Terahertz-Wave Beam Generation by Photonic Integrated Device

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Among several successful approaches of generating a THz wave, photomixing of two different lightwaves is one of the most promising techniques for forming and steering a beam because its frequency and phase can be controlled in the optical domain. This technology is based on three main functions; arrayed lightwave generation, arrayed phase tuning and arrayed photomixing. In this paper, we present an arrayed photonics integrated circuits for these functions and demonstrate their performances.

As for photomixing, we made arrayed UTC-PDs which have 4 × 4 two dimensional arrayed micro slot antenna. The antenna is designed to have a center frequency of 300 GHz. Each photomixer generated a THz wave with the frequency of 300 GHz and it was radiated to vertically from the four arrayed antennas. The peak power of the combined THz wave is increasing proportionally to the square of the number UTC-PDs, which shows successful power combination or beam forming with a directional gain [1].

Phase tuning is inevitable for beam steering. In order to control the phase at each photomixer, we developed arrayed phase shifter based on a silica planar lightwave circuit. It consists of two 1x8 optical splitters, eight optical phase shifters (OPSs), and eight 2x1 optical couplers. Each OPS is operated on the basis of the thermo-optic effect. When a voltage is applied to a heater on the OPS, the refractive index is changed and the phase of the lightwave after the OPS is shifted. We testified feasibility of dynamic beam steering with a repetition rate of 1 kHz using two channels of the OPS. An experimental result indicates that the beam is steered between 10 and –20 degrees [2].

For a future practical use, arrayed light sources with the same sets of dual wavelengths are preferable for operating the arrayed photonixers which make the bulky fibers unnecessary. Thus, we designed and fabricated arrayed light sources consisting of dual distributed feedback (DFB) lasers and semiconductor optical amplifiers (SOAs). The integrated device is designed based on InP/InGaAsP material system which consists of two DFB lasers, a 2x1 multimode interference (MMI) coupler, three MMI splitters and eight SOAs. We measured the output lightwavess coupled by a hemispherical ended fiber. We observed the lightwave power with a high uniformity [3] and confirmed the feasibility that the devised integrated light sources are applicable to the arrayed terahertz-wave generator.

Acknowledgement

This work was supported by the Collaborative Research Based on Industrial Demand/JST Grant Number JPMJSK1513, the MIC/SCOPE #195010002, and JSPS KAKENHI (JP19K21977, JP20H00253).

References

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