InP Photonic Integrated Circuit for 2D Optical Beam Steering

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Abstract: 2D optical beam steering through an InP photonic integrated circuit with on-chip monitors and an AWG-like structure has been demonstrated.

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Electronically controlled 2D optical beam steering is potentially useful for applications like LIDAR, 3D imaging, precision targeting, guidance and navigation, etc. Recently, we have demonstrated an InP photonic integrated circuit (PIC) for this purpose [1-2]. Fig.1 (a) shows the layout of the PIC which consists of the input semiconductor optical amplifier (SOA), the 1×2 MMI tree which splits the input into eight channels, an SOA array and a phase shifter array which are used to boost the power and control the phase of each channel, then the waveguide array with embedded 2nd-order gratings for the out-of-plane emission, and the monitor array. The mechanism for 2D beam steering is that: the array of phase shifters is used to add a phase slope across the waveguide array so as to steer the beam perpendicularly to the waveguide in the array (lateral direction); the input wavelength is changed to steer the beam along the waveguide in the array (longitudinal direction) because the emission angle of the grating depends on wavelength [1]. As shown in Fig. 1 (a) additional bends are added to make each channel have equal length. All these bends use the same radius (200 μm) and the same total lengths. Such AWG-like structure prevents additional differential phase being generated when changing wavelength. Fig. 1 (b) shows the blown-up of the monitors. Each channel is split into three equal parts by a 1×3 MMI. Two close parts from two adjacent channels are combined by a 1×2 MMI to form interferometers with the interference monitored by a photodiode (PD) as seen from Fig. 1 (b). In this work we show that the on-chip monitors and the AWG-like PIC structure have made the 2D beam steering easier.

The monitors can be used to characterize the phase shifters on-site so that the dependence of the generated phase shift on injected current, i.e. the phase-current curve, can be established. Then the phase slope across the array required by a specific steering angle θ, which is $\phi_i = 2\pi(i-1)d\sin(\theta)/\lambda$ where d is the array pitch and λ is the wavelength, can be set directly by referring to the established phase-current curves. The result is shown in Fig. 1 (c).

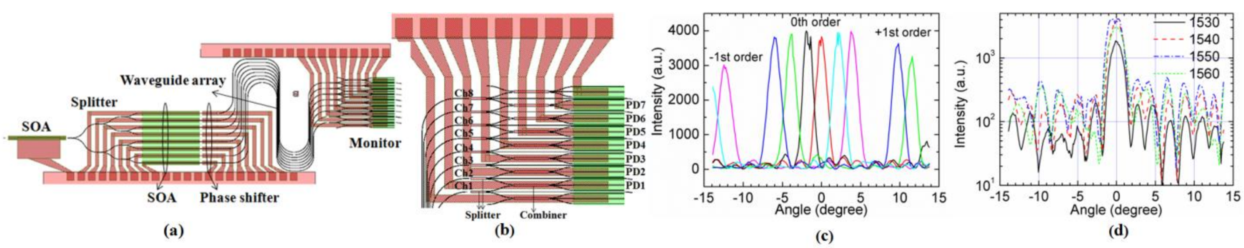

Fig. 1 (a) Layout of the PIC; (b) Blown-up of the monitor array; (c) Far-field pattern in the lateral direction for the input wavelength of 1540 nm and different steering angles; (d) Far-field pattern in the lateral direction for the input wavelength of 1530, 1540, 1550, and 1560 nm.

Also because the PIC takes an AWG-like structure, the far-field pattern of the beam keeps having a good shape and high side-lobe suppression (~2.0 degree 3dB beam width and 10 dB side-lobe suppression from -15 to 15 degree) when changing the input wavelength even when we do not reset the phased shifter currents as shown in Fig. 1 (d).

In summary we have demonstrated 2D optical beam steering through an InP PIC with on-chip monitors and an AWG-like structure.

References

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