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Simulation of charge carrier transport in a dual-sided microstructured semiconductor neutron detector (DSMSND)

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The dual-sided microstructured semiconductor neutron detectors (DSMSND) provide a much higher neutron detection efficiency as compared to a coated planar semiconductor device. This is achieved by alternatively staggering 6LiF-filled trenches between the top and bottom surface of a microstructured silicon diode. This design restricts neutron streaming paths and generates a more complex electric-field distribution and depletion characteristics in the diode, thus creating an indirect path for signal charge-carrier transport between device electrodes. Simulation of signal formation in these devices is performed in multiple steps. COMSOL Multiphysics software is used for simulating semiconductor physics and to obtain important quantities including depletion characteristics, electric field solution, and the weighting potential solution. Geant4 is deployed for radiation transport, interaction modeling, and optimization of the sensor geometry. Finally, Allpix2 is used for mobile charge carrier transport and total charge collection. The results of this simulation work provided an estimate of charge cluster shape and intensity for a pixel array configuration corresponding to the Timepix3 read-out system. The simulated neutron detection efficiency was 57.6%.

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