Abstract—This paper discusses key challenges in CZT growth, characterization, fabrication and electronics to obtain uniform, stable high count operation without polarization and other degradation effects. Redlen has developed advanced growth and fabrication process to produce high quality CZT sensors which have been assembled to a number of readout electronics systems and evaluated. The DECTRIS team measured the performance of detectors by attaching them to the Pilatus based readout system. The results indicate stable and reliable operation at count rates of 100 Mcps/mm² and higher. In addition, we present results of attachment experiments, performance evaluation and reliability testing performed at MARS Bioimaging, Dxray and SureScan Corporation. All experiments indicate that the CZT technology has reached a level of performance suitable for commercial applications in non-destructive testing, security screening, dental and high flux medical imaging applications.

I. CZT FABRICATION AND CHARACTERIZATION

High flux operation of CZT detectors presents well-known challenges due primarily to the material defects which lead to polarization and other instability effects. The origin of these effects can be traced back to high densities of impurities and growth defects that in turn lead to severe charge-carrier trapping. Under high flux conditions, the trapped charge builds up inside the detector affecting its stability, and in extreme conditions leads to complete collapse of electric field and device operation. A quantitative comparison between areas where polarization is induced, and the electron- and hole-collection X-ray maps obtained at low flux will be shown.

Recent advances in THM growth that require additional processing steps has enabled us to dramatically improve hole mobility-lifetime product by an order of magnitude. Another critical improvement is the ability to produce low dark current contacts through metal and surface engineering. Our low dark current fabrication method doesn’t increase hole trapping and polarization effects. In addition, low dark current helps in photon-counting ASIC operation creating less burden for the baseline restoration loop.

As a result of these manufacturing improvements we can achieve operation at room temperature, high count rate, and stability without artificial stabilization of the detector through IR or heating. Finally, we have been able to produce uniform wafers with low EPD values.

High-count rate operation of CZT can be only effectively verified using pixelated ASIC attachment. We have performed simulations and measurements to establish operational limits with Medipix-3 (110µm pitch), Pilatus-3 (172µm pitch), Dxray ASIC (1mm pitch), and in Surescan baggage scanner.

II. CHARACTERIZATION WITH PILATUS READOUT

1.5mm thick CZT detectors with Platinum (Pt) contacts have been fabricated at Redlen and directly attached to PILATUS3 ASIC with re-triggering capability at the Dectris facility. The resulting 172um pixel pitch module was measured by the Dectris group using the same characterization procedure as used for CdTe and Si sensors.

The samples were characterized using the following characterization steps: optical inspection, flat-field measurements (using 25keV fluorescence source), direct beam tests (tungsten X-ray tube with 60kVp and 3mm Al filter), followed by bias voltage, where full charge collection is achieved and leakage current measurements. The exact test conditions and test results will be discussed in detail at the workshop. We would like to emphasize that CZT detectors operated successfully up to 200 Mcps/mm² (up to 19mA X-ray tube current) and achieved 0.3% stability within this measurement window.

III. TESTING WITH DXRAY ASIC

2mm thick CZT detectors with Platinum (Pt) contacts have been fabricated at Redlen and temporarily attached using pogo-pin set-up to 1mm pixel pitch Dxray photon counting ASIC. The test results will be presented at the workshop.

IV. ATTACHMENT TO MEDIPIX-3 AT MARS BIOIMAGING

One of the challenges in CZT radiation module manufacturing is direct attachment of the CZT detectors to fine pitch CMOS readout ASICs. We are currently conducting experiments performed by the MARS Bioimaging group where Redlen’s CZT detectors are being attached to the Medipix-3 ASIC. The experimental results will be presented at the workshop.

V. OPERATION IN SURESCAN SCANNER

SureScan Corporation is using Redlen CZT detectors grown by THM in CT detector arrays for its x1000 Multi-Energy Stationary Gantry CT Explosive Detection System (EDS). The x1000 is designed to have an operational life of 10 to 15 years in airport baggage handling environments operating at 20 hours/day, 7 days/week, and 365 days per year. These modules operate at counting rates of 0.5 Mcps/mm² with energy resolution of 8% and demonstrate reliable and stable operation.

VI. CONCLUSIONS AND FUTURE WORK

In order to prepare for high volume commercial production we are moving from individual tile processing to whole wafer processing using silicon methodologies, such as waxless processing, cassette based / touchless wafer handling. We are developing parametric level screening at the wafer stage to ensure high wafer quality before detector fabrication in order to maximize production yields. These will enable us, and other CZT manufacturers who pursue similar developments, to provide high volume production for photon counting applications in an economically feasible manner.