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A Systematic 3D Simulation Study Comparing BNL's 3D-Trench Electrode Detectors with Conventional 3D Detectors and Initial Electrical Test Results of the First Prototype Batch

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With the need for very radiation hard semiconductor devices for the High Luminosity upgrade at the Large Hadron Collider, new types of silicon pixel detectors have been proposed. Since 3D Si pixel detectors have been shown to be more radiation hard than the planar ones, scientists at Brookhaven National Laboratory have chosen to design a novel type of 3D Si pixel detectors. Systematic full 3D simulations using Silvaco's TCAD programs have been done to compare the characteristics of this novel 3D pixel design which features at least one trench electrode in a single pixel cell (3D-Trench Electrode pixel) with the conventional 3D pixel with all column electrodes in a single pixel cell. In order to optimize the electric field's uniformity while maintaining the effectiveness in space packing, we have chosen a hexagonal shape in our simulation. The 3D simulations show much lower depletion voltage and a more uniform electric field in the new 3D-Trench Electrode pixel detectors as compared to conventional 3D pixel detectors with column electrodes. We've created two sizes of this pixel, a small one (short electrode spacing in a single cell) for High Energy physics applications for high radiation environments and a much larger one for Photon Science applications at the National Synchrotron Light Source II at Brookhaven National Laboratory. The first prototype 3D-Trench Electrode pixel detectors have been manufactured at the National Microelectronics Centre, and are currently being tested. The preliminary electrical measurements will be presented.

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