【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project : Research on reconfigurable unitary optical mode converters and wavefront synthesizers using semiconductor photonic integrated circuits

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Research Area : Optoelectronics
Keywords : Monolithically integrated photonic circuit, semiconductor optical device, InP

【Purpose and Background of the Research】

Space optics have conventionally been used in order to synthesize a desired optical wavefront by controlling optical phase in space. However, their operation speed has been limited in a few milli-second range due mainly to their large sizes. In this research, we will realize adaptive optical wavefront synthesizer circuits monolithically integrating a few hundreds/thousands of active optical components, such as lasers, optical amplifiers, optical phase controllers, polarization controllers, and optical power monitors, on an InP substrate, based on our semiconductor monolithic photonic integration technologies developed over the past years. We will extend the circuit to more universal multiple input arbitrary optical unitary conversion circuits so that they would widely be utilized in next generation optical communications, optical interconnects, medical/bio imaging, and optical quantum computing.

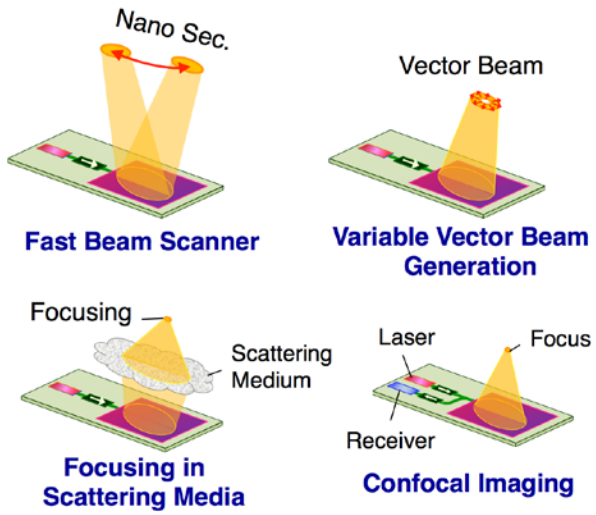

Fig. 1 Applications of adaptive lightwave synthesizer circuits.

【Research Methods】

By making use of high-efficiency modulation by carriers and electro-optic effects in InP-related semiconductors, we will make fast (less than nano second) and low power adaptive optical wavefront synthesis possible. In addition, we make high-power operation possible by integrating lasers and optical amplifiers monolithically, which is not possible in passive materials like silicon or silica glass.
Moreover, by extending the function of the wavefront synthesizer chip, we will develop an optical circuit chip transforming N mutually-orthogonal optical beam inputs into desired different optical beams each simultaneously, or in other words, performing N x N unitary conversion among arbitrary

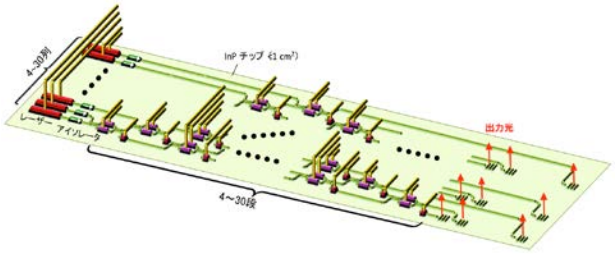

Fig. 2 Arbitrary optical unitary conversion circuit.

Nth-dimension orthogonal bases. By integrating multiple waveguide 2 x 2 optical couplers in tandem, we realize a large scale unitary conversion circuit with $N \geq 10$ on a small chip less than 1cm^2.
We will also integrate many InP micro optical power monitors to rapidly control the coupling ratio of each optical coupler, so that we can materialize an adaptive multiple input arbitrary optical unitary conversion circuit for the first time.

【Expected Research Achievements and Scientific Significance】

Since the wavefront synthesizer circuit will make fast beam scanning of sub-nano-second level possible, it can be directly applied to reconfigurable optical interconnects, resulting in reduction of power consumption in IT equipments largely. It also realizes 3 dimensional optical imaging in scattering media at a low cost, and thereby bringing about revolutionary change in the fields of medicine, biology, and environmental sensing.
On the other hand, the multiple input arbitrary optical unitary conversion circuit will be directly applied to transceivers for the mode division multiplexed optical communication link, which is regarded as the next generation high-capacity optical communication scheme. Furthermore, the circuit is expected to bring ultimate sensitivity to optical sensing and optical quantum computing.

【Publications Relevant to the Project】

T. Tanemura, Y. Nakano, et al., "Integrated phased-array switches for large- scale photonic routing on chip," Laser & Photonics Reviews, Wiley-VCH, vol. 6, no. 4, pp. 549-563, July 2012.

【Term of Project】 FY2014-2018

【Budget Allocation】 434,000 Thousand Yen

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