

TEM Cameras for Material Science Applications **TEM Cameras for Life Sciences Applications**

GHADIMI R., DABERKOW I., KOFLER C., MANIETTE Y., HUBER T., SPARLINEK P., BOBOLAS K., FANDERL U., HEIKE T.,
AND TIETZ H.R.
TVIPS GmbH, Eremitenweg 1, 82131 Gauting, Germany

For high-end scientific imaging in Transmission Electron Microscopy (TEM) a CMOS (Complementary Metal Oxide Semiconductor) image sensor has been designed available in three different resolutions: 2k × 2k, 4k × 4k and 8k × 8k pixel. Instead of using CCD (Charge Coupled Device) image sensors for image recording TVIPS employs image sensors based on custom designed CMOS technology for applications in life sciences [1] and material science, since 2006. Recent advantages in CMOS technology made it possible to produce monolithic image sensors with up to 64 MegaPixel resulting in an image area of 128 × 128 mm². The coupling of the scintillator with the image sensor is accomplished with a fiber optic which increases the amount of light collected compared to lens-optical coupling and as a result the sensitivity of the camera. The scintillator can be optimized for high tensions ranging from 20 kV up to 400 kV.

The read out of the image sensor is done simultaneously on 2, 4, or 8 channels respectively with 10 MHz. Two different read out modes have been implemented in the image sensor. The sensor can be operated in the so called "Non Destructive Readout" (NDR) mode or in the "rolling shutter" (RS) mode. For low noise and high sensitivity single image acquisition, the NDR mode is used. In this mode the camera internally subtracts a reset image from the exposed frame whereby the noise is reduced to a minimum similar to the typical read out noise of slow scan CCD cameras. Due to the high signal to noise ratio it is possible to clearly detect single primary electrons with this type of image sensor [2]. Several applications like cryo microscopy or investigation of beam-sensitive materials, which require high resolution images under low dose conditions, will benefit from the NDR mode of these cameras. The read out time of a 4k × 4k area is 1 second.

For fast readout the sensor can be operated in the RS mode where line by line is first readout and then reset. In this mode real time observation and data storage with frame rates of 8.5 fps on sub areas as large as 1k × 8k can be achieved.

Unlike CCDs, CMOS image sensors do not show any blooming effects or smearing artefacts caused by intensive illumination or overexposure. This inherent ability and the high dynamic range render them entirely suitable for all types of applications using high and low intensities in the same image such as recording diffraction patterns.

The cameras have been integrated onto the TVIPS EM-MENU 4 image processing package for transmission electron microscopy. The camera is also a new device in the TVIPS CAMC4 COM module. This allows all TVIPS cameras to be controlled by external software. So far the camera systems have been successfully installed on Philips CM200, Titan Krios, Tecnai I2/20, Tecnai G2 Polara, JEM-1400/1230/2100/2200FS/3100FEF and Zeiss Libra microscopes.

[1] Becker T. et al. (2012), "Structural basis of highly conserved ribosome recycling in eukaryotes and archaea", Nature, 482: pp 501–506

[2] Ghadimi R. et al., "Characterization of 16 MegaPixel CMOS Detector for TEM by Evaluating Single Events of Primary Electrons", Microscopy and Microanalysis, July 2011, 17 : pp 1208-1209