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Phase Error Measurement of Arrayed-waveguide Grating

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1. Introduction

An arrayed-waveguide grating (AWG) is a planar lightwave circuit for wavelength division multiplexing, and demultiplexing in a photonic network. We proposed and fabricated a fast wavelength selective AWG using PLZT ((Pb, La)(Zr, Ti)O_3) [1, 2]. However, phase errors of an arrayed-waveguide due to optical path length fluctuations cause deteriorations of characteristics, and especially cause large crosstalk between channels in the AWG [3]. We measured phase errors of PLZT-AWG based on the interference measurement technique [4, 5] to compensate them.

2. Theory

A transfer function of an AWG is derived by

$$T(k) = \sum_{m=0}^{N-1} A_m(k) e^{-j\phi_m(k)} e^{-jmnk\Delta L}, \qquad (1)$$

where k is wavenumber, N is the number of waveguides in the arrayed-waveguide, A_m is an amplitude coefficient of m-th waveguide in the arrayed-waveguide, ϕ_m is a phase error of m-th waveguide in the arrayed-waveguide, n is an effective index in the arrayed-waveguide and ΔL is a path difference of the AWG. The phase error is caused by fluctuations of waveguide width, waveguide height, and refractive indices. On wave number dependence, exp($-jmnk\Delta L$) is faster varying than amplitude coefficients and phase errors. Therefore, Fourier transform of transfer function has N peaks of each waveguide in the arrayed-waveguide, and the peaks are separable. The m-th peak is derived by

$$t_m(x) = \int_{-\infty}^{\infty} A_m(k) e^{-j\phi_m(k)} e^{-jk(x+mn\Delta L)} dk. \qquad (2)$$

Inverse Fourier transform of eq. (2) gives $A_m(k)$exp($-j\phi_m(k)$)exp($-jmnk\Delta L$), and the argument is derived by

$$\theta_m(k) = -\phi_m(k) - mnk\Delta L. \qquad (3)$$

Because the path difference ΔL is derived by

$$\Delta L = \frac{M}{n}\frac{2\pi}{k_0}, \qquad (4)$$

where M is the diffraction order, k_0 is center wave number of the AWG, the argument $\theta(k{=}k_0)$ is equal to the phase error derived by

$$\theta_m(k_0) = -\phi_m(k_0) - 2\pi mM. \qquad (5)$$

3. Experimental

An optical vector network analyzer is one of techniques to measure a transfer function [6]. Fig. 1 shows experimental setup for the swept wavelength interferometry.

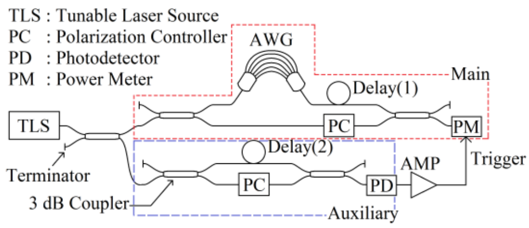

Fig. 1 Experimental setup

The interferogram is derived by

$$I(k) = 1 + |T(k)|^2 + 2\,\mathrm{Re}[T(k)\exp(jkL)], \qquad (6)$$

where L is path difference between arms of main interferometer. The transfer function can be separated in Fourier domain by choosing appropriate path difference L. The wavelength of a tunable laser source was swept from 1530 to 1570 nm with a speed of 20 nm/s. The auxiliary interferometer creates triggers to sample the interferogram in equal frequency increments of 0.25 GHz. An averaging time of power meter is 25 μs which is shorter than trigger interval of 100 μs. Polarization controllers were used to maximize of the interferogram intensity. We calculate phase errors from the interferogram by discrete Fourier transform.

4. Conclusions

We measured and compensated phase errors of the PLZT-AWG. Except one waveguide in arrayed-waveguide, compensated phase errors ranged from -0.2 rad. to 0.1 rad..

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