Optical Design of Evanescently coupled photodiode for Terahertz wave generation

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1. Introduction

Terahertz wave which is defined as 0.1-10 THz has potential to enable larger capacity wireless transmission. One of the promising techniques to generate terahertz waves is photomixing at a high-speed photodiode such as the uni-traveling carrier photodiode (UTC-PD). To overcome the power saturation of the UTC-PD, we integrated two arrayed UTC-PDs to combine these powers and demonstrate 0.5-m wireless data transmission [1]. For practical transmission distance, the number of the UTC-PDs should be increased. Thus, the integration technology of the input optical waveguides and the UTC-PDs has to be developed. In this study, we propose the photonics integration device consisting of the input optical waveguide and the evanescently coupled UTC-PD. We found that thicknesses of the matching layer and the waveguide upper cladding layer are dominant factors for higher photoabsorption. We successfully got photoabsorption efficiency of about 22% at 7-μm long UTC-PD by optimizing these layers.

2. Device concept

The UTC-PD consists of the n-InGaAsP(bandgap wavelength is 1.43μm) matching layer, i-InGaAsP (bandgap wavelength is 1.43μm) carrier transit layer and p-InGaAs photoabsorption layer. These layers are integrated on a InP/InGaAsP(bandgap wavelength 1.40μm)/InP waveguide in between InP separation layer as shown in Fig. 1. The matching layer protrudes from the UTC-PD. Since the UTC-PD layers have higher refractive index than the waveguide cladding layer, this integration structure is regarded as two waveguides located in parallel and optical coupling is expected between these two devices.

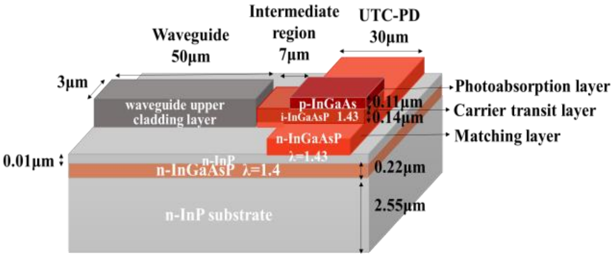

Fig. 1. Schematic of waveguide structure

3. Results and discussion

We set wavelength of the input light at 1.55μm. In consideration of using 7-μm long UTC-PD in future practical use, we measured absorbed power at 7μm far from the edge of the UTC-PD. Fig. 2 shows the power distribution of the guided light (left side) and evanescently coupled light (right side). Optical coupling between the waveguide layers and the UTC-PD layers causes power distribution going up and down. The photoabsorption efficiency depends on thicknesses of the matching layer and waveguide upper cladding layer. Fig.3 shows the dependence of photoabsorption efficiency on thicknesses of these layers. We got power efficiency of 22% at the optimized thicknesses of 0.1-μm thick waveguide upper cladding layer and 0.4-μm thick matching layer.

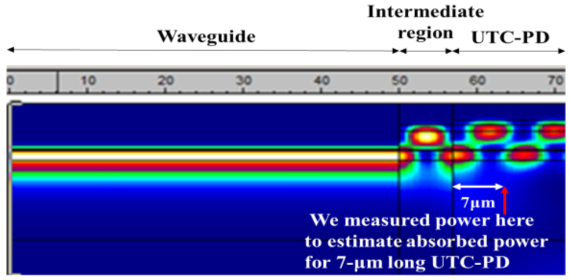

Fig. 2. Simulated power distribution

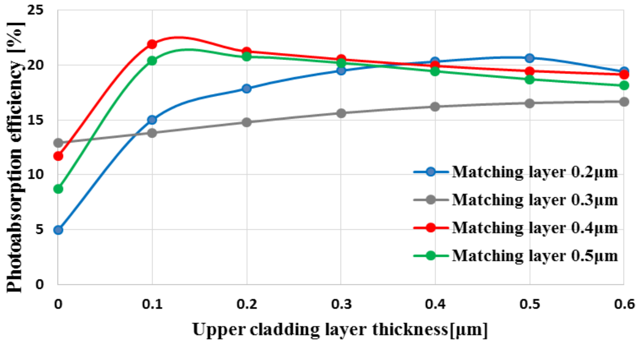

Fig. 3. Photoabsorption efficiency

4. Conclusion

We confirmed that thicknesses of the matching layer and the waveguide upper cladding layer are dominant factors for highly efficient photoabsorption. With an optimized structure, we obtained 22% photoabsorption efficiency which would enable the photonics integration device for terahertz wave generation.

Acknowledgement

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References

[1] J. Haruki et al.,"First demonstration of 300-GHz band wireless data transmission with arrayed photomixers," to be presented at 21st Microoptics Conference (MOC'16), Berkeley, Oct., 2016.