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High-Performance M/LWIR Dual-Band HgCdTe/Si Focal-Plane Arrays

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Mercury cadmium telluride (HgCdTe) grown on large-area silicon (Si) substrates allows for larger array formats and potentially reduced focal-plane array (FPA) cost compared with smaller, more expensive cadmium zinc telluride (CdZnTe) substrates. In this work, the use of HgCdTe/Si for mid-wavelength/long-wavelength infrared (M/LWIR) dual-band FPAs is evaluated for tactical applications. A number of M/LWIR dual-band HgCdTe triple-layer *n-P-n* heterojunction device structures were grown by molecular-beam epitaxy (MBE) on 100-mm (211)Si substrates. Wafers exhibited low macrodefect densities (<300 cm^{-2}). Die from these wafers were mated to dual-band readout integrated circuits to produce FPAs. The measured 81-K cutoff wavelengths were 5.1 μm for band 1 (MWIR) and 9.6 μm for band 2 (LWIR). The FPAs exhibited high pixel operability in each band with noise-equivalent differential temperature operability of 99.98% for the MWIR band and 98.7% for the LWIR band at 81 K. The results from this series are compared with M/LWIR FPAs from 2009 to address possible methods for improvement. Results obtained in this work suggest that MBE growth defects and dislocations present in devices are not the limiting factor for detector operability, with regards to infrared detection for tactical applications.

Key words: HgCdTe, dual band, FPAs, Si substrates, infrared detectors, molecular-beam epitaxy (MBE)

INTRODUCTION

HgCdTe is the material of choice for developing high-performance infrared (IR) detectors. IR detection can be divided into two applications: tactical and strategic. Tactical applications typically observe warm targets with high background irradiance. On the other hand, strategic (or space) applications typically deal with cool targets with low background irradiance. Raytheon Vision Systems (RVS) has been developing HgCdTe devices for IR detection from short-wave infrared (SWIR) to long-wave infrared (LWIR) on both lattice-matched and lattice-mismatched substrates for more than three decades.[1–6] Single- and dual-color focal-plane arrays (FPAs) have been developed with excellent quantum efficiency and operability.[7] RVS is capable of producing devices on large-area substrates with three production systems: a RIBER Epineat capable of a maximum 125-mm-diameter wafer and two VG-V100 devices capable of a maximum 200-mm-diameter wafer. HgCdTe epitaxially grown on large-area Si substrates allows IR FPAs to be scaled to larger formats than are possible with the largest (80 mm × 80 mm) CdZnTe substrates presently available. Large Si substrates also allow higher array count per wafer for reduced die cost.

To our knowledge, only one other group has reported results regarding dual-band M/LWIR HgCdTe grown on alternative substrates to CdZnTe. Selex has reported results for M/LWIR FPAs based on

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