3 μm 리소그라피 공정을 이용하여 AlGaAs/InGaAs QW-FET 웨이퍼로 제작된 MSM 광검출기

MSM Photodetector Fabricated on AlGaAs/InGaAs QW-FET Wafers Using 3 μm Lithography Process

조영준, 오경환*
한국항공우주연구원, *광주과학기술원
yjcho@kari.re.kr

1.Introduction

The planar metal-semiconductor-metal (MSM) photodetectors are promising candidates for OEIC applications owing to ease of fabrication, compatibility with field-effect transistor process technology. To achieve high bandwidth (over 10 GHz), sub-micron metal electrodes pattern which degraded the responsivity is needed. In this paper, using simple processing steps and photolithography technique, high performance MSM photodetector was fabricated with AlGaAs/InGaAs Quantum Well FET layer structure.

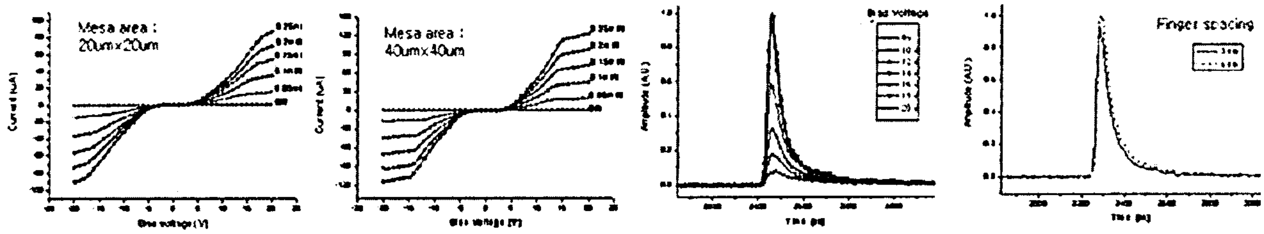
2.Experimentsandresults

The layer structure consists of 30-nm-thick AlGaAs barrier enhancement layer, InGaAs layer, undoped GaAs and GaAs/AlGaAs superlattice buffer layer on S.I. GaAs substrate. After Ti/Au Schottky metal was deposited on the epilayers by e-beam evaporator, mesa was etched for device isolation. And then SiN was coated as anti reflection coating. The Schottky metal pattern was made by photolithography technique. The device characterizations were done by DC and RF measurement. The CW responsivity was characterized as a function of bias voltage and optical power using a 850nm injection laser. Table 1 summarizes the DC responsivities and dark currents of various devices. These results are relatively high and comparable to the early reported data.

Table 1. DC responsivity and dark-current of the devices

active area	responsivity	dark current at 10 V
20 μm x 20 μm	0.282 A/W	3.83 nA
40 μm x 40 μm	0.451 A/W	6.32 nA
100 μm x 100 μm	0.455 A/W	11.7 nA

Fig. 1(a), (b) shows the DC response characteristics for various optical power levels between 0 and 0.25 mW. The response speed of the devices is assessed by measurement in the time domain. A 850 nm gain-switched injection laser with a pulse duration of 40 ps FWHM was used for this purpose. The impulse response was measured on wafer by means of a 40 GHz microwave probe in conjunction with a 50 GHz sampling oscilloscope. Fig. 1(c) and (d) shows impulse responses of 40 μm x 40 μm active region with 2 μm metal finger width and 3 μm metal finger spacing depend on the bias voltage and metal electrodes gap respectively.



(a) (b) (c) (d)

Fig 1. DC and RF measurements. (a), (b) Photocurrents and dark-currents of 20 μm x 20 μm and 40 μm x 40 μm active area. (c), (d) Temporal responses depending on bias voltage and metal finger spacing, respectively.

Rise time technique was used to estimate the device bandwidth. The relations between rise time (Tr) and bandwidth (f_{3dB}) describes as[1]

$$T_r = (\tau_{tr} + \tau_{RC})\ln 9 \quad \text{and} \quad f_{3dB} = [2\pi(\tau_{tr} + \tau_{RC})]^{-1} \qquad (1)$$

where τ_{tr} is the transit time, and τ_{RC} is the RC-time constant. Measured rise time was Tr =21.81 ps and its bandwidth was 16.02 GHz by (1). The reported bandwidth of MSM PD with electrode spacing of 1-3 μm is 1.3-11 GHz. The device in this paper shows higher bandwidth compared with conventional MSM devices which have large metal electrodes spacing (2-3 μm). 2DEG effects due to the AlGaAs/InGaAs/GaAs heterostructures further enhance the barrier height results in the reduction the dark-current and add in transport of photogenerated carriers by internal field[2].

3.Conclusion

We have fabricated and characterized MSM photodetectors on a Quantum Well-FET (with a thin InGaAs channel layer) wafer with newly designed simple processing steps. DC and RF characteristics show the high performance without complex submicron lithograph technique. The performance of the 40 μm x 40 μm active area device with 2 μm metal finger width and 3 μm finger gab shows the responsivity in the quasisaturated regime is 0.451 A/W and dark-current is 6.32 nA at 10 V bias. Bandwidth of the device is 16.02 GHz at 15 V bias. Equivalent circuitmodel was derived by measured S-parameters which representing the parasitic properties of the detector[3-4]. The device can be directly integrated with QW-FET or HEMT amplifier to make a front-end of a receiver circuit.

References

[1] Govind P. Agrawal, " Fiber-optic communication systems", A Wiley-Interscience Publication, Sec.4.1.2 (2002).

[2] B. Nabet, A. Cola, F Quaranta, and M. Cesareo, R. Rossi, and R.Fucci, and A. Anwar,"Electron cloud effect on current injection across a Schottky contact", Apply. Phys. Lett.,vol. 9, pp.4007-4009 (2000).

[3] B. Nabet, A. Cola, A. Cataldo, X. Chen, and F. Quaranta, "Photodetectors based on heter-ostructures for opto-electronic applications", *IEEE trans. Microwave Theory and Technol.*, vol. 51, no.10 (2003).

[4] M.. Tomaska, F. Uherek, and J. Jakabovic, "High-speed heterostructure photodetectors characterization", in 2nd Int. Advanced Semiconductor Devices and Microsystems Conf., pp.99-102, Oc (1998).