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New 3D neutron sensors with high detection efficiency, high gamma rejection and reduced fabrication complexity

We designed, simulated and fabricated new sensors with MEMS based high aspect-ratio trenches (3D) to be filled with ^{10}B neutron converter with a Geant4-predicted efficiency of ˜20%, to be compared with ˜4% of traditional deposition on a planar sensor's surface. Compared to sensors proposed by other groups [1][2], the fabrication complexity is strongly reduced, and is suitable for volume productions. High gamma-ray rejection can be achieved by minimizing the silicon active volume and/or by signal processing.
A prototype batch was recently fabricated at Fondazione Bruno Kessler (FBK) in Trento, Italy, showing excellent first results from electrical measurements. Tests on wafers indicated full depletion voltages between 80 and 100V (depending on the sensor's geometry) and breakdown voltages in excess of 500 V, with leakage currents as low as ˜5 nA/cm^2. Furthermore preliminary functional tests with an ^{241}Am α -source have shown full charge collection efficiency. Both electrical and functional test results are in good agreement with TCAD simulations, thus validating the design approach and the quality of the fabrication process.
While these initial results were obtained from diodes, which allow bump-bonding-free tests, the wafer layout includes also pixel detectors compatible with MEDIPIX read-out chip, with different geometrical options adopted for trenches. We plan to develop a full imaging system based on these sensors, which could achieve very good, spatial, time and energy resolution, thus opening many application opportunities.

[1] Q. Shao et al., Applied Physics Letters, vol. 102, 063505, 2010

[2] D. S. McGregor et al., Journal of Crystal Growth, vol. 379, pp. 99-110, 2013.

Summary

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