PHOTOCATHODES IN HIGH-SPEED X-RAY IMAGING ARRAYS

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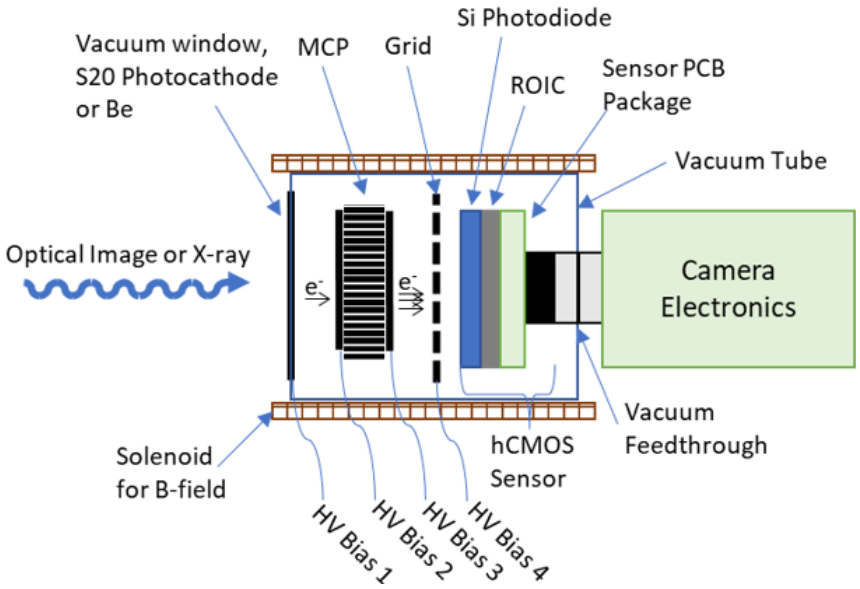
ABSTRACT

In the context of bringing nuclear fusion into commercial reality for electrical power production, there exists a major need for high-speed (<100ps) x-ray imaging devices which can give quantitative spatial, temporal and chromatic information about fusion events which are undertaken in laboratory experiments. Device configurations have demonstrated partial satisfaction of this need, including solid-state photodiodes [1] for high-flux, hard x-ray imaging, and structured photocathodes for lower-flux conditions [2]. Unfortunately, the imaging need extends over a very-large spectrum (5-130keV); and within that range we need to detect even single-photon events with high-resolution. These requirements present a significant challenge not only in obtaining sufficient signal/noise; but also necessitate synchronization of signals from multiple high-speed detectors in imaging a single fusion event.

We are designing next-generation x-ray imagers by employing a hybrid approach which utilizes a front-end photocathode, coupled with a micro-channel plate, a drift/confinement region and a high-resolution hybrid-CMOS solid-state backside imaging array. Each of these subsystems within the overall imaging tool can be gated to image frames in the low pico-second range within a single fusion shot (which typically lasts about 25 ns.) The method is called Multi-Frame Gated Optical and X-Ray Imaging (MGXI). A conceptual depiction of the MGXI tool is shown below. Because of the numerous degrees of freedom available to us, the expense of multiple individual stand-alone imaging vacuum tubes is avoided by testing each subsystem using a demountable test chamber, which we will describe. This presentation will show the new photocathodes which we are designing and testing for the MGXI.



[1] C. E. Hunt, *et al.*, "p-i-n High-Speed Photodiodes for X-RAY and Infrared Imagers Fabricated by *In-Situ*-Doped APCVD Germanium Homoepitaxy", *IEEE Trans. on Electron Devices* (submitted) (2020)
[2] Y. P. Opachich *et al.*, "Structured photocathodes for improved high-energy x-ray efficiency in streak cameras", *Review of Scientific Instruments* **87**, 11E331 (2016); https://doi.org/10.1063/1.4961302