Development of high speed combined X-ray imaging and spectroscopy detectors for energies up to 150 keV

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The Diamond Light Source (DLS) as most of synchrotron radiation facilities produces photons whose energy cover a very large energy range. In the X-ray region the range spans from soft X-rays to the hard X-ray range up to 150 keV. Detector technologies face many different challenges for a so large energy range and for the very diverse range of experiments performed at synchrotron facilities. One of the challenges is to produce detectors for diffraction at high energies (greater than 30 keV) with good detection efficiency, excellent dynamic range, and fast framing rate. Detectors that are presently used for X-ray diffraction at high energy exploit phosphors as photon converter in order to get good detection efficiency. These systems are typically to too slow for certain applications. Flat panels have faster frame rates but their dynamic range is decidedly more modest. In addition their fixed pattern noise is rather big. Another drawback is the afterglow of phosphors that can become the limiting factor to the framing rate of the detector.

In the intermediate energy range (6 20 keV) photon counting detectors using silicon sensors with superb dynamic range and excellent framing rate (200 frames per second in the case of Pilatus 100K) are commercially available. Unfortunately because of the silicon sensor their detection efficiency drops dramatically when the photon energy increases.

For the reasons mentioned before the DLS has a strong interest in finding materials that can offer better detection efficiency with respect to silicon. Indeed the DLS has been committed for a few years in the EU funded joint research activity HiZPAD to study the application of CdTe sensors at synchrotron experiments. Diamond is willing to support studies on semiconductors with high atomic number as X-ray sensors as well as their application in detectors for synchrotron research. The student will be involved in the development, characterization and application of such modules. Fundamental studies will be carried out on novel materials and sensors at Surrey and tests with synchrotron beams.

This project will extend the range of research areas covered by SEPnet funded research studentships within RDI to include room temperature wide band gap semiconductor detector development for high energy X-ray detection. Although the application of the technology to be developed is focused on synchrotron instrumentation over the duration of the studentship, high speed combined X-ray imaging and spectroscopy above 30 keV X-ray energy is also of interest for security imaging applications and hence this project will strengthen the Radiation detection instrumentation (RDI) theme’s track record in this area of research identified as one of the “grand challenges” by the Science Technology and Facilities Council (STFC). Increasing RDI activity towards security matters is also in line with the recent recommendation to RDI by the South East Physics Network (SEPnet) Science Advisory Panel.

Nicola Tartoni is the head of the DLS detector group. The involvement of the detector group of the UK’s world class synchrotron facility into RDI activities is a strategic advantage for future joint bids for research funding, as well as potential hosts for student placements in particular Euro Master students with RDI specialisation. The project will also increase and extend the SEPnet RDI connection to the Harwell Science campus a major hub of UK research activity.

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