Journal of ELECTRONIC MATERIALS, Vol. 42, No. 11, 2013
DOI: 10.1007/s11664-013-2636-6

1/*f* Noise in HgCdTe Focal-Plane Arrays

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Characterization of mid-wavelength infrared (MWIR) and long-wavelength infrared (LWIR) HgCdTe focal-plane arrays (FPAs) indicates that limitations on operability at elevated temperatures are due to detector dark current and excess 1/*f* noise. Dark-current models in HgCdTe are well established and understood; however, the same cannot be said for 1/*f* noise. In this paper we propose two models for separate sources of 1/*f* noise in HgCdTe photodiodes based upon charge fluctuations out of McWhorter-like surface traps. The two 1/*f* noise components are designated as (1) systemic, being associated with passivated external surfaces of the diodes, and (2) isolated defect, being, it is proposed, associated with the internal surfaces of built-in physical defects such as dislocations. The models are utilized to explain data measured on LWIR and MWIR test-diode structures, and predictions are made regarding the performance of MWIR and LWIR FPAs at elevated temperatures.

Key words: HgCdTe, 1/*f* noise, infrared, diodes, focal-plane arrays

INTRODUCTION

The performance of infrared focal-plane arrays (FPAs) at elevated temperatures is limited by dark current and excess 1/*f* noise. Models for dark current in HgCdTe diodes are well established and understood.[1] However, excess 1/*f* noise is more problematic. Models have been developed for 1/*f* noise in diodes based upon the tunneling of charge from McWhorter-like traps located at external surfaces of the diode.[2,3] A uniform distribution of such traps over energy and distance, $N_t(x, E)$, induces a 1/*f*-like charge power spectrum, covering many orders of magnitude. In turn, this fluctuation modulates the width of charge regions located at the surfaces of the semiconductor, leading to a modulation of the relative dark-current contributions from the diode's associated depletion and diffusion volumes.[4,5] These surfaces can be either external or internal. External surfaces are associated primarily with the diode passivation process and generate systemic 1/*f* noise, which is characterized by the well-known tail observed in FPA root-mean-square (rms) noise histograms, resulting in significant loss in FPA operability. Internal surfaces are associated with physical defects such as dislocations[6] and can generate high dark current and/or high noise. The noise histograms associated with these isolated defects are typically characterized by a Gaussian distribution around the expected shot-noise value, but are accompanied by a number of high-fliers, primarily in noise, but also in dark current, for the longer cutoff wavelengths. This paper proposes meaningful models for both the systemic and isolated defect types of 1/*f* noise relevant to the performance of HgCdTe FPAs.

SYSTEMIC 1/*f* NOISE

McWhorter's fluctuating surface trap model for semiconductors is readily adapted to the passivated external surfaces of a photodiode architecture. A simple $N^+/N^-/P/P^+$ diode geometry is shown in Fig. 1. The fixed charge in the passivation is assumed to be positive, and for the sake of simplicity the donor concentration is assumed to satisfy $N^- \ll P$, the acceptor concentration, so that the main depletion region of the diode is formed completely on the *N*-side. The fixed positive charge generates an accumulation layer on the *N*-side, and a depletion region at the surface on the *P*-side of the diode. The surface on the *P*-side may or may not support an inversion layer,

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(Received December 17, 2012; accepted May 3, 2013;