

Edge-On Sensors for Wide Energy Range X-Ray Detection with Photon Counting

1. Scope

SINTEF is developing technology for x-ray imaging with photon counting and binning to increase the information that is obtainable from the generated image. For some applications this may also reduce the required radiation dose. To adopt this to a wide photon energy range SINTEF MiNaLab has developed silicon x-ray sensors in the so called edge-on configuration where the incident photons impinge on the chip edge. For strip detectors this mean that the whole strip length acts as the absorption region thus compensating for the relatively low absorption of silicon at high x-ray energies. To adapt this technology also to energies below 10keV, the guard ring at the edge facing the incident photons have been replaced by an active-edge structure. Theoretical calculations show that this configuration should cover the energy range from 5 to 200keV.

The SINTEF effort in this field also implies realization of x-ray optics and a front end readout ASIC with extreme noise properties and sorting the deposited photon energy into 6 bins.

2. Technical properties

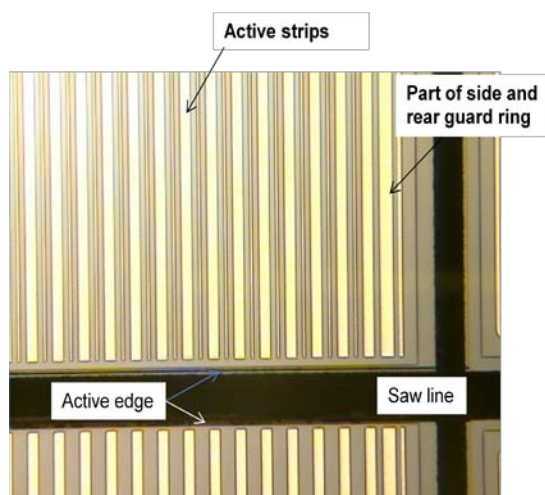


Figure 2.1 Diced edge-on detector chips with active edge

- 64 strips
- width 80 μm
- length 11.3 mm (absorption length)
- pitch 200 μm
- chip thickness 300 μm

Figure 2.1 shows a picture of edge-on sensor chips after dicing. These have guard rings on three edges, while the edge which will face the incident photons have an active edge structure. This is realized by 3D processing techniques such that we have been able to put a heavily phosphor doping into the entire edge. The operational voltage should be ≥ 60 V, while the typical breakdown voltage is 220 V and typical strip leakage 20 pA at 100 V. The speed will be the same as for planar sensors with the same thickness and capacitance.

The great advantage of the edge-on configuration is shown in Figure 2.2, which shows the spectrum from an ^{241}Am source taken with an edge-on detector at room temperature (left curve) compared with the same spectrum taken with a cooled CdTe detector. Both spectra show the characteristic ^{241}Am line at 59.5keV, and the spectrum taken with the silicon edge-on detector has about the same quality as the spectrum taken with the much more expensive and cooled CdTe detector.

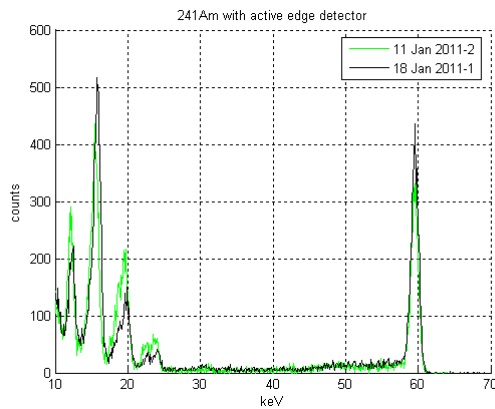


Fig 2.2 a ^{241}Am spectrum taken with silicon edge-on detector
Room temperature

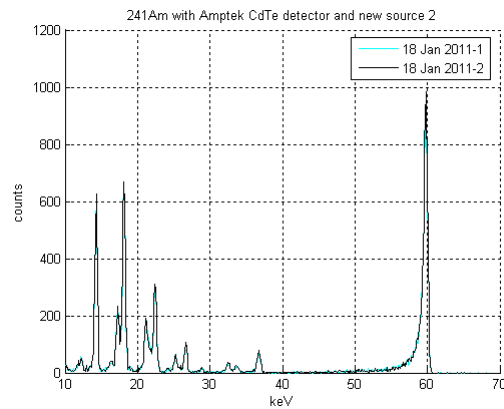


Fig 2.2 b ^{241}Am spectrum taken with cooled CdTe detector

3. Applications

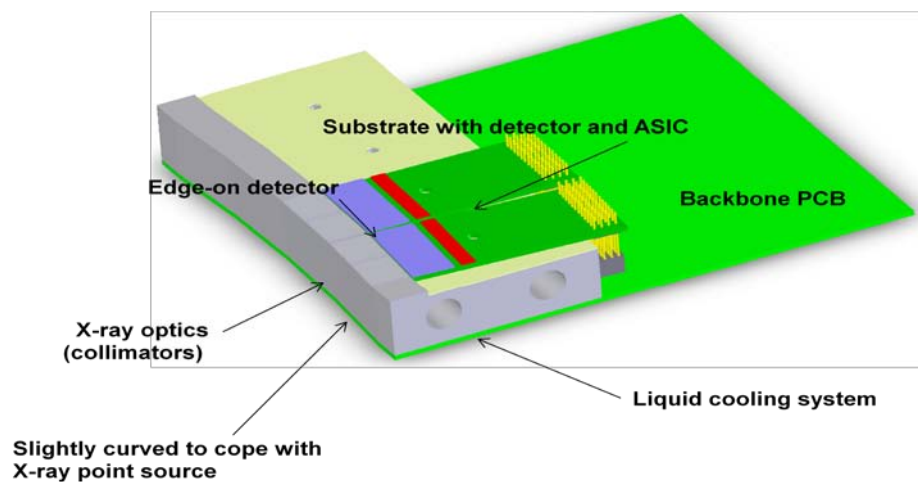


Fig 3.1 Line sensor realized with edge-on sensor chips

As demonstrated in Figure 2.2, edge-on silicon sensor chips can be used to realize line sensors for x-ray imaging with about the same efficiency and energy resolution as much more expensive CdTe detectors. Such a system is illustrated in Figure 3.1. The edge-on sensor chips can be operated with no cooling even if some cooling may be advantageous. In comparison CdTe detectors always need cooling and are more difficult to operate.

SINTEF MiNaLab already produces silicon edge-on detectors for a medical imaging application with photon counting. Other possible applications may be baggage scanning and other applications within the security field including detection of radioactive material, material analysis and non-destructive testing. Using silicon edge-on sensor solutions may represent low cost alternatives for these applications.