SOPHIA® 4096B
DEEP-COOLED, ULTRA-LARGE-FORMAT CCD CAMERAS

Datasheet

- 4096 x 4096 sensor format
- 15 x 15 micron pixel size
- 61.4 x 61.4 mm imaging area
- ArcTec™ technology for maximum deep cooling
- Read noise as low as 2.0 e⁻ roots
- 150,000 / 350,000 well depth
- Up to 4 MHz readout (quad port)
- 16-bit and 18-bit digitization
Great choices:

- The SOPHIA 4096B-154 features the e2v CCD230-84 back-illuminated sensor, which provides an expansive 61.4 x 61.4 mm imaging area, 4096 x 4096 pixel resolution, and large 15 μm pixels.

- The SOPHIA 4096B-154A model incorporates the e2v CCD231-84 "astro" back-illuminated sensor, combining exceptionally low read noise with a very large well depth.

SOPHIA cameras are ideal for applications ranging from astronomy to fluorescence imaging.

Key Camera Features:

- **Better Optical Design:**
  Improved field-flattener performance with reduced window-to-CCD-surface distance along with minimized window thickness. Optimized design improves edge sharpness and lowers the distortion.

- **Air and Water Cooling:**
  SOPHIA cameras reach deep temperatures without liquid nitrogen or cryocoolers, so there are no requirements for storage or bulky equipment. The SOPHIA 4096B is designed for remote operation.
Shutter Options:
Supports an integrated high-performance 90 mm mechanical shutter or provides software control of external shutters. The integral shutter is field replaceable, reducing downtime and cost.

CCD Positioning:
Incorporates the ability to “zero out” the variability in the mechanical assembly so as to achieve precise and repeatable CCD orientation. The CCD can be adjusted for tilt, pitch, and z-axis translation, reducing the requirement for system-level adjustments.

When Speed is Paramount:
The SOPHIA 4096B has the most advanced readout electronics:

- 4-port simultaneous readout
- Multiple ADC speeds (up to 16 MHz)
- Binning and ROI readout
- Custom readout modes for microsecond exposures
**Lifetime Vacuum Guarantee:**
Decades of expertise ensure the most reliable vacuum design in the industry. ArcTec technology utilizes an all-metal, hermetic vacuum seal with no epoxies. Princeton Instruments is the only scientific imaging company that guarantees both cooling temperature and vacuum for the lifetime of the camera.

**Multi-TEC Design:**
A complete redesign of the CCD cooling mechanism and vacuum chamber guarantees even heat dissipation for very large CCD formats. Designed to withstand thermal cycling and ensure repeatable CCD positioning and alignment.

**Wide Dynamic Range:**
Extremely low noise, maximum well depth, 18-bit digitization, and dark current below the zodiacal photon background enable extremely long exposure times for weak-signal detection.

**We give you the most options!**
The SOPHIA 4096B is a perfect solution for the most challenging low-light applications:

- Air or liquid cooling
- Microsoft® Windows® 10 or Linux® 64-bit operating system support
- Seamless integration of controls and data acquisition into MATLAB® (MathWorks), LabVIEW® (National Instruments), ASCOM, Maxim DL™ (Cyanogen Imaging), and Python®
- SDK / API compatible with Microsoft Windows and Linux
**CCD Options:** Anti-reflection (AR) coatings on back-illuminated CCDs further improve quantum efficiency.

- Standard midband AR coating, available on the SOPHIA 4096B-154 and -154A, optimizes the response in the visible range (with QE reaching 95%).

- Deep depletion with fringe suppression and dual-AR coatings, available on the SOPHIA 4096B-154A, increases the QE response between 400 and 1000 nm, making this option an excellent choice for emerging NIR applications. Fringe suppression reduces the etalonning effect in the NIR.
eXcelon® Advantages

B_eXcelon provides superior QE over the standard back-illuminated (“B/I”) version in the UV-NIR range.

Data taken with white light source through a monochromator comparing etaloning performance of eXcelon vs. back-illuminated CCDs.
## SOPHIA 4096B Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>SOPHIA 4096B-154</th>
<th>SOPHIA 4096B-154A</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCD image sensor</td>
<td>e2v CCD230-84; scientific grade 1; AIMO. The large image area addresses demanding scientific imaging applications. Back-illuminated spectral response and low readout noise provide outstanding sensitivity. Available with midband coating (-MB version) or eXcelon process (-X version with proprietary eXcelon).</td>
<td>e2v CCD231-84; scientific grade 1; NiMO. The back-illuminated &quot;astro&quot; version offers higher full well capacity and lower readout noise than the CCD230-84 for demanding low-light applications. Astro midband (-MB version) and astro deep depletion with multiple AR coatings (-AR version) available.</td>
</tr>
<tr>
<td>CCD format</td>
<td>4096 x 4096 imaging pixels; 15.0 x 15.0 µm pixels; 100% fill factor</td>
<td></td>
</tr>
<tr>
<td>Imaging area</td>
<td>61.4 x 61.4 mm</td>
<td></td>
</tr>
<tr>
<td>Deepest cooling temperature</td>
<td>&lt; -90°C thermoelectric cooling with liquid chiller;</td>
<td>&lt; -60°C thermoelectric cooling with air</td>
</tr>
<tr>
<td></td>
<td>&lt; -60°C thermoelectric cooling with air</td>
<td></td>
</tr>
<tr>
<td>Thermostating precision</td>
<td>±0.1°C</td>
<td></td>
</tr>
<tr>
<td>Dark current (e-/pixel/sec)</td>
<td>0.0003 @ -60°C</td>
<td>0.8 @ -60°C</td>
</tr>
<tr>
<td>Cooling method</td>
<td>Thermoelectric air or liquid cooling (liquid chiller required)</td>
<td></td>
</tr>
<tr>
<td>Full well</td>
<td>150 ke- (typical)</td>
<td>350 ke- (typical)</td>
</tr>
<tr>
<td>ADC speed</td>
<td>4 MHz, 2 MHz, 1 MHz, 100 kHz; 4-port readout</td>
<td>3 MHz, 1 MHz, 500 kHz, 100 kHz; 4-port readout</td>
</tr>
<tr>
<td>ADC bits</td>
<td>16 bits @ all ADC speeds; 18 bits @ 1 MHz and 100 kHz; 4-port readout</td>
<td>16 bits @ all ADC speeds; 18 bits @ 500 kHz and 100 kHz; 4-port readout</td>
</tr>
<tr>
<td>System read noise</td>
<td>&lt;22 e- rms @ 4 MHz/port; &lt;8.5 e- rms @ 1 MHz/port; &lt;4.0 e- rms @ 100 kHz/port</td>
<td>&lt;8.0 e- rms @ 3 MHz/port; &lt;4.0 e- rms @ 1 MHz/port; &lt;2.0 e- rms @ 100 kHz/port</td>
</tr>
<tr>
<td>Readout modes</td>
<td>4-port, 2-port, or 1-port readout; kinetics; external sync</td>
<td></td>
</tr>
<tr>
<td>Nonlinearity</td>
<td>&lt;1% @ 100 kHz</td>
<td></td>
</tr>
<tr>
<td>Software-selectable gains</td>
<td>1, 2, 4 e-/ADU</td>
<td></td>
</tr>
<tr>
<td>Data interface</td>
<td>USB 3.0 (5 m interface cable provided); optional fiberoptic interface available for remote operation</td>
<td></td>
</tr>
<tr>
<td>I/O signals</td>
<td>Two MCX connectors for programmable frame readout, shutter, trigger in</td>
<td></td>
</tr>
<tr>
<td>Software (optional)</td>
<td>LightField for Microsoft Windows 10 (64 bit); PICam SDK for Microsoft Windows and Linux; Automation for third-party software</td>
<td></td>
</tr>
<tr>
<td>Internal shutter</td>
<td>90 mm mechanical shutter with internal control or TTL</td>
<td></td>
</tr>
<tr>
<td>External shutter</td>
<td>90 mm mechanical shutter with TTL control</td>
<td></td>
</tr>
<tr>
<td>Certification</td>
<td>CE</td>
<td></td>
</tr>
<tr>
<td>Operating environment</td>
<td>+5°C to +30°C non-condensing</td>
<td></td>
</tr>
<tr>
<td>Camera head dimensions</td>
<td>See page 9</td>
<td></td>
</tr>
</tbody>
</table>

Specifications are subject to change.
# SOPHIA 4096B Frame Rates

## Frame Rates (frames/sec)

### SOPHIA 4096B-154

<table>
<thead>
<tr>
<th>Readout Rate (MHz)</th>
<th>Region of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4096 x 4096</td>
</tr>
<tr>
<td>4</td>
<td>0.44</td>
</tr>
<tr>
<td>2</td>
<td>0.29</td>
</tr>
<tr>
<td>1.0</td>
<td>0.18</td>
</tr>
<tr>
<td>0.1</td>
<td>0.023</td>
</tr>
</tbody>
</table>

### SOPHIA 4096B-154A

<table>
<thead>
<tr>
<th>Readout Rate (MHz)</th>
<th>Region of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4096 x 4096</td>
</tr>
<tr>
<td>3</td>
<td>0.50</td>
</tr>
<tr>
<td>1</td>
<td>0.21</td>
</tr>
<tr>
<td>0.5</td>
<td>0.11</td>
</tr>
<tr>
<td>0.1</td>
<td>0.022</td>
</tr>
</tbody>
</table>
LightField® Software
The Future of Scientific Imaging and Spectroscopy Software

The combination of LightField and the SOPHIA 4096B provides researchers with the most advanced and reliable toolset for experimental setup, data acquisition, and post processing:

▶ Powerful 64-bit software package includes Microsoft Windows 10 support
▶ Complete control of Princeton Instruments cameras and spectrometers
▶ Dependable data integrity via automatic saving to disk, time stamping, and retention of both raw and corrected data
▶ Full experimental details and system settings are archived and can be reloaded for future experiments ensuring maximum reproducibility
▶ For light-sensitive experiments, the user interface offers "low light" and "no light" modes during data acquisition
▶ LightField works seamlessly in multi-user facilities, remembering each user's hardware and software configurations
▶ Simple math functions and complex transforms can be applied to live or stored data, includes an easy-to-use editor to create your own formulas
▶ Integrated LabVIEW (National Instruments), MATLAB (MathWorks), ASCOM, Maxim DL (Cyanogen Imaging), and Python support
▶ Exports to your favorite file formats, including TIFF, FITS, ASCII, AVI, IGOR, and Origin
▶ Demo camera mode allows the user to view all of the settings and parameters associated with any camera without physically connecting the camera
▶ Live data processing operations provide real-time evaluation of incoming data to optimize experimental parameters

The most comprehensive software support

Acclaimed LightField software for Microsoft Windows 10 (64 bit)
Seamless integration of controls and data acquisition into LabVIEW, MATLAB, ASCOM, Maxim DL, and Python
PICam software development kit (SDK) for Linux and Microsoft Windows
Additional Optics & Coatings

In addition to advanced camera technology, Princeton Instruments provides the highest-performing optical components and optical subassemblies available for a diverse array of industries, including the medical, semiconductor, materials processing, analytic instrumentation, aerospace, and defense markets.

Since the 1960s, our Acton brand has become synonymous with the finest precision-engineered optics and coatings:

- UV laser optics
- Optical filters
- VUV / UV broadband optics
- CCD enhancement coatings
- Mirror blanks and windows

Our core product competencies include:

- Excimer Laser Optics
- Excimer Laser Mirrors
- Excimer Laser Beamsplitters
- Femtosecond and Picosecond Laser Coatings
- Anti-Reflection Coatings
- UV Anti-Reflection Coatings
- Broadband Anti-Reflection Coatings
- Narrowband Anti-Reflection Coatings
- Aluminum Mirrors
- Silver Mirrors
- Gold Mirrors
- Iridium Coatings
- UV-Enhanced Mirrors
- UV-Enhanced Silver Mirrors
- Bandpass Filters
- UV Bandpass Filters
- UV Rejection Filters
- Solar Blind Filters
- Solar Blue Filters
- UV Reflective Filters
- Beamsplitters
- UV Beamsplitters
- Neutral Density Filters
- UV Neutral Density Filters
- CCD Enhancement Coatings
- Lumogen Coatings
- Metachrome® Coatings
- Filter Coatings on CCDs
- Optical Contract Manufacturing
What is in the box?

SOPHIA 4096B cameras can be provided in custom configurations to suit your experiment. Please contact your local Princeton Instruments representative. The most common configurations are listed below:

Optional accessories:
- LightField software
- PICam SDK/API for Linux and Microsoft Windows (provided for free)
- Liquid chiller
- Fiberoptic data extension cable for remote operation from up to 30 m

Other CCD cameras from Princeton Instruments include:
- SOPHIA 2048B – 2k x 2k version of SOPHIA large-format CCD cameras
- SOPHIA-XO – 2k x 2k and 4k x 4k soft x-ray direct-detection CCD cameras
- NiRvana® – Scientific-grade SWIR InGaAs cameras

Be sure to check out KURO™, the world’s first back-illuminated 2k x 2k sCMOS cameras!
SOPHIA 4096B
DEEP-COOLED, ULTRA-LARGE-FORMAT CCD CAMERAS

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Page 8:
Gravity waves and Milky Way image courtesy of Dr. Young-In Won, Korea Polar Research Institute.

SWIR angiography image courtesy of Dr. Oliver T. Bruns and Dr. Thomas S. Bischof, Bawendi Lab, MIT, Cambridge, MA, USA.

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SOPHIA 4096B / Deep-Cooled, Ultra-Large-Format CCD Cameras