

Large-Format Germanium Detectors

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Silicon charge-coupled devices (CCDs) are commonly utilized for scientific imaging applications in the visible, near infrared, and soft X-ray bands. These devices offer numerous advantages including large format, excellent uniformity, and low noise. The skipper CCD [1] adds to these capabilities by enabling multiple samples during readout, reducing read noise to negligible levels and facilitating new experiments in particle detection such as DAMIC and SENSEI [2,3]. CCDs built on bulk germanium offer all of the advantages of silicon CCDs while covering an even broader mass and spectral range. MITLL has been developing germanium CCDs for several years, with design, fabrication, and characterization of kpixel-class front- and back-illuminated devices discussed recently [4-5]. We have been steadily improving the performance and format of these devices, with our second-generation CCDs currently in fabrication and expected to be completed late 2020 / early 2021. These devices will include numerous design and process improvements aimed at demonstrating low read noise, improving charge-transfer efficiency, and increasing yield, with the goal of eventually matching or exceeding the capabilities of silicon CCDs on these key metrics.

We have also been pursuing a collaboration with Professor Sol Gruner at Cornell to fabricate germanium active-pixel sensors by hybridizing germanium diode arrays to the Cornell Mixed Mode Pixel Array Detector (MMPAD) [6] ASIC. These devices offer the potential for high-speed, low-noise, radiation-tolerant detectors. As part of this work, we have developed a process to bump bond devices at the chip level, followed by backside thinning and passivation via ion implant and laser anneal. Eventually, we plan to utilize 3D integration techniques to enable wafer-scale back illumination processing and fabrication of larger format arrays with finer pixel pitch.

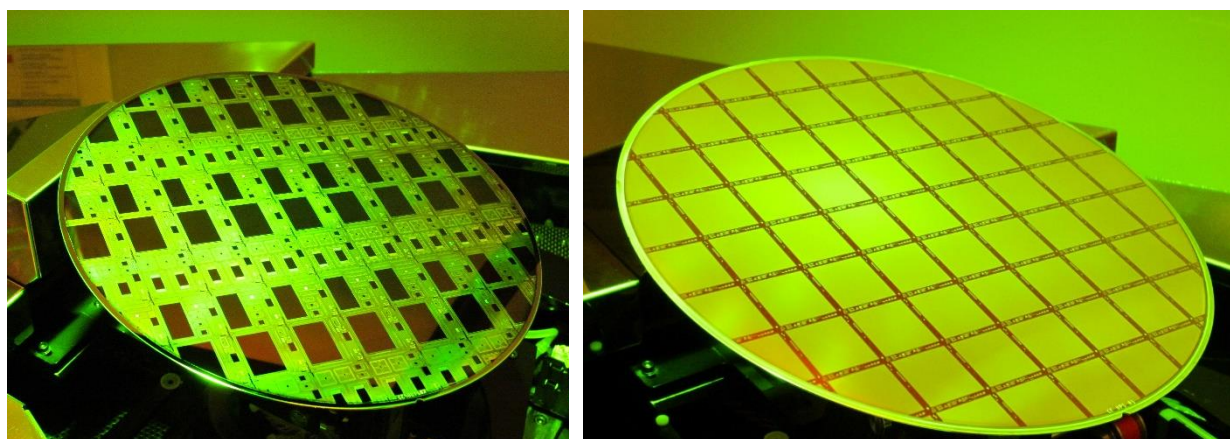


Fig. 1. Images of CCDs (left) and diode arrays (right) fabricated on 200-mm diameter germanium wafers.

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