Phase control of THz-wave in multi-port waveguide structure coupled with bull's-eye antenna

Seigo Ohno*[1,2,3]

[1] Department of Physics, Graduate School of Science, Tohoku University, Sendai, Japan
[2] Division for the Establishment of Frontier Sciences, Organization for Advanced Studies, Tohoku University, Sendai, Japan
[3] Tera-Photonics Research Team, RIKEN Center for Advanced Photonics (RAP), RIKEN, Sendai, Japan
E-mail: seigo@tohoku.ac.jp

Abstract

We have analytically and numerically investigated phase control feature of terahertz wave in a waveguide structure coupled with a bull's-eye antenna via polarization state incident to the bull's-eye antenna. In this presentation, we will introduce the theoretical extension to the multiport waveguide aligned in parallel nearby the tiny hole of the bull's-eye antenna and show some numerical results.

1. Introduction

A terahertz (THz) wave has been attracted as a candidate of the carrier wave for wireless communications in the next generation with increasing the communication traffic. We have focused on a structure consists of a waveguide coupled with a bull's-eye antenna with bearing in mind the importance between collection of propagating waves in the air and the processing circuits. It was analytically and numerically turned out that, in such structure, the phase of the propagating wave in the waveguide can be controlled by the polarization direction of the incident wave to the bull's-eye antenna [1]. Furthermore, the propagation direction in the waveguide can be switched by the rotation direction of elliptically polarized wave incident to the antenna. This directional switching phenomenon can be understood as a similar one with the optical spin-momentum locking phenomenon discussed in the optical region [2,3].
In this presentation, we will introduce the extension of our analytical model to the multi-port waveguide and show its numerical results.

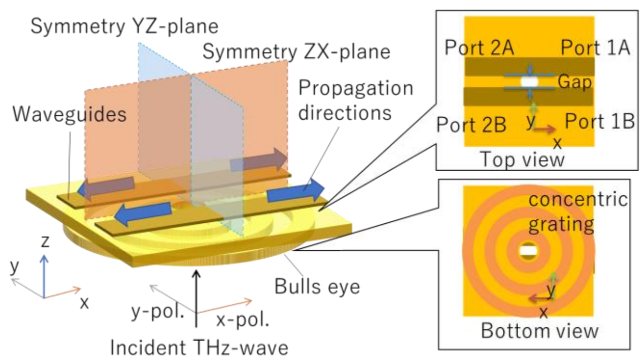

Figure 1: Concept of considering system.

2. Concept of system

Our conceptual system of waveguides coupled with a bull's-eye antenna is shown in Fig. 1. The bull's-eye antenna consists of a subwavelength scale hole and surrounding concentric grating is putted on a bottom of a metal substrate. Two parallel micro-strip waveguides are symmetrically aligned across the backside hole with a small gap. A THz wave normally incident to the bull's eye antenna is collected by the antenna and is focused to the center hole. Then the wave propagates to the back side of the substrate passing through the hole. When the hole is sufficiently close to the micro-strip and sufficiently smaller than the waveguide mode distribution on the micro-strip, the wave passing thorough the hall can couple to the each microstrip and the waves propagate to the ports labeled 1A, 1B, 2A, and 2B.

Here we consider the parity of the propagating mode depending on the polarization of the incident wave. When the polarization direction is x-direction, the parity of the propagating wave between the ports 1 and 2 is odd and that between A and B is even. In the y-polarized case, even and odd parities are respectively obtained between 1 and 2 and between A and B. This means there is phase controllability not only between 1 and 2, but also A and B when the polarization direction is changed as shown in our previous work [1].

In our presentation, we will show the analytical expression and numerical results.

Acknowledgements

The author would like to thank Dr. H. Minamide, Dr. Y. Tokizane, and Dr. Y. Takida in RIKEN, Prof. J. Shikata in Nihon University, and Prof. Y. Kanamori and Dr. T. Okatani in Tohoku university for their fruitful and constructive discussion.
This work was partly supported by JST A-STEP (JPMJTM20JX) and RIKEN Science and Technology Hub Collaborative Research Program.

References

[1] S. Ohno, Y. Tokizane, J. Shikata, H. Minamide, Phase and Direction Control of a Terahertz-Wave Propagating in a Waveguide Coupled with a Bull's-eye Structure, *URSI Radio Science Letters* 2: 1-4, 2020.

[2] J. Petersen, J. Volz, A. Rauschenbeutel, Chiral Nanophotonic Waveguide Interface Based on Spin-Orbit Interaction of Light, *Science* 346: 6205, 67-71, 2014.

[3] M. F. Picardi, A. V. Zayats, J. Rodríguez-Fortuño, Janus and Huygens Dipoles: Near-Field Directionality Beyond Spin-Momentum Locking, *Physical Review Letters* 120: 11, 117402, 2018.