COMBINED X-RAY IMAGING AND SPECTROSCOPY – A LOW COST SOLUTION

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X-ray sensor arrays are commercially available for scientific and medical applications. Whilst these can be large (in both physical size and number of pixels), sensitive and capable of providing energy dispersive information about the incident radiation, they are also expensive. This limits their application as an aid to the routine alignment of X-ray optics and in teaching, and can restrict the development of new applications. In this study we examined the use of low cost CMOS sensors for X-ray imaging and spectroscopy. Some examples of imaging using modified webcams are presented as well as those for a simple energy dispersive X-ray detector based on an Omnivision OV7221 sensor, a device used in cellular telephones, PC multimedia and children's toys.

The OV7221 sensor is a low voltage CMOS VGA camera (640 by 480 pixels) with an individual pixel size of 6 by 6 µm. X-ray sensitivity is enabled by replacing its front glass window with a 5 µm thick aluminium foil. X-rays are then detected as an increase in a pixel's dark current due to the generation of additional electron-hole pairs within its active region. In principle for a silicon detector the number of electron-hole pairs generated by an X-ray photon of energy E_0 (eV) should be given by E_0/3.65. Consequently, if the rate of arrival of X-rays at each pixel is less than its refresh rate, a pixel's brightness should be an indication of the energy of the X-ray it has registered. This precludes the use of conventional long exposure times to increase sensitivity, as on chip time integration (as used by amateur astronomers) would introduce pulse pile-up and destroy any energy information. However, exposures of several minutes were achieved by recording the image as an AVI video file, in which the energy information is retained through the brightness of each pixel in each individual frame. These were extracted before stacking the frames using image-processing software to simulate the effect of a long exposure time. X-ray cameras were assessed using a miniature X-ray tube with a Cu target operating at a voltage of 20 or 30 kV and a current of 100 µA. Figure 1 shows a radiographic image of a lamp filament produced using a modified OV7411 sensor. Figure 2 shows the X-ray fluorescence spectrum collected from a stainless steel foil using a modified OV7221 sensor and giving an energy resolution of approximately 570 eV.

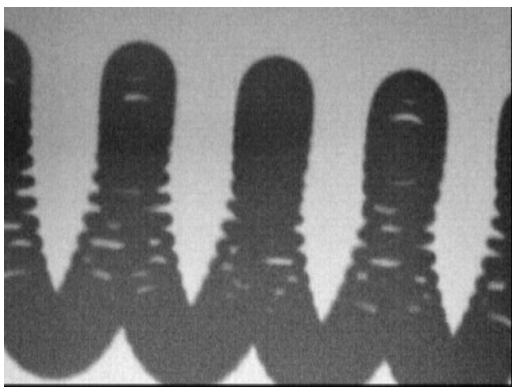

Figure 1 Image of a lamp filament

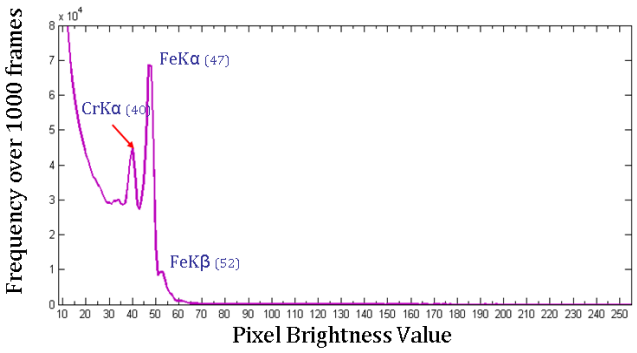

Figure 2 XRF spectrum from a steel foil