PI-MTE3
LARGE-FORMAT, IN-VACUUM CAMERAS
Datasheet

- Direct detection of soft x-rays
- Up to 4k x 4k sensor formats
- Reads out as fast as 3 full fps

TELEDYNE
PRINCETON INSTRUMENTS
Everywhereyoulook™
Breakthrough In-Vacuum Performance

PI-MTE3 in-vacuum CCD cameras are engineered for direct detection in VUV, EUV, and x-ray imaging applications from ~10 eV to 30 keV.

The back-illuminated CCDs (large 2k x 2k or 4k x 4k formats) utilized by the PI-MTE3 platform offer >95% peak quantum efficiency. Efficient liquid cooling results in low dark current, facilitating long integration times.

Due to their four-port readout architecture, these low-noise, 16 or 18-bit cameras provide frame rates up to 7x to 10x higher than previous-generation two-port cameras.

Applications

- XUV imaging
- SAXS/GISAXS
- Semiconductor metrology
- Grazing-incidence imaging/spectroscopy
- X-ray diffraction
- X-ray phase contrast imaging
- X-ray spectroscopy
- X-ray microscopy

Key Features

- High frame rates (~3 full fps @ 2k x 2k resolution)
- Low-noise, multi-port readout
- 24/7 in-vacuum operation: 10⁻⁹ Torr
- Edge-mounted sensor: the first row of the sensor is close to the camera edge
- CCD cooled to < -55°C using +10°C liquid
- All liquid connectors meet latest synchrotron guidelines
- Design allows mounting of filter and Be window

The Princeton Instruments PI-MTE3 2048B and 4096B are the most advanced CCD cameras for in-vacuum direct detection of soft x-rays yet!
Key Camera Features

- Offset CCD provides close access to samples for small-angle/grazing-incidence applications

PI-MTE3

- High frame rates with multi-port, 16 MHz effective readout
- Advanced thermal design for 24/7 operation in-vacuum
- Lowest dark current for long integration times
- Intuitive LightField software for real-time flatfield and background correction
- 100% in-vacuum testing, including cables and cooling tubes
- UHV compatibility to 10^-9 Torr vacuum
- Compatibility with Python®, Linux®, MATLAB® (MathWorks), and LabVIEW® (National Instruments)
- Integration with EPICS software
- Reduced vacuum chamber thermal load
- Low-outgassing electronics
Key Camera Features

Large-format, back-illuminated 2048 x 2048 and 4096 x 4096 resolution CCD sensors with >95% peak quantum efficiency in the 10 eV to 30 keV range

Deep cooled to reduce thermally generated noise

100% in-vacuum testing, including cables and cooling tubes

The most comprehensive software support

Acclaimed LightField for Microsoft® Windows® 10 (64 bit)

Compatible with EPICS and Python software

PICam software development kit (SDK) for Linux and Microsoft Windows
Exceptional Reliability

Princeton Instruments has been designing x-ray cameras for more than three decades. As of today, hundreds of these low-noise cameras are being used at leading laboratories and facilities around the world! The exceptional reliability of our high-performance cameras is attributable to no-compromise engineering design and production techniques.

100% Tested In-Vacuum
Every PI-MTE3 camera is tested in-vacuum as a complete system... including all cooling and electrical cables.

You receive a 100% in-vacuum–tested system!
# PI-MTE3 Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>PI-MTE3 2048B</th>
<th>PI-MTE3 4096B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CCD image sensor</strong></td>
<td>e2v CCD230-42; scientific grade 1; MPP; back illuminated; no AR coating</td>
<td>e2v CCD231-84 or 230-84; scientific grade 1; MPP; back illuminated; no AR coating</td>
</tr>
<tr>
<td><strong>CCD format</strong></td>
<td>2048 x 2048 imaging pixels; 15.0 x 15.0 µm pixels; 100% fill factor</td>
<td>4096 x 4096 imaging pixels; 15.0 x 15.0 µm pixels; 100% fill factor</td>
</tr>
<tr>
<td><strong>Imaging area</strong></td>
<td>30.7 x 30.7 mm</td>
<td>61.4 x 61.4 mm</td>
</tr>
<tr>
<td><strong>Deepest cooling temperature (@ +20ºC)</strong></td>
<td>-55°C (typical) with liquid chiller</td>
<td>-50°C (typical) with liquid chiller</td>
</tr>
<tr>
<td><strong>Thermostating precision</strong></td>
<td>±0.1°C</td>
<td>±0.1°C</td>
</tr>
<tr>
<td><strong>Dark current (e-/pixel/sec)</strong></td>
<td>0.0015</td>
<td>230-84: 0.0015, 231-84: 8.0</td>
</tr>
<tr>
<td><strong>Cooling method</strong></td>
<td>Liquid cooling</td>
<td></td>
</tr>
<tr>
<td><strong>Full well, single pixel (typical)</strong></td>
<td>150 ke-</td>
<td>230-84: 150 ke-, 231-84: 300 ke-</td>
</tr>
<tr>
<td><strong>ADC speed</strong></td>
<td>16 MHz (4 MHz x 4 ports); 4 MHz (1 MHz x 4 ports); 400 kHz (100 kHz x 4 ports)</td>
<td>12 MHz (3 MHz x 4 ports); 4 MHz (1 MHz x 4 ports); 400 kHz (100 kHz x 4 ports)</td>
</tr>
<tr>
<td><strong>ADC bits</strong></td>
<td>16 bits</td>
<td>18 bits</td>
</tr>
<tr>
<td><strong>System read noise @100 kHz Per Port (e- rms)</strong></td>
<td>6.5</td>
<td>230-84: 6.0, 231-84: 3.4</td>
</tr>
<tr>
<td><strong>Readout modes</strong></td>
<td>4-port, 2-port, or 1-port readout; Kinetics; External Sync</td>
<td></td>
</tr>
<tr>
<td><strong>Nonlinearity</strong></td>
<td>&lt;2% @ 100 kHz</td>
<td></td>
</tr>
<tr>
<td><strong>Software-selectable gains</strong></td>
<td>1, 2, 4 e-/ADU</td>
<td>0.2, 1.1 e-/ADU</td>
</tr>
<tr>
<td><strong>Host interface</strong></td>
<td>USB 3.0</td>
<td></td>
</tr>
<tr>
<td><strong>I/O signals (TTL)</strong></td>
<td>Trigger In, Expose Out, Shutter Out/In, Readout, Ready</td>
<td></td>
</tr>
<tr>
<td><strong>Software (optional)</strong></td>
<td>LightField for Microsoft Windows 10 (64 bits); PICam SDK for Microsoft Windows and Linux; EPICS support via automation</td>
<td></td>
</tr>
<tr>
<td><strong>Bake-out temperature</strong></td>
<td>50°C (maximum)</td>
<td></td>
</tr>
<tr>
<td><strong>Vacuum compatibility</strong></td>
<td>10⁻⁹ Torr</td>
<td></td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td>CE</td>
<td></td>
</tr>
<tr>
<td><strong>Operating environment</strong></td>
<td>+5°C to +30°C non-condensing</td>
<td></td>
</tr>
<tr>
<td><strong>Feedthrough</strong></td>
<td>DN100 or 6” industry-standard CF flange</td>
<td></td>
</tr>
<tr>
<td><strong>Camera weight</strong></td>
<td>2.31 kg (5.10 lbs)</td>
<td>2.7 kg (5.9 lbs)</td>
</tr>
<tr>
<td><strong>Camera head dimensions (L x W x H)</strong></td>
<td>217.6 mm (8.56&quot;) x 102.3 mm (4.03&quot;) x 73.9 mm (2.91&quot;)</td>
<td>220.4 mm (8.68&quot;) x 102.3 mm (4.03&quot;) x 75.6 mm (2.98&quot;)</td>
</tr>
</tbody>
</table>

*Specifications are subject to change.*
Quantum Efficiency Curve

Frame Rates (frames/sec)

PI-MTE3 2048B

<table>
<thead>
<tr>
<th>Binning</th>
<th>16 MHz</th>
<th>4 MHz</th>
<th>400 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 1</td>
<td>3.2</td>
<td>0.9</td>
<td>0.09</td>
</tr>
<tr>
<td>2 x 2</td>
<td>7.4</td>
<td>2.9</td>
<td>0.33</td>
</tr>
<tr>
<td>4 x 4</td>
<td>14.3</td>
<td>7.7</td>
<td>1.05</td>
</tr>
<tr>
<td>8 x 8</td>
<td>22.2</td>
<td>15.4</td>
<td>2.9</td>
</tr>
</tbody>
</table>

PI-MTE3 4096B

<table>
<thead>
<tr>
<th>Binning</th>
<th>12 MHz</th>
<th>4 MHz</th>
<th>400 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 1</td>
<td>0.56</td>
<td>0.21</td>
<td>0.024</td>
</tr>
<tr>
<td>2 x 2</td>
<td>1.36</td>
<td>0.70</td>
<td>0.081</td>
</tr>
<tr>
<td>4 x 4</td>
<td>2.80</td>
<td>1.81</td>
<td>0.253</td>
</tr>
<tr>
<td>8 x 8</td>
<td>4.68</td>
<td>3.66</td>
<td>0.680</td>
</tr>
</tbody>
</table>
LightField® Software

The Future of Scientific Imaging and Spectroscopy Software

The combination of LightField and PI-MTE3 cameras 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), Python, and MATLAB (MathWorks) 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
System Components

The PI-MTE3 can be provided in custom configurations to suit your experiment. Please contact your local Princeton Instruments representative. The most common configurations are listed below.

Since the PI-MTE3 is highly sensitive to the effects of shipping and handling as well as debris, we have designed a special, robust shipping container that protects the camera and reduces contamination.

Optional accessories:
- LightField software
- PICam SDK/API for Linux and Microsoft Windows (provided for free)
- Liquid chiller

Other x-ray cameras from Princeton Instruments:
- SOPHIA-XO – Large-format 2k x 2k and 4k x 4k cameras for direct detection of soft x-rays
- PIXIS-XO – Small-format 1k x 1k and 2k x 2k cameras for direct detection of soft x-rays
- PIXIS-XF – Fiber-coupled camera designs with 1k x 1k and 2k x 2k resolutions

Also check out our KURO™ (world’s first back-illuminated sCMOS cameras) and SOPHIA® (CCD cameras) for UV-NIR imaging!
PI-MTE3
LARGE-FORMAT, IN-VACUUM CAMERAS

Contact your local Princeton Instruments representative for additional information.

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