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Chromium compensated gallium arsenide sensors evaluation using Timepix1, Timepix3, Medipix3 and Timepix2 readout electronics

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Gallium arsenide is extensively studied for about seven decades as an excellent material for semiconductor lasers, LEDs, and microwave electronics. GaAs has noticeable advantages over silicon and Cd(Zn)Te for radiation detectors. Particularly GaAs has higher electron mobility compared to Si and Cd(Zn)Te; higher average atomic number compared to Si; and lower probability and energy of the fluorescence photons compared to the Cd(Zn)Te [1]. These advantages result in a fast charge collection, good absorption efficiency up to 50 keV and a better uniformity compared to Cd(Zn)Te. Applications for the GaAs are foreseen in medical, mammography, small animal imaging, electron microscopy, synchrotrons, XFELs and non-destructive testing of composite materials.

High-quality GaAs wafers grown with vertical gradient freeze (VGF) and liquid encapsulated Czochralski (LEC) methods are widely available on market, which makes attractive the adaptation of silicon processing technology for the large-scale production of GaAs detectors. The problem of intensive
carrier trapping in commercial semi-insulating GaAs has been solved by the application of GaAs material compensated by post-growth doping with chromium [2].

In frame of Eurostar GoNDT project [3], Advacam has developed radiation detectors by chromium compensation of commercially available 3"n-type GaAs wafers. Wafers were annealed in quartz reactor; processed by polishing and CMP; and were patterned, metallized, and diced.

We have demonstrated a wafer-level processing of 500 um thick GaAs using sensor designs compatible with Timepix/Medipix family readout ASICs. Individual diced sensors were flip chip bonded to Timepix1 [4], Timepix2 [5], Timepix3 [6] and Medipix3 [7] ASICs using conventional SnPb or InSn low temperature solder bumps. Assemblies were evaluated to study the optimal sensor design and bias voltage; uniformity; sensor stability; energy resolution; Modulation Transfer Function (MTF) and high X-ray flux operation.

Presentation summarises the GaAs performance results received from the contributing authors. It presents analytical comparisons to the other commercially available GaAs sensor material in terms of uniformity and spectral resolution. The Advacam's GaAs presents better uniformity and similar or better energy resolution.

The presentation includes the first high photon flux open beam results up to 160 Mcnt/s/mm2, where small part of the sensor shows recoverable polarisation effect.

Finally, the presentation covers the future development work and gives an outlook to the GaAs radiation detector applications.

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