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Proton Induced Traps within EM-CCDs

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Electron multiplying (EM)-CCD technology has been successfully implemented for many ground-based applications (from astronomical telescopes to synchrotrons and life sciences), but has yet to be utilized within the space environment. The technology has the potential to offer superior photon-counting performance compared to competing technologies, however the effects of radiation damage must be understood and mitigated. The primary concern is damage from solar protons that manifests as signal trapping sites within the device. These traps can act to capture and defer signal charge to later pixels, degrading Charge Transfer Efficiency (CTE). They are of particular concern for photon-counting applications where the loss of a single photoelectron represents the loss of the entire signal packet, leaving nothing to detect or correct.

Here we present results from in-situ defect characterisation within irradiated Teledyne e2v CCD201 20 EM-CCDs using the "trap pumping"technique. At least 4 silicon defects have been identified that have the potential to degrade charge transfer performance of EM-CCD based instruments within a radiation environment. The key physical properties for each defect are presented, including population densities following exposure to proton fluences consistent with long duration space missions. The final population of silicon defects within a device is thought to be dependent upon the temperature at which the device is irradiated, and so differences between irradiation at room temperature (298 K) and cryogenic temperatures (165 K) are also discussed. We conclude with mitigation strategies to improve CTE in the presence of these traps, supported by results from TCAD simulation of charge transfer in the CCD201-20 image and register pixels.

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