

A Heterogeneous Three-Tier 3D-Integrated Detector for Soft X-Rays

VIXRID (Vertically Integrated X-Ray Intelligent Detector) is a demonstrator for a heterogeneous 3D-integrated X-ray detector. The detector is constructed from three tiers: a sensor tier, an analog signal processing and digitization tier implemented in a 28nm process, and a digital compression tier implemented in a 28nm process. The detector has a pixel size of 100 x 100 μm , and supports continuous readout at a rate of 1.1 Mfps. The digital compression tier implements multiple parallel algorithms for different quadrants, including hyper-dimensional computing (HDC) for one-shot training and sigma delta stream computing for power efficient lossy compression. This allows benchmarking of their performance for the compression and classification of X-ray images.

3D integration offers immense promise for fast, efficient X-ray detectors by allowing analog and digital processing to be integrated beneath sensor pixels, offering low parasitics, small pixel sizes and minimal dead area. A three-tier design additionally allows ideal substrate isolation between digital and analog domains. However, the cost and complexity of 3D integration technologies have limited their use in scientific applications. VIXRID takes advantage of a shared Assembly Design Kit (ADK), 3D-DRC and 3D-LVS rules, and a 3D-MPW organized through the US DOE's Microelectronics Science Research Centers to design a cost-efficient 3D demonstrator. VIXRID uses a combination of Back Side Through Silicon Vias (B-TSVs) and Direct Bond Interconnect (DBI) with an effective pitch of 10 μm to create power- and area-efficient interconnect between tiers.

Authors: QUINN, Adam; PARPILLON, Benjamin (Fermi National Accelerator Lab); MICHELOGIANNAKIS, George (Lawrence Berkeley National Laboratory); GONZALEZ-GUERRERO, Patricia (Lawrence Berkeley National Laboratory)

Presenter: QUINN, Adam

Session Classification: Detector Systems - I

Track Classification: Soft X-ray Detectors: Detector Systems