Technology advancement of the CCD-201-20 EMCCD for the WFIRST coronograph instrument: sensor characterization and radiation

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ABSTRACT

The Wide Field InfraRed Survey Telescope-Astrophysics Focused Telescope Asset (WFIRST-AFTA) mission is a 2.4-m class space telescope that will be used across a swath of astrophysical research domains. JPL will provide a high-contrast imaging coronagraph instrument—one of two major astronomical instruments. In order to achieve the low noise performance required to detect planets under extremely low flux conditions, the electron multiplying charge-coupled device (EMCCD) has been baselined for both of the coronagraph's sensors—the imaging camera and integral field spectrograph. JPL has established an EMCCD test laboratory in order to advance EMCCD maturity to technology readiness level-6. This plan incorporates full sensor characterization, including read noise, dark current, and clock-induced charge. In addition, by considering the unique challenges of the WFIRST space environment, degradation to the sensor's charge transfer efficiency will be assessed, as a result of damage from high-energy particles such as protons, electrons, and cosmic rays. Science-grade CCD201-20 EMCCDs have been irradiated to a proton fluence that reflects the projected WFIRST orbit. Performance degradation due to radiation displacement damage is reported, which is the first such study for a CCD201-20 that replicates the WFIRST conditions. In addition, techniques intended to identify and mitigate radiation-induced electron trapping, such as trap pumping, custom clocking, and thermal cycling, are discussed.

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