# Some Early Imaging Results with a 4096x4096-Element X-ray Image Sensor

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**Abstract**

A full frame 4096×4096-element CCD image sensor has been developed for 1:1 x-ray imaging near room temperature, and some early imaging results have been obtained. The active area of the device is 61.44 mm square, making it one of the largest monolithic image sensors made to date. The device consists of the CCD chip, a fiber optic faceplate and an x-ray scintillator scene of the type commonly used with film.

The unit cell is 15μm square, but in x-ray imaging it is generally of more interest to operate the device for optimum performance at larger effective pixel sizes. Hence, with this device, one can operate in one of the several pixel-binning modes where the resultant pixel sizes of most interest are 30, 45 and 60μm square. With this design, it is possible to have some defective 15μm-wide columns, and to program the camera readout in one of the binning modes so that the bad data can be discarded at the moment of readout, and the maximum amount of valid image information is collected from the adjacent good columns, for use in reconstituting a final image.

The fiber optic faceplate attenuates the x-ray flux that passes through the scintillator so that there is a negligible amount of direct x-ray excitation in the silicon chip itself. This is a desirable feature because the direct excitation causes an image signal with a high shot-noise content.

In mammography a typical exposure time is one second, but the readout time can be several seconds depending, among other things, on the particular pixel binning mode used. Thus the sensitivity depends relatively strongly on the pixel-binning mode used.

Early imaging results are reported for a mammographic application. The quality of the imagery in the 2×2-pixel binning mode is considered to be excellent, especially in view of the fact that the device was not cooled.

The dark current density at room temperature is estimated to be approx. 30pA/cm$^2$ and the camera noise floor referred to the chip output and at a sample rate of 2.5MHz was estimated to be approx. 100e$^-$. Lower dark current densities have been achieved with this same unit cell design and with the same wafer process, and lower camera noise floors are expected as the chip readout is optimized for the mammographic application.