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Fast and sub-electron noise CCDs with the multi-amplifier sensing architecture for astronomy

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Optical detectors in future astronomical facilities require both single-electron resolution and fast readout capability to meet ambitious science goals including obtaining spectra for diffuse dwarf galaxies, identifying rapidly fading transient events, and directly imaging Earth-like extrasolar planets. Skipper CCDs used in dark matter detection experiments have shown their ability to reach deeply sub-electron noise floors that scales inversely with the number of measurements performed for a charge packet at the cost of increasing readout time. As an outgrowth from the Skipper CCD concept, the multi-amplifier sensing (MAS) CCD meets both the fast readout and ultra-low noise priorities by implementing a serial line of non-destructive floating gate amplifiers that independently samples multiple pixels of charges simultaneously. This reduces the readout time by a factor of the number of output stages for an equivalent number of charge measurements compared to a Skipper CCD. Using the successful LBNL thick, fully-depleted, p-channel legacy design, MAS CCDs are expected to retain the advantages of high near-IR quantum efficiency, low fringing, and radiation tolerance for broad adoption in next generation massive spectroscopic surveys and space-based telescopes. We present recent work in instrumenting the first front-illuminated 16-channel MAS CCDs using DESI front-end readout electronics to achieve a combined read noise close to a single electron with only a single sample per amplifier. We discuss the promising charge transfer efficiency, full well capacity, and linearity characterization results that demonstrate the potential of MAS CCDs to serve a wide range of science cases in astronomy. Finally, we describe the current and upcoming efforts on developing large format devices with 64 channels and the accompanying readout electronics that would enable MAS CCDs to be deployed at scale for planned experiments including DESI-II and Stage-V spectroscopy.

contribution subject matter

CCD sensors

Keywords for your contribution subject matter (this will assist SOC in accurately characterizing your contribution)

Skipper CCDs

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