High-Power and Ultra-Fast Photodiodes at THz Regime  
(Invited Paper)
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Commanding the full electromagnetic (EM) spectrum (near 1 MHz to around 0.3 THz), which includes generation, modulation, wireless transmission, and detection by use of photonic approaches, plays an important role in modern electronic warfare, THz bandwidth measurement instruments (network analyzer), and the next-generation of wireless communication at the millimeter-wave or THz wave bands [1,2]. An ultra-fast photodiodes (PDs) serves as the key components in this system. In this paper, we review our recent work about near-ballistic uni-traveling carrier photodiodes (NBUTC-PDs) [3,4] at THz regime. Figure 1 shows the conceptual band diagram of three kinds of device structure. Device A is the typical UTC-PD, B and C is the near-ballistic UTC-PD (NBUTC-PD) structure [3,4]. As compared to device A, we can clearly see that there is an additional n- and p-type charge layer in the collector layer of device B and C, respectively. The purpose of such two layers is for controlling the E-field distribution and suppressing the space-charge screening effect or inter-valley scattering effect of electrons [4]. In our previous works [3,4] the flip-chip bonding packages of NBUTC-PD has been adopted to enhance the efficiency and benefit optical alignment. In addition, the device heating can be minimized by bonding the active PD onto high thermal conductivity substrate (AlN). Figure 2 shows the measured optical-to-electrical (O-E) frequency response of NBUTC-PDs under 3mA output photocurrents. We can clearly see that > 300 GHz O-E bandwidth can be achieved under a 50 Ω load with high output photocurrent. In order to boost the photo-generated THz power, a femto-second optical pulse train system has been established [4]. Figure 3 shows the photo-generated THz power under short pulse train and sinusoidal excitations. Compared with optical sinusoidal signal excitation, a 3-dB enhancement in output power can be achieved. Furthermore, both devices can have strong and fast bias modulation characteristics [4]. It leads to their applications for THz radar [5] or wireless communication systems [6].

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**References:**


