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Ageing and Proton Irradiation Effects on an EMCCD Manufactured in a CMOS Process

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Electron Multiplying Charge Coupled Devices (EMCCDs) have revolutionised low light level imaging, providing highly sensitive detection capabilities. Implementing Electron Multiplication (EM) in Charge Coupled Devices (CCD) can increase the Signal to Noise Ratio (SNR) and lead to an improvement in low light level application. With the increase in demand for CMOS sensors with comparable or superior performance to CCDs, this paper describes the implementation of a low voltage EMCCD in a CMOS process. EMCCDs are known to experience an ageing effect, such that the gain achieved gradually decreases over the period of operation. This ageing process has been observed at high avalanche potentials, with a decrease in gain that is comparable to traditional EMCCDs. This paper presents results detailing the effect of EM ageing in EMCMOS (Electron Multiplying Complementary Metal-Oxide-Semiconductor) on factors such as CTI and thermal dark signal. When aged at room temperature an average decrease of 10% over a period of 175 hours was noted before plateauing, however there was a distinct variation across the pixels. The two new pixels experienced considerably higher reduction in the gain, surpassing a 20% loss in the gain. The sensor was developed for operation in space and as such its radiation hardness when exposed to proton damage, was tested. This paper presents the results of a proton irradiation completed at the Paul Scherrer Institut (PSI) at a fluence of 109 protons/cm2, 10MeV equivalent. The pre-irradiation characterisation, irradiation methodology and post irradiation results are detailed, including an increase in CTI, averaging at over 20%. Finally this paper presents a comparison of the damage caused by EM gain ageing and proton irradiation.

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