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High-spatial resolution measurements with GaAs sensor with the charge integrating MÖNCH detector

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In contrast to silicon-based sensors, high-Z sensors materials like GaAs or Cd(Zn)Te provide a good quantum efficiency for the detection of hard X-rays above 15 keV. However, high-Z sensors require a careful characterization to better understand their performance since they typically suffer from crystal inhomogeneities, charge-trapping (leading to the so-called polarization effect) and high energetic fluorescence photons which are not present in silicon. Extensive studies performed with GaAs:Cr sensors bump-bonded to the charge integrating detector JUNGFRAU have proved that JUNGFRAU with GaAs:Cr is a promising X-ray detector for imaging applications at synchrotron facilities for high energies [1][2].
In this work we present a GaAs:Cr sensor bump-bonded to a MÖNCH readout chip. The MÖNCH0.3 detector [3] is a low-noise charge-integrating hybrid pixel detector which has 160k, 25 µm pitch pixels covering an active area of 1 x 1 cm2 with a noise of 35 electrons ENC (rms) with Si sensors.

Recently we have characterized a GaAs:Cr sensor bump-bonded to MÖNCH03 and we measured a low noise of ~80 e- ENC in high gain mode and at 6 µs exposure time.Recent imaging measurements acquired with a GaAs:Cr sensor mounted to a MÖNCH readout chip have shown that it is possible to use subpixel interpolation algorithms and thus enhance the spatial resolution beyond the actual pixel size. In this contribution, first imaging results of a Siemens Star with GaAs and Silicon based sensors acquired at the TOMCAT beamline of the Swiss Light Source at energies from 10 keV to 30 keV will be presented. We will show the preliminary results on the quantum efficiency as a function of the energy for both sensor materials, the energy dependent spatial resolution (affected by fluorescence / charge sharing), including energy-binned imaging achievements as well as a quantitative evaluation of the spatial resolution by means of determining the MTF.

These preliminary results are very promising since they open new possibilities to apply interpolation algorithms for micrometre resolution for colour imaging with MÖNCH at high energies. Further measurements with an X-ray microfocus tube are under way to exploit the energy-resolving power of colour imaging.

[1] D. Greiffenberg et al. JINST (2019) 14 P05020

[2] D. Greiffenberg, et al. Sensors (2021),21, 1550

[3] R. Dinapoli et al, J. Instrum. 9 (2014) p. C050115.

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