Application of the sCMOS camera Andor Neo for X-ray and neutron imaging

Application Note

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The imaging group at Helmholtz-Zentrum-Berlin is operating large-scale facilities for imaging at the research reactor BER-2 and at the synchrotron source BESSY-II. The facilities are providing service to users from Germany and all around the world by helping them to find answers of their scientific questions. The spectrum of applications is very broad starting from investigation of fundamental physical phenomena, going through resolving of engineering problems and ending with examples of archaeology and palaeontology. The demand for a high quality of the performed experiments requires high-end detector system with extreme low noise levels providing high spatial and dynamic resolution. The optimization of these parameters and finding the best sensor for a certain task isn't a trivial task. Usually the high-speed cameras are not optimized for low-signal applications and their signal-to-noise ratio characteristics doesn't allow to apply them in the field of neutron imaging, for example, where the light intensities are quite low. The new camera development at Andor called Neo combines the advantages of the high-speed CMOS technology with impressive sensitivity and low noise levels. This new type of cameras has the name sCMOS (scientific CMOS - DC152-QF-FI). In this way it is possible to take snapshots with 100 fps in full resolution (2560 x 2160 pixels) with extreme good signal-to-noise characteristics. This feature is very important for applications at large scale facilities where the beam time is extreme valuable and large read out times can't be tolerated. The Andor Neo replaces completely the used up to now in our group ANDOR CCD camera (DW436N-BV) and opens new perspectives for dynamic (time-resolved) imaging and time-of-Flight (TOF) applications.

The detector setups used for X-ray and neutron imaging are based on optical system projecting the image from a scintillator screen on the camera chip with a high precision. In order to prevent the radiation damages in the electronic components the image is reflected by a mirror to the camera which is staying beside the beam. The utilization of optical magnification allows for high-resolution imaging where the Andor Neo shows its advantages. The small pixel size of 6.5 µm gives the possibility to break the resolution limits in the neutron imaging by applying of lenses with high light transmission and thin scintillator screens.

A detector setup based on optical magnification 4X was tested at laboratory based micro focus X-ray CT scanner. The relatively low intensity provided by the x-ray tube in a combination with thin scintillator screen (10 µm Gadox) have simulated the conditions in case of high–resolution neutron imaging experiment. The obtained results are presented in Fig. 1.

Fig. 1 Tomographic investigation of MEA assembly of PEM fuel cell. The diameter of the GDL fibres is approximately 10 µm. The experiment was performed at micro focus X-ray CT scanner using a high resolution detector based on sCMOS Andor Neo with an effective pixel size of 1.6 µm. The exposure time was 20 s per image. 1000 angular projections over 360° were recorded in 6 hours. Top and bottom view of the sample (on the left and in the middle). Single tomographic slice (on the right)

The ability of Andor Neo camera for investigation of dynamic processes was tested by imaging of running electromotor at 1500 rpm. The tests were performed imaging of a pattern connected to the axis of the motor by visible light. The snapshots sequences were taken with exposure times of 0.1 ms by using of Global and Rolling shutter. For achieving of higher speed of the recorded images a Region-Of-Interest (ROI) of 528 x 512 was used. Selected snapshots are shown in Fig. 2.

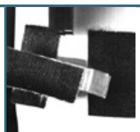
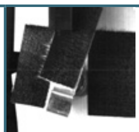
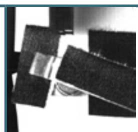
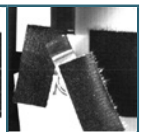
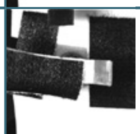
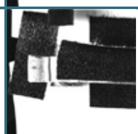
Global shutter				
Rolling shutter				
Time scale	0 ms	10 ms	20 ms	30 ms

Fig. 2 Real time imaging of a running electromotor at 1500 rpm. The rotation of the attached plate (marked by black tape) to the axis is visualized in an image sequence. Exposure time: 0.1 ms / image.

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The typical image distortion in case of using the Rolling Shutter mode was observed.

The high-speed sCMOS camera Andor Neo was integrated in the software interface of the neutron imaging instrument CONRAD-2, Fig. 3. The integration in the LabView based software was performed by using the Software-Developer-Kit (SDK) provided by Andor.

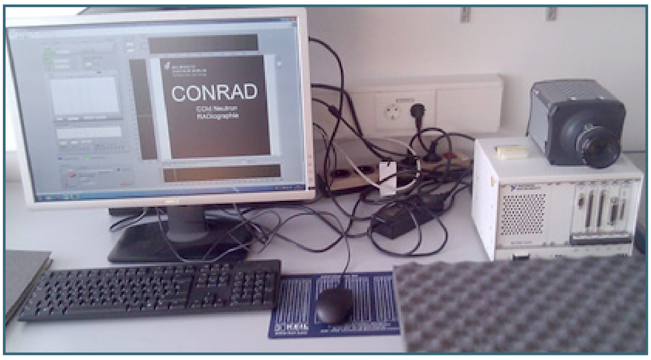

Fig. 3 Test stand used for integration of the high-speed sCMOS camera Andor Neo in the software interface of the neutron imaging instrument CONRAD-2.

The performed tests of the new sCMOS camera Andor Neo confirmed that it can be used very successfully for high resolution and high speed imaging with X-rays and neutrons. For the future it will be the main "working horse" at the neutron imaging setup CONRAD-2 and for sure it will satisfy a large number of scientific users by providing high quality results.

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