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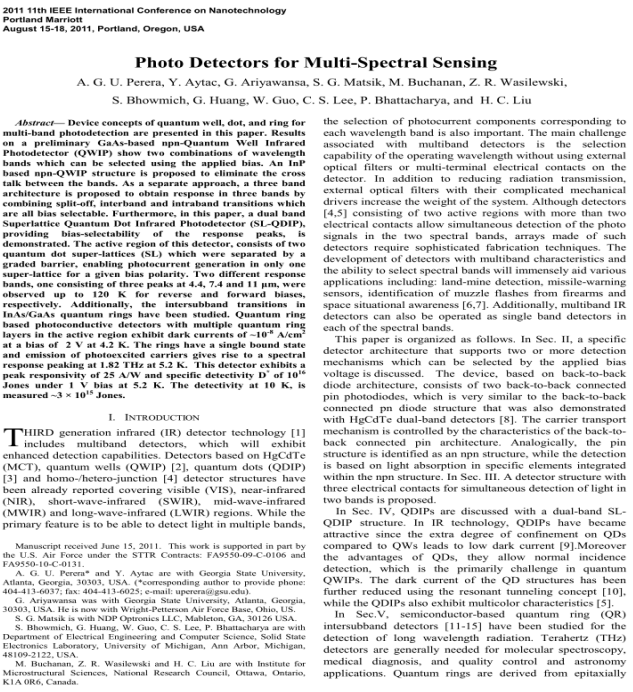

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Photo Detectors for Multi-Spectral Sensing

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***Abstract*— Device concepts of quantum well, dot, and ring for multi-band photodetection are presented in this paper. Results on a preliminary GaAs-based npn-Quantum Well Infrared Photodetector (QWIP) show two combinations of wavelength bands which can be selected using the applied bias. An InP based npn-QWIP structure is proposed to eliminate the cross talk between the bands. As a separate approach, a three band architecture is proposed to obtain response in three bands by combining split-off, interband and intraband transitions which are all bias selectable. Furthermore, in this paper, a dual band Superlattice Quantum Dot Infrared Photodetector (SL-QDIP), providing bias-selectability of the response peaks, is demonstrated. The active region of this detector, consists of two quantum dot super-lattices (SL) which were separated by a graded barrier, enabling photocurrent generation in only one super-lattice for a given bias polarity. Two different response bands, one consisting of three peaks at 4.4, 7.4 and 11 μm, were observed up to 120 K for reverse and forward biases, respectively. Additionally, the intersubband transitions in InAs/GaAs quantum rings have been studied. Quantum ring based photoconductive detectors with multiple quantum ring layers in the active region exhibit dark currents of ~10^{-6} A/cm^2 at a bias of 2 V at 4.2 K. The rings have a single bound state and emission of photoexcited carriers gives rise to a spectral response peaking at 1.82 THz at 5.2 K. This detector exhibits a peak responsivity of 25 A/W and specific detectivity D* of 10^{10} Jones under 1 V bias at 5.2 K. The detectivity at 10 K, is measured ~3×10^{15} Jones.**

I. Introduction

THIRD generation infrared (IR) detector technology [1] includes multiband detectors, which will exhibit enhanced detection capabilities. Detectors based on HgCdTe (MCT), quantum wells (QWIP) [2], quantum dots (QDIP) [3] and homo-/hetero-junction [4] detector structures have been already reported covering visible (VIS), near-infrared (NIR), short-wave-infrared (SWIR), mid-wave-infrared (MWIR) and long-wave-infrared (LWIR) regions. While the primary feature is to be able to detect light in multiple bands, the selection of photocurrent components corresponding to each wavelength band is also important. The main challenge associated with multiband detectors is the selection capability of the operating wavelength without using external optical filters or multi-terminal electrical contacts on the detector. In addition to reducing radiation transmission, external optical filters with their complicated mechanical drivers increase the weight of the system. Although detectors [4,5] consisting of two active regions with more than two electrical contacts allow simultaneous detection of the photo signals in the two spectral bands, arrays made of such detectors require sophisticated fabrication techniques. The development of detectors with multiband characteristics and the ability to select spectral bands will immensely aid various applications including: land-mine detection, missile-warning sensors, identification of muzzle flashes from firearms and space situational awareness [6,7]. Additionally, multiband IR detectors can also be operated as single band detectors in each of the spectral bands.

This paper is organized as follows. In Sec. II, a specific detector architecture that supports two or more detection mechanisms which can be selected by the applied bias voltage is discussed. The device, based on back-to-back diode architecture, consists of two back-to-back connected pin photodiodes, which is very similar to the back-to-back connected pn diode structure that was also demonstrated with HgCdTe dual-band detectors [8]. The carrier transport mechanism is controlled by the characteristics of the back-to-back connected pin architecture. Analogically, the pin structure is identified as an npn structure, while the detection is based on light absorption in specific elements integrated within the npn structure. In Sec. III. A detector structure with three electrical contacts for simultaneous detection of light in two bands is proposed.

In Sec. IV, QDIPs are discussed with a dual-band SL-QDIP structure. In IR technology, QDIPs have became attractive since the extra degree of confinement on QDs compared to QWs leads to low dark current [9].Moreover the advantages of QDs, they allow normal incidence detection, which is the primarily challenge in quantum QWIPs. The dark current of the QD structures has been further reduced using the resonant tunneling concept [10], while the QDIPs also exhibit multicolor characteristics [5].

In Sec.V, semiconductor-based quantum ring (QR) intersubband detectors [11-15] have been studied for the detection of long wavelength radiation. Terahertz (THz) detectors are generally needed for molecular spectroscopy, medical diagnosis, and quality control and astronomy applications. Quantum rings are derived from epitaxially

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Focal Plane Arrays for Space Telescopes: August , San Diego, California, USA, Volume Front Cover. Craig Ralph McCreight, Thomas John., English, Conference Proceedings edition: Focal plane arrays for space telescopes: August , San Diego, California, USA / Thomas J. Grycewicz, .Focal Plane Arrays for Space Telescopes. Editor(s): August San Diego, California, United States SPIE , Charge-coupled CMOS and hybrid detector arrays, (12 January); kachemile.com .. It is expected that the sensor experiment will carry FPAs and associated radiation.To accomplish this goal, a high resolution space-based camera is being SPIE , Focal Plane Arrays for Space Telescopes, (12 January); doi.(August ,San Diego, California). Vol Space Structures - Power and Conditioning .. Infrared Detectors, Focal Plane Arrays and Imaging . (February , Newport Beach, California) Advanced Technology Optical Telescopes IV (August , San Diego, California, USA).Composite Optics, Inc., San Diego, CA, USA , , San Diego, CA, USA; In English; Focal Plane Arrays for Space Telescopes, Aug. 4- 6.IM] 3 Aug lUniversity of California, San Diego, La Jolla, CA , USA Keck Array telescope in February , with five receivers installed in the mount constant) causes accelerating expansion of space. (a) BiCEP2 focal plane with four detector tiles, at the South Pole before installation in.S.D. Hector, M.L. Schattenburg and E.H. Anderson, J. Vac. The spectral archive of cosmic x-ray sources observed by the Einstein Observatory Focal Plane Crystal . Burgensen, P.H. Townsend, C.A. Ross and C.A. Volkert (MRS, Pittsburgh, .. (). R Constellation-X Spectroscopy X-ray Telescope assembly and.In the fall of ICR(Initial Confirmation Review) was given, starting the Phase B of the JWST project. NASA/GSFC is managing the JWST project, while STScI (Space Telescope Science Institute) of Visible to 28 m, Proceedings of SPIE, `Focal plane arrays for space telescopes,' San Diego, CA, Aug. , , Vol.on current and the most rapidly developing focal plane arrays using: CdZnTe Hubble space telescope delivered a deep-space picture, a Kazimierz Dolny, October 1317, formance improves, the detectivity D*(called D-star)isde resolution than an HgCdTe FPA with similar storage ca-. pacity.[PDF] Focal Plane Arrays For Space Telescopes: August , San Diego, California, USA [PDF] Consultancy, Inspection And Review Services In.Development of focal plane arrays started in seventies last century and has revolutionized .. (), the CCD camera aboard the Hubble space telescope delivered a deep-space The Spitzer Space Telescope was launched in August superlattice infrared detectors, in: S.D. Gunapala, D.R. Rhiger, C. Jagadish.Netherlands, for providing us with measurements of the Vivaldi antenna PAF . Klooster, Multi-Beam Focal Plane Arrays with Digital Beamforming for High Preci- sion Space-Borne Remote Sensing, Under review for IEEE Transactions on sd is the average number of elementary basis Wiley & Sons, Inc., Granulation, however, requires a rather complicated focal plane mask, at major solar telescopes (von der Luhe et al., ; Scharmer et al., ; . The telescope aperture is sampled by an array of lenslets, which in turn and Space Weather Instrumentation III, 46 August , San Diego, CA, USA.Charge-Coupled Devices," Proc. of the SNIC Symposium, Stanford, CA (at SPIE's

"Focal plane arrays for space telescopes," San Diego, Aug).