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Fabrication of active-edge detectors without support wafer using a unique ”perforated edge” approach

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Minimisation of insensitive volume in silicon sensors is highly demanded in many applications for high energy physics, structural biology, synchrotron experiments and nuclear medicine. A large contribution to this insensitive volume is the guard rings and current terminating structures required in conventional planar silicon sensor that surround the chip periphery. The maximum size of silicon sensors that is optimal is limited by the diameter or dimensions of the substrate and the overall yield of the fabrication process (the smaller the sensors the higher the overall manufacture yield). For these reasons, many imaging applications require the tiling of multiple sensors modules together to cover large areas. For standard silicon detectors, the insensitive guard-ring regions will result in a loss of information and result in imperfect images. Stanford Nanofabrication Facility (SNF), was the first to introduce the ‘active edge’, a new edge terminating structure, that replaces the insensitive guard ring area. The concept is based on the original ‘3D technology’ proposed by S. Parker et al in 1995. The technique requires through silicon substrate electrodes, formed first by etching high aspect ratio holes using modern micromachining known as Deep Reactive Ion Etching (DRIE), originally developed for MEMS technologies. Several laboratories worldwide have investigated this approach using a support wafer that is required to provide mechanical integrity once the through substrate trench surrounding the entire periphery of the sensor is etched. The trench electrodes are subsequently doped using gas phase doping technique. Once the sensors are completed, the support wafer must be removed. This further complicates an already difficult technology. SINTEF have recently investigated a new edgeless design concept, known as the ‘perforated edge’. The design allows possible future manufacture without the use of the support wafer. The integrity of the device wafer is retained since only small segments are removed during DRIE. We present here the design concept, fabrication, and the first characterization of this newly developed edgeless detector that can potentially be fabricated by a cost-effective manufacture process with high yield, suitable for state-of-the-art pixel sensor module assembly.

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