



# Fraunhofer IMS

FRAUNHOFER INSTITUTE FOR MICROELECTRONIC CIRCUITS AND SYSTEMS IMS



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- 1 *xposure CMOS line scan camera.*
- 2 *Photomicrograph of xposure sensor.*
- 3 *xposure camera system.*
- 4 *Readout chain.*

## xposure

### 600/200 kHz High Speed RGB Line-Scan Sensor

The AIT Austrian Institute of Technology GmbH and the Fraunhofer Institute for Microelectronic Circuits and Systems (Fraunhofer IMS) developed a novel CMOS line-scan sensor – xposure – for applications in the field of fast optical inspection systems such as printed text checking, material and surface analysis. The xposure sensor represents an important technological step towards high-speed & high quality imaging. Fraunhofer IMS fabricates the sensor in its own 0.35  $\mu\text{m}$  CMOS process. The process used is certified for automotive applications. The xposure camera is especially designed for high-speed inline-quality inspection. With in total 60 lines the xposure camera is much more than a high-speed linescan camera. Each of the 60 lines can be read out individually. One line (monochrome) can be captured with 600 kHz and three lines (RGB) with 200 kHz. All 60 lines can be captured at frame rates up to 10 kHz.

The xposure camera offers single sensor multi-line-scan capabilities which opens unexpected capabilities for e.g. inline 3D surface analysis. Even more high-performance applications come into reach by adding for example computational imaging methods, which include correction of optical aberration, noise reduction, adaptive time delay integration (TDI) and dynamic range enhancement by employing multiple exposures. The xposure camera is an enabler for a novel embedded network of smart high-performance cameras

### xposure sensor

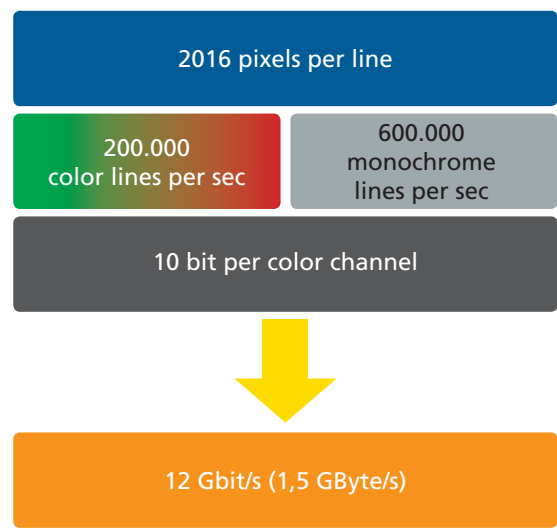
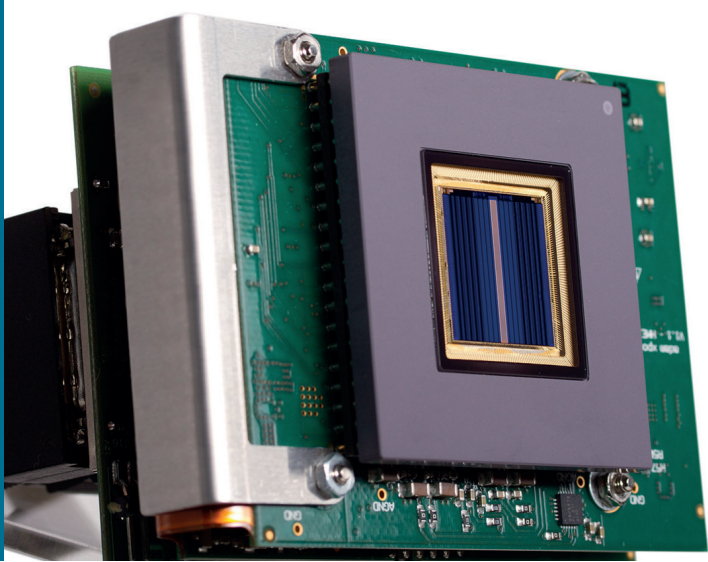
The sensor comprises 60 lines which can be uncoated for b/w applications or coated with alternating filters (R, G, B). Every line of the sensor consists of 2K pixels. The pixel pitch is 9  $\mu\text{m}$ . The horizontal fill factor is almost 100 %. A patented anti Moiré effect technology is applied to the sensor. The processing of the color filters used by the xposure highspeed color line-scan sensor takes place at Fraunhofer IMS.

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It is a user specific processing with multiple full RGB lines. The advantage compared to Bayer patterns lies in the dense RGB information. No interpolation (demosaicing) is needed and color artifacts at image edges are avoided. The outstanding sensitivity of the sensor in combination with its very dense line spacing allows for using standard optics and illumination. An additional advantage of the sensor is the free adjustability of the exposure time and the line-scan frequency.

The pixel readout uses a correlated double sampling technique to increase signal-to-noise ratio. The sensor uses on-chip column parallel analog-to-digital conversion, thus eliminating the need of external high-speed ADC's. The integrated column-parallel architecture enables line readout frequencies of up to 600 kHz for the monochrome sensor version and up to 200 kHz for the color sensor version. Readout of a certain region of interest (ROI) or the complete 60 light sensitive lines of the chip in area-scan mode permits easy adjustment of the sensor.

### Application Examples

- Color-print inspection: High quality color with 50  $\mu\text{m}$  resolution at 10 m/s speed
- High-speed railway inspection: Photometric stereo with 300 kHz RB enable 0.3 mm resolution and 3D profiling at 300 km/h train speed
- Industrial quality inspection: 600 kHz monochrome provide 2  $\mu\text{m}$  resolution at 4.3 km/h speed
- Inline 3D-recognition: by photometric stereo in RGB mode
- Plastic material recycling: in multispectral mode using multiple filter lines
- Security print inspection: Lightfield camera operation enables inspection of advanced security features line-scan mode with up to 600 kHz
- Areascan mode for easy mechanical adjustment
- 40 GigE Vision Ethernet Standard (QSFP with 4 x 10 GBit/s Ethernet)
- large high-end FPGA (Altera Arria 10 SOC with Linux OS) allows customizable pre-processing, protocols or interfaces
- cascading of cameras to form a network of cameras
- cascading of trigger and sync signals (1 camera can act as a master)
- very compact due to using newest FlexPrint technologies with 10 GHz, thus flexible mounting and flexible camera housings possible
- customized IO boards inside the camera possible with same dimensions (e.g. CameraLink (mini), machine interfaces, LED lighting control)

### Sensor Data

Parameter	Measured Values				
	463 nm	518 nm	627 nm	860 nm	
Dynamic range	54.4	53.2	54.0	53.5	dB
Max. signal to noise ratio	41.4	40.8	41.2	41.0	dB
Dark noise	25.5	25.4	25.2	25.7	e-
Noise Equivalent Energy	33	29	24	32	pJ/cm <sup>2</sup>
Camera gain	0.058	0.058	0.059	0.058	DN/e
Quantum efficiency	42.2	42.1	42.7	23.8	%
Saturation irradiance	32953	28642	30912	53141	ph/px
Nonlinearity	1.13	0.50	0.77	0.74	%

EMVA 1288 monochrome sensor, 500 kHz Line-rate, 1.4  $\mu\text{s}$  exposure time

### Specification

Pixels per Line	2016	plus 32 dark pixels/line
Pixel Size	9 x 9 $\mu\text{m}^2$	100 % fill factor
Number of Lines	60	organized in 20 triples
Vertical Pitch	18 $\mu\text{m}$	
Line-rate Mono (max.)	600 kHz	Single line read out
Line-rate RGB (max.)	200 kHz	Tri-linear read out
Frame-rate (max.)	10 kHz	read out of all 60 lines
ADC's	600 kSamples/s	On-chip, column-parallel
Sensor Output	16 taps à 10 bit, 80 MHz	
Total image Data Dandwithin	15 Gbit/s	