bandwidth of Kepler's USB 3.0 and optional QSFP (fiber) interfaces make it possible to push up speeds on sensors already supported by FLI, such as increasing the frame rate of the KAI-29052 interline transfer CCD by a factor of 10.

#### Modularity

For customer convenience, Kepler's shutter, fans, and digital board have all been designed to be user-replaceable.



KL400 with Optional 45mm Shutter

#### Camera Applications:

Orbital Debris Detection  
ExoPlanet Research  
Millimag Photometry

#### Software Support

MicroManager  
MATLAB  
LabVIEW  
ASCOM



Kepler cameras include Pilot Control Software

#### In Production

#### PRELIMINARY Specifications

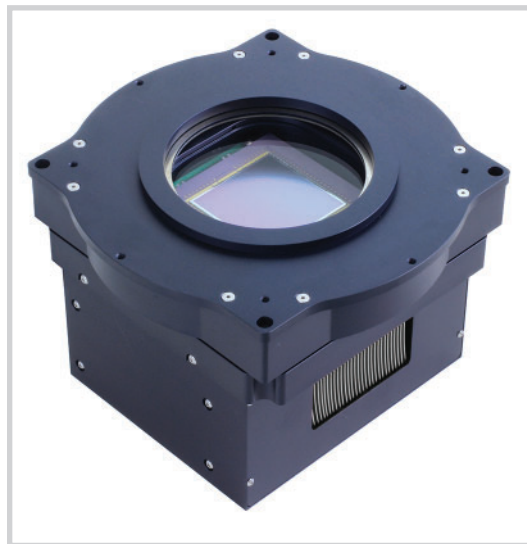
Kepler Model	KL400 FI, KL400 BI	KL4040	KL6060 FI, KL6060 BI
Sensor Type	Front & Back illuminated	Front illuminated	Front & Back illuminated
Resolution	2048 x 2048	4096 x 4096	6144 x 6144
Pixel Size	11 x 11 microns	9 x 9 microns	10 x 10 microns
Imaging Area	22.5 x 22.5 mm	36.9 x 36.9 mm	61.4 x 61.4 mm
Sensor Diagonal	31.9 mm	52.1 mm	86.9 mm
Maximum Frame Rate	48 fps (24 fps HDR)	24 fps (QSFP)	10 fps (LDR; QSFP)
Read Noise	1.5 e- (FI) / 1.6 e- (BI)	3.7 e-	3.0 e- (BI HDR)
Full Well Capacity (e-)	120000 (FI) ; 90000 (BI)	70000 e-	130000 (FI); 100000 (BI)
Dynamic Range (HDR)	96 dB (FI) / 93 dB (BI)	86 dB	90 dB (HDR)
Shutter	Rolling	Rolling; Rolling with Global Reset	Rolling; Rolling with Global Reset
Peak QE	58% (FI) / 95% (BI)	74% (CMT)	72% (FI); 95% (BI)
Cooling	45°C Below Ambient	40°C Below Ambient	40°C Below Ambient
Dark Current @ -20C	0.2 eps (FI); 0.6 eps (BI)	0.15 eps	0.1 eps

Specifications subject to change without notice.

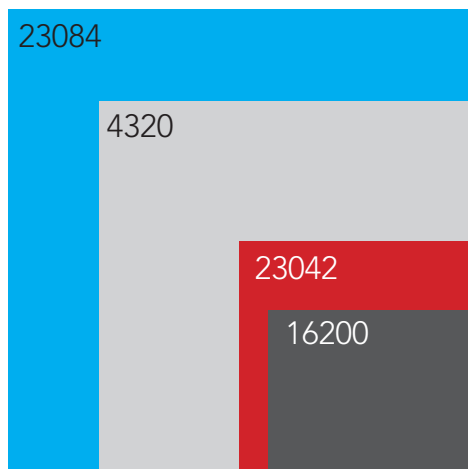
# Kepler Deep Cooled Cameras

## Large Area CCDs

FLI has brought three large area CCDs to its deep cooled Kepler platform: the back-illuminated CCD230-42 and CCD230-84, and the front-illuminated KAF-4320. The CCD230-42 has long been a popular sensor in our ProLine and MicroLine platforms. The Kepler platform gives it added cooling, as well as support by our new FLI Pilot software, SDK, and ASCOM driver. The DC cameras have an optional SFP fiber interface.



Kepler DC4320



Sensor Area

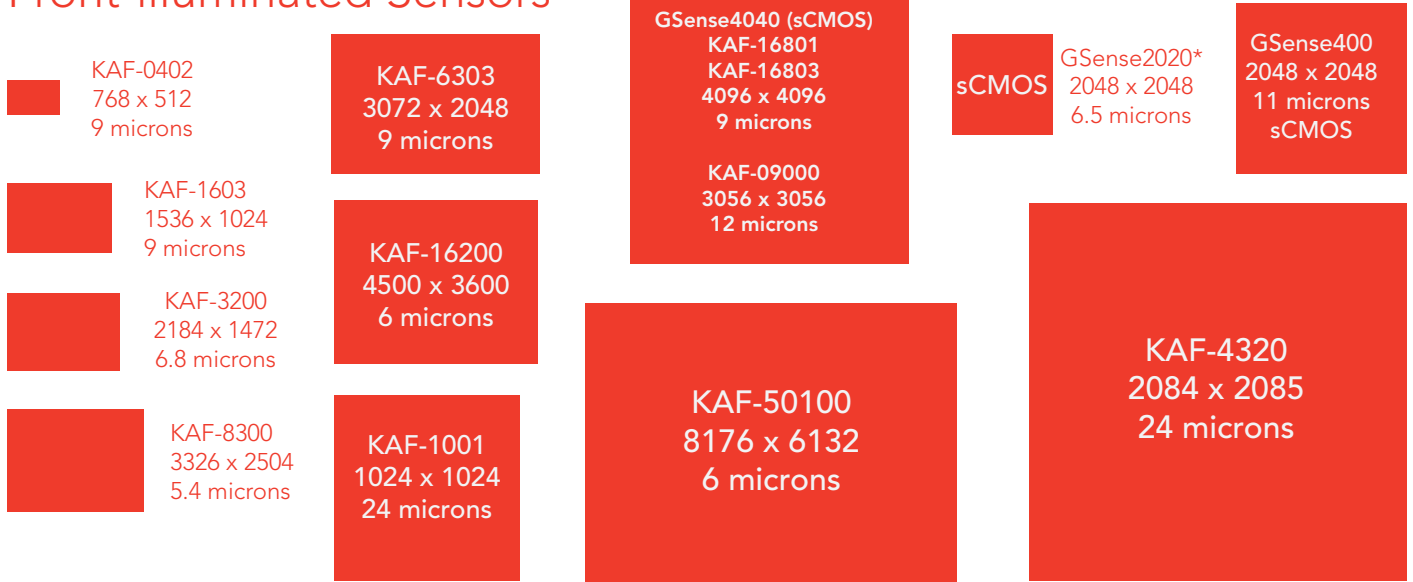
Kepler Model	DC4320	DC23042	DC23084
Sensor Type	Front illuminated CCD	Back illuminated CCD	Back illuminated CCD
Resolution	2048 x 2048	2048 x 2048	4096 x 4096
Pixel Size	24 x 24 microns	15 x 15 microns	15 x 15 microns
Imaging Area	49.2 x 49.2 mm	30.7 x 30.7 mm	61.4 x 61.4 mm
Sensor Diagonal	69.5 mm	43.4 mm	86.9 mm
Interface	USB 3.0	USB 3.0	USB 3.0
Read Noise	23 e- at 1.2 MHz	15 e- at 500 kHz	15 e- at 500 kHz
Full Well Capacity (e-)	500,000	150,000	150,000
Digitization Clock	1.2 MHz & 3 MHz	500 kHz & 2 MHz	500 kHz & 2 MHz
Optional Shutter	90 mm	65 mm	90 mm
Peak QE	72%	94%	94%
Cooling	60°C Below Ambient	70°C Below Ambient	60°C Below Ambient
Dark Current @ -25C	0.4 eps	0.2 eps	0.2 eps

Specifications subject to change without notice.

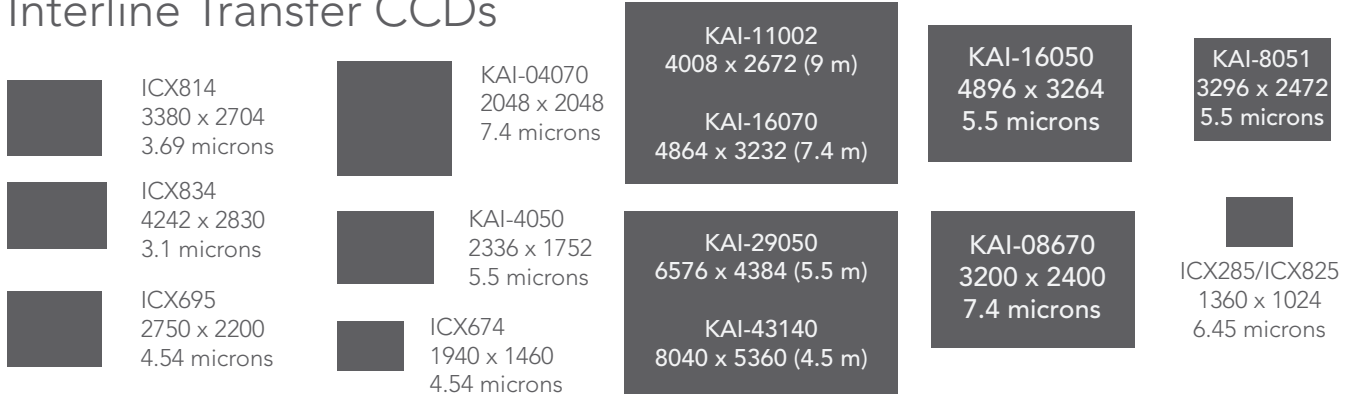
# Sensors

FLI supplies cooled CCD and CMOS cameras using the sensors on this chart. Sensors shown actual size. Sensors marked with an asterisk (\*) are under development.

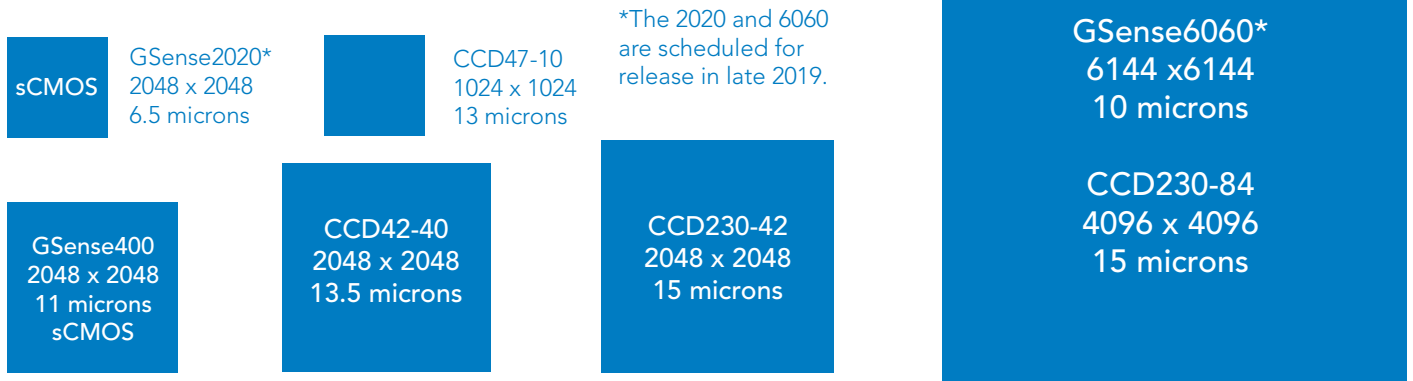
## Front-illuminated Sensors



## Interline Transfer CCDs



## Back-illuminated Sensors



\*The 2020 and 6060 are scheduled for release in late 2019.

# Sensors

## Sensors Supported in FLI Cameras

Red = Front-Illuminated

Dark Gray = Interline

Blue = Back-illuminated (Thinned)

Sensor Source	Sensor	Camera	Pixels X	Pixels Y	Pixel microns	Array Size (mm)		Area (mm <sup>2</sup> )	Diag (mm)	Video Size <sup>1</sup>	Pixels	Full Well
						X	Y					
ON Semi	KAF-50100	ML	8176	6132	6	49.1	36.8	1804.9	61.3	3.8	50.1M	40.3K
ON Semi	KAF-16801	PL,ML	4096	4096	9	36.9	36.9	1359.0	52.1	3.3	16.7M	100K
ON Semi	KAF-16803	PL,ML	4096	4096	9	36.9	36.9	1359.0	52.1	3.3	16.7M	100K
GPixel	GSense4040	KL	4096	4096	9	36.9	36.9	1359.0	52.1	3.3	16.7M	70K
ON Semi	KAF-16200	ML	4500	3600	6	27.0	21.6	583.2	34.6	2.2	16.2M	40K
ON Semi	KAF-09000	PL,ML	3056	3056	12	36.7	36.7	1344.8	51.9	3.2	9.3M	110K
ON Semi	KAF-8300	ML	3326	2504	5.4	18.0	13.5	242.9	22.5	1.4	8.3M	25.5K
ON Semi	KAF-6303	ML	3072	2048	9	27.6	18.4	509.6	33.2	2.1	6.3M	100K
ON Semi	KAF-4320	DC	2048	2048	24	49.2	49.2	2415.9	69.5	4.3	4.2M	500K
GPixel	GSense400	KL	2048	2048	11	22.5	22.5	507.5	31.9	2.4	4.2M	120K
GPixel	GSense2020	KL	2048	2048	6.5	13.3	13.3	177.2	18.8	1.2	4.2M	45K
ON Semi	KAF-3200	ML	2184	1472	6.8	14.9	10.0	148.7	17.9	1.1	3.2M	55K
ON Semi	KAF-1603	ML	1536	1024	9	13.8	9.2	127.4	16.6	1.0	1.6M	100K
ON Semi	KAF-1001	PL,ML	1024	1024	24	24.6	24.6	604.0	34.8	2.2	1048K	500K
e2v	CCD30-11	ML	1024	256	26	26.6	6.7	177.2	27.4	1.7	262K	300K
ON Semi	KAI-43140	ML	8040	5360	4.5	36.2	24.1	872.1	43.5	2.7	43.1M	13K
ON Semi	KAI-29050	ML	6576	4384	5.5	36.2	24.1	872.1	43.5	2.7	28.8M	20K
ON Semi	KAI-16050	ML	4896	3264	5.5	26.9	18.0	483.4	32.4	2.0	16.0M	20K
ON Semi	KAI-16070	ML	4864	3232	7.4	36.0	23.9	860.9	43.2	2.7	15.7M	44K
Sony	ICX834	ML	4242	2830	3.1	13.2	8.8	115.4	15.8	1.0	12.0M	10K
ON Semi	KAI-11002	ML	4008	2672	9	36.1	24.0	867.5	43.4	2.7	10.7M	60K
Sony	ICX814	ML	3380	2704	3.69	12.5	10.0	124.4	16.0	1.0	9.1M	15K
ON Semi	KAI-08670	ML	3600	2400	7.4	26.6	17.8	473.1	32.0	2.0	8.6M	44K
ON Semi	KAI-08051	ML	3296	2472	5.5	18.1	13.6	246.5	22.7	1.4	8.1M	20K
Sony	ICX695	ML	2750	2200	4.54	12.5	10.0	124.7	16.0	1.0	6.0M	17K
ON Semi	KAI-04070	ML	2048	2048	7.4	15.2	15.2	229.7	21.4	1.3	4.2M	44K
ON Semi	KAI-04050	ML	2336	1752	5.5	12.8	9.6	123.8	16.1	1.0	4.1M	20K
Sony	ICX674	ML	1940	1460	4.54	8.8	6.6	58.4	11.0	0.7	2.8M	20K
Sony	ICX285/825	ML	1360	1024	6.45	8.8	6.6	57.9	11.0	0.7	1.4M	21K
GPixel	GSense6060	KL	6144	6200	10	61.44	62.0	3809	87.3	5.5	37.7M	120K
e2v	CCD230-84	DC	4096	4096	15	61.4	61.4	3775	86.9	5.4	16.8M	100K
e2v	CCD230-42	PL,ML,DC	2048	2048	15	30.7	30.7	943.7	43.4	2.7	4.2M	150K
e2v	CCD42-40	PL,ML	2048	2048	13.5	27.6	27.6	764.4	39.1	2.4	4.2M	100K
GPixel	GSense400	KL	2048	2048	11	22.5	22.5	507.5	31.9	2.0	4.2M	92K
GPixel	GSense2020	KL	2048	2048	6.5	13.3	13.3	177.2	18.8	1.2	4.2M	45K
e2v	CCD47-20	ML	1024	1024	13	13.3	13.3	177.2	18.8	1.2	1048K	100K
e2v	CCD47-10	ML	1024	1024	13	13.3	13.3	177.2	18.8	1.2	1048K	100K
e2v	CCD42-10	ML	2048	512	13.5	27.6	6.9	191.1	28.5	1.8	1048K	100K
e2v	CCD77-00	ML	512	512	24	12.3	12.3	151.0	17.4	1.1	262K	300K

GPixel Sensors are sCMOS; all other sensors are CCDs.

CCDs supported in the MicroLine cameras (ML) are also supported in Hyperion cameras. However, Hyperions only support 25 and 45mm shutters.

<sup>1</sup>Video size: In the world of video, a diagonal of 16mm is called a 1" sensor.