# Fast X/γ-Ray Imaging Using Electron Multiplying CCD Based Detector

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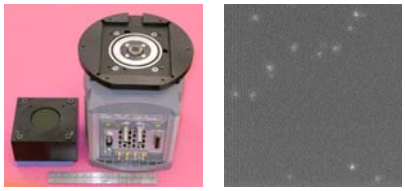
New designs of electron multiplying CCDs (EMCCDs) combine superior spatial resolution and low noise of a conventional CCD with the internal gain of an avalanche photodiode (APD). The presence of internal gain not only enhances the device sensitivity, but virtually eliminates the read noise associated with current CCDs, even when the device is read at very high rates of 100 frames per second or higher. Thus, the EMCCDs can simultaneously provide very high sensitivity and a high signal to noise ratio (SNR), making pulse-mode operation possible.

At RMD we are exploiting these properties of EMCCD for use in x-ray and radionuclide imaging. Specifically, we have developed a system that makes use of a CCD with 512 × 512, 16 μm × 16 μm pixels, and measures 8.2 × 8.2 $mm^2$ in active imaging area. To enhance the detector sensitive area, two fiberoptic tapers measuring 3:1 and 5.9:1 in reduction ratio are fabricated, which can be coupled to the EMCCD using specially designed mechanical fixtures. The EMCCD is thermo-electrically cooled to -35°C to minimize dark current. The internal gain is software selectable and may be varied from 1 to 1000.

To achieve high spatial resolution and high sensitivity for x-ray/γ-ray imaging, specially developed microcolumnar CsI(Tl) scintillators are pressure coupled to the fiberoptic window/taper. The CsI screens with column diameters in the range of 2 to 30 μm and measuring 40 $mg/cm^2$ to 1.2 $g/cm^2$ were fabricated at RMD for this purpose [1]. Figure 1(a) is a photograph of the detector and a 3:1 fiberoptic taper. Figure 1 (b) is an image frame in a sequence of images obtained by exposing the detector to a radioisotopic $^{57}Co$ source (122 keV γ-rays). The camera gain was set at 100. As can be seen from the figure, the camera is quite sensitive and is capable of imaging individual gamma events.



(a) (b)

Figure 1: (a) A photograph of the newly developed EMCCD camera, and (b) an image showing sensitivity of the camera to individual 122 keV γ-ray photons from a $^{57}Co$ source.

Due to the flexibility of its design, the system can be configured for use in several imaging applications. This paper will describe the detector design and its efficacy for small animal x-ray computed tomography (CT), high speed radiographic imaging for time resolved x-ray diffraction studies, and as a high resolution gamma-camera for various applications in nuclear medicine. The imaging performance of the detector using various fiberoptic tapers with frame rates ranging from 30 to 500 fps will be presented.

**References**

[1] - V.V. Nagarkar, V.Gaysinskiy, I. Shestakova, S. Taylor, H. Barrett, G. Entine, Thick Microcolumnar CsI(Tl) Films for Small Animal SPECT, IEEE 2004, Rome, Italy October 16-22 2004.