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Device Design and Technology Developments for Quantum Sensing Charge-Coupled Devices

Saturday, January 26, 2019 5:00 PM (25 minutes)

We describe the development of charge-coupled devices (CCDs) capable of detecting single electrons. The CCDs utilize a non-destructive readout amplifier that allows for the multiple sampling of the signal charge with a corresponding reduction in the read noise by the inverse square root of the number of samples. The CCDs have been fabricated on high-resistivity silicon that enables the full depletion of substrates that to date have been as thick as 650 microns. The fully depleted CCD technology was originally developed for astronomy and astrophysics applications, e.g. the Dark Energy Camera, and more recently has been used for direct dark-matter detection given the single-electron sensitivity that the non-destructive readout capability allows. A 4126 x 866, (15 micron pixel)2 CCD developed by the authors achieved a read noise of 0.068 e- after the averaging of 4000 samples [1]. In this work we describe the device and technology design to allow for the operation of the electron counting CCDs at large substrate-bias voltages, typically in the range of 50 −100V, as well as efforts to improve the performance especially as regards to improving the readout times needed for single-electron detection.

[1] J. Tiffenberg, M. Sofo-Haro, A. Drlica-Wagner, R. Essig, Y. Guardincerri†, S. Holland, T. Volansky, and T.-T. Yu, "Single-Electron and Single-Photon Sensitivity with a Silicon Skipper CCD,"PRL 119, 131802, 2017.

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