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Single electron Sensitive Readout (SiSeRO) devices: A novel X-ray detector technology for the future X-ray astronomical missions

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Single electron Sensitive Read Out (SiSeRO) is a novel on-chip charge detector output stage for silicon charge-coupled device (CCD) image sensors that can enable significantly greater responsivity and improved noise performance than traditional CCDs. Developed in collaboration with MIT Lincoln Laboratory and fabricated in their CCD process technology, SiSeRO devices use a p-MOSFET transistor with a depleted internal gate beneath the transistor channel. The transistor source-drain current is modulated by the transfer of charge into the internal gate. At Stanford, we have developed a readout module for these devices and characterized the performance of a number of prototype sensors with different architectures. We have achieved a charge/current conversion gain of better than 800 pA per electron, an equivalent noise charge (ENC) of around 4.5 electrons root mean square (RMS), and a full width half maximum (FWHM) of approximately 130 eV at 5.9 keV, at a readout speed of 625 Kpixel/s and detector temperature of -23 C. Since the charge packet in SiSeRO devices remains unaffected by the readout process, we are also able to implement Repetitive Non-Destructive Readout (RNDR) of the charge, achieving a significantly improved noise performance. In this paper, we discuss the SiSeRO working principle, the readout module developed at Stanford, and the characterization test results of the first SiSeRO prototypes. Second generation SiSeRO devices are currently being fabricated, including configurations with parallel SiSeRO outputs and multiple SiSeRO elements in series. Such advances should improve speed performance whilst maintaining low noise.

contribution subject matter

CCD sensors

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

SiSeRO, CCD, X-ray detectors

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