High Power Performance of Ultrahigh Bandwidth MSM TWPDs

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Summary: Low-temperature-grown GaAs (LTG-GaAs) based photodetectors (PDs) merits a lot of attentions due to their ultrahigh electrical bandwidth performance. By utilizing photomixing technique, these high speed PDs can radiate power in the THz frequency regime [1]. In such application, these PDs usually need to be suffered high optical power illumination and operated in high bias voltage. In this paper, we studied the behavior of a novel MSM traveling wave photodetector (MSM TWPD) under high optical power illumination and high bias level by Electrical-Optical (E-O) sampling technique based on a femtosecond Ti:sapphire laser. This novel device has been demonstrated with ultra-high bandwidth (570GHz) and reasonable quantum efficiency (8%) [2]. With a large photo-absorption volume and better capability of undertaking high bias voltage, improved high power performance can also be obtained in this device compared with previous LTG-GaAs based p-i-n TWPD [3].

The measured bias dependent E-O sampling traces of impulse response in low optical power regime are shown in figure 1 (a). The radiated average optical power at 800 nm was 0.877mW with 100MHz repetition rate, corresponding to 308 fC collected charge for every optical excitation pulse at 20V bias. The FWHM of each trace is slightly increased with the bias voltage. This effect is possible due to the lifetime increasing effect of LTG-GaAs in high electric field [4]. With respect to the impulse responses in high power regime, which are shown in figure 1 (b), the trend of these bias dependent traces is opposite to in figure 1(a). The radiated average optical power in Figure 1(b) was 7.56mW, corresponding to ~1600 fC collected charge for every optical excitation pulse at 20V bias. The FWHM of each trace decreased with the increasing in bias voltage. This high power behavior is similar to most transport-time-limited PDs in their high power regime, which is possibly originated from the combination of defect saturation and space charge screening effect in LTG-GaAs layer [3]. These high power measurement results demonstrate a much improved bandwidth performance (~1.5ps, 20V bias) in the high output current regime (~1600fC) compared with previous LTG-GaAs based p-i-n TWPD (~6ps, 1400 fC) [3], InGaAs based vertical p-i-n PD (~ 7.2 ps, 68 fC) [5], and GaAs based p-i-n TWPD (~5.5ps, 59 fC) [6]. The superior performance in power-bandwidth product of MSM TWPD is due to its larger photo-absorption volume and better capability of handling high bias voltage without breakdown compared with p-i-n PDs.

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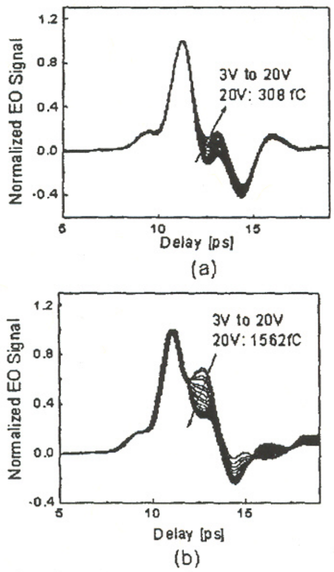
The dependence between FWHM and bias voltage under high optical illumination (7.56mW) is shown in Figure 2. We can clearly see that there exists an optimum bias point for the FWHM of impulse response. The FWHM will decrease with voltage when the bias is lower than 20V. However when voltage further increases the FWHM broaden again. This interesting behavior indicates that under extremely high bias (>30V) and high optical power regime, carrier multiplication or lifetime increasing effect might be the dominating nonlinear mechanism. The detail theory and newest measurement results will be presented in the conference.



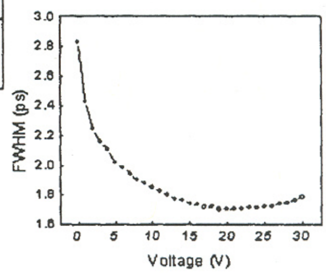


Figure 2. Bias dependent (up to 30V) FWHM in high power regime (7.56mW)

Figure 1(a) (b). Bias dependent E-O signal at low power regime (0.877mW) (a) and high power regime (7.56mW) (b)

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