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Evaluation of a Novel Large-Area GaAs:Cr Sensor for Photon Science Applications

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GaAs:Cr is of great interest for use as the sensor material of hybrid pixels detectors (HPDs) at fourth-generation light sources, due to its increased stopping power at higher (> 20 keV) photon energies compared with standard Si sensors [1]. Many such facilities will offer increased photon flux at higher energies, opening up new experimental possibilities. This includes X-ray fluorescence tomography (XRFT) experiments [2] envisioned at the I-TOMCAT beamline, with a maximum photon energy of 60 keV, at the SLS 2.0. Devices that are viable for use at beamlines require large-area, uniform sensors with small pixels, e.g. 5 μm for the aforementioned XRFT experiments, which also demand excellent energy resolution (3 keV full width half maximum for 60keV photons). However, GaAs:Cr features defects, which cause variations in performance across the sensor, distortions in the images recorded [3] and poor charge-carrier properties [4], negatively affecting devices'imaging performance and energy resolution. Furthermore, the availability of large-area (> a single chip) sensors has previously been limited.

We are currently characterising a new variety of GaAs:Cr supplied by DECTRIS AG. One 500 μm thick pixelated sensor with an area of ˜ 4×8 cm^2 has been bonded to a JUNGFRAU1.0 [5] module, which consists of two by four readout chips. Each chip has 256 × 256 75 μm pitch pixels, resulting in a 500 k pixel device. Utilising the charge-integrating nature of JUNGFRAU, we are able to study the behaviour and properties of this new sensor material over a large area [6]. Our studies include calibration of the detector's gain, measurements of its energy resolution and detector output as a function of exposure time, the latter of which permits direct measurement of the dark current and dynamic range of each pixel. Our initial results indicate that this new material has improved uniformity compared with earlier varieties of GaAs:Cr [6, 7], making it highly promising for photon science applications at higher energies.

Past studies have attempted to apply sub-pixel interpolation algorithms to a 25 μm pitch HPD with GaAs:Cr sensor to enhance the device's spatial resolution [8]. The increased charge-sharing in GaAs:Cr compared with Si, due to the shallower absorption depth of incident photons, means it should be possible to apply such algorithms to a 75 um pitch device with GaAs:Cr, although it is not possible with Si sensors. We are currently measuring the detector's spatial resolution, as quantified in terms of its modulation transfer function, and performing initial tests applying interpolation algorithms. This will enable us to determine the extent to which the spatial resolution of a 75 μm pitch GaAs:Cr sensor can be enhanced and the range of applications for which such a system is suitable at next-generation light sources. The results of these studies will be presented along with the more basic characterisation of the new sensor material.

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