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Property improvement of flat-top 50 GHz-88 ch arrayed waveguide grating using phase correction waveguides

Kazutaka Nara[1a)] and Noritaka Matsubara[2]

[1] *FITEL Photonics Laboratory, Furukawa Electric Co., Ltd.*
6 Yawatakaigan-dori, Ichihara, Chiba 290–8555, Japan
[2] *Telecomunications Company, Furukawa Electric Co., Ltd.*
6 Yawatakaigan-dori, Ichihara, Chiba 290–8555, Japan
a) *nara@ch.furukawa.co.jp*

Abstract: We have proposed a novel circuit design with the phase correction waveguides in part of the arrayed waveguides to improve the property of an AWG with a narrow spacing and a large channel count without the additional processes such as a UV trimming method. Employing this novel circuit design, we have successfully demonstrated a flat-top 50 GHz-88 ch with a low crosstalk experimentally.

Keywords: arrayed waveguide grating, phase correction waveguide, narrow spacing, large channel count

Classification: Optoelectronics, Lasers and quantum electronics, Ultrafast optics, Silicon photonics, Planar lightwave circuits

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1 Introduction

An arrayed waveguide grating (AWG) multi/demultiplexer employing silica-based planar lightwave circuit technologies is one of the most important components which support present dense wavelength division multiplexing (WDM) systems. Recently, new AWGs such as a small size [1], an athermalization [2, 3], and a low loss flat-top [4] are developed actively.

Meanwhile, to increase a transmission capacity, the multi/demultiplexer with a narrow spacing and a large channel count is also developed. Specifically, a channel spacing is 50 GHz with a half of a conventional 100 GHz spacing and a number of channels is 88 ch with a twice of a conventional 44 ch. Currently, it is realized by a combination of two 100 GHz-44 ch AWGs and a 50 GHz/100 GHz interleaving filter, but the only AWG, namely a 50 GHz-88 ch AWG is required strongly for the cost reduction.

However, we have known that a property of the AWG such as a crosstalk and a chromatic dispersion deteriorate drastically as the channel spacing is narrow and a number of channels is large [5]. Therefore, to improve property of the AWG with a narrow spacing and a large channel count, a compensation technique using an ultra violet (UV) radiation has been reported [5]. But it is disadvantage for a lower cost owing to additional processes.

In this letter, we propose a novel circuit design using the phase correction waveguides in part of the arrayed waveguides to improve the property without the additional processes. In addition we demonstrate a flat-top 50 GHz-88 ch with a low crosstalk using this novel circuit design experimentally.

2 Design for property improvement

Figure 1 (a) and 1 (b) show a measured transmission spectrum and a chromatic dispersion of a flat-top 50 GHz-88 ch AWG for a center channel using a conventional design, respectively. In Figure 1, we also describe a designed transmission spectrum and chromatic dispersion. From Fig 1, both the measured transmission spectrum and chromatic dispersion deteriorate drastically. Thus we have known that these deteriorations are mainly caused by a quadratic phase error distribution in the arrayed waveguides [6]. The calculated results which add the quadratic phase distribution Φ_i are shown by a red line. Φ_i is expressed as follow.

$$\Phi_i = \Phi_0 \left(\frac{2}{M}\right)^2 \left(i - \frac{M}{2}\right)^2 \tag{1}$$

where i is the array number, Φ_0 is the amplitude of Φ_i, M is the number of arrayed waveguides. Here, from Figure 1 we can approximate the properties

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by the quadratic phase distribution with $\Phi_0 = -0.7\pi$.

Next, the transmission spectrums of 7 samples for the center channel which are fabricated by an identical photomask are shown in Figure 1 (c). We can see the transmission spectrum repeats very well. This result means the property deteriorations are mainly caused by the photomask and we can obtain the designed properties if we add the quadratic phase distribution with $\Phi_0 = +0.7\pi$ to the photomask previously.

Therefore, as shown in Figure 2 we bring in a phase correction waveguides with the quadratic distribution which change a waveguide width and length at center of the arrayed waveguides.

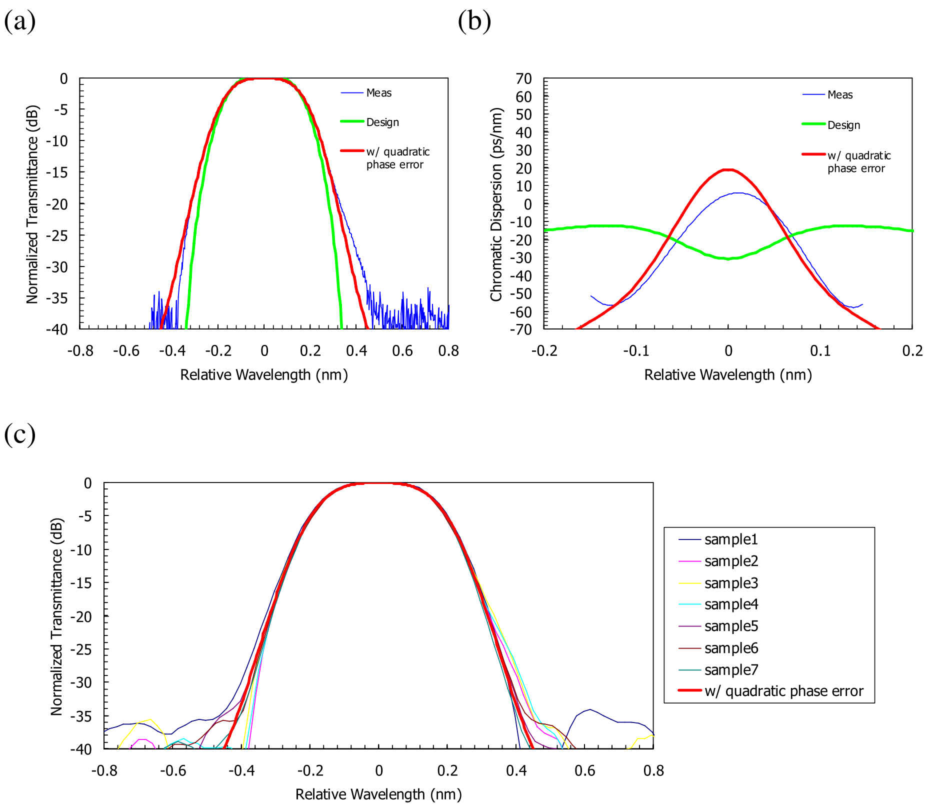

Fig. 1. Measured (a) transmission spectrum, (b) chromatic dispersion and (c) transmission spectrums of 7 samples for center channel using conventional design

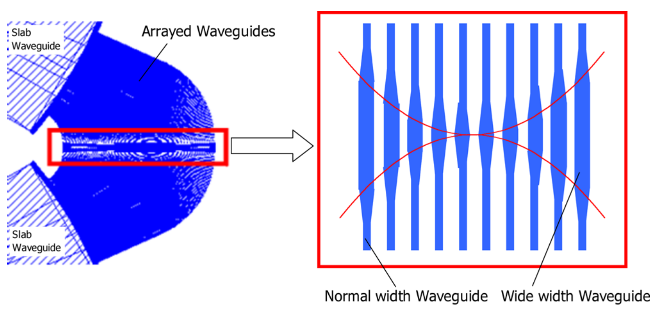

Fig. 2. Schematic configuration of phase correction waveguides with quadratic distribution

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3 Experimental results

Employing a novel design with the phase correction waveguides, we fabricated the flat-top 50 GHz-88 ch AWG. Here, a free spectral range (FSR) is ~7 THz, a diffraction order is 28, and a path difference of the arrayed waveguide is 29.8 μm.

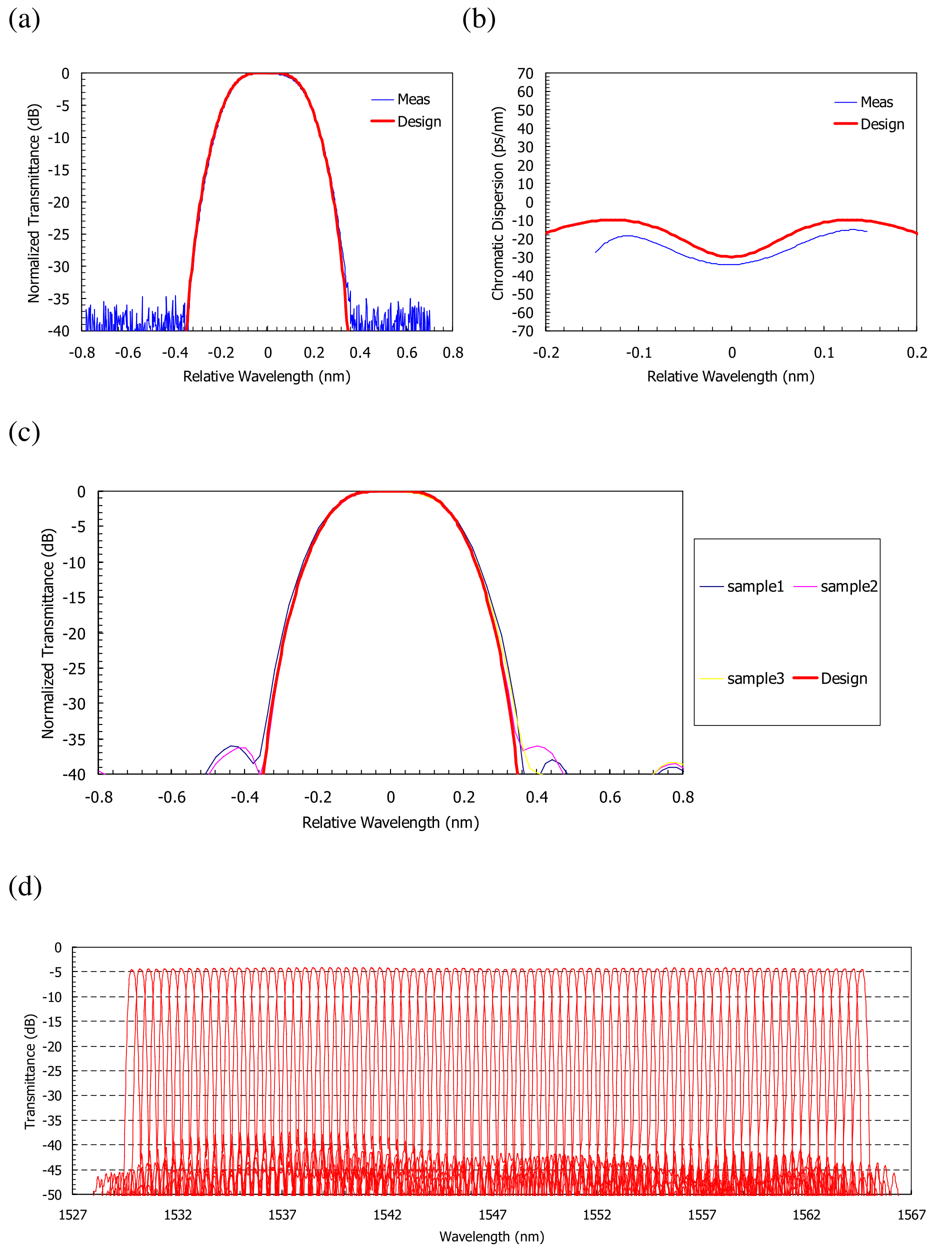

Fig. 3. Measured (a) transmission spectrum, (b) chromatic dispersion, (c) transmission spectrums of 3 samples for center channel and (d) all 88 channels using novel design

In Figure 3 (a), (b) and (c) show the measured transmission spectrum, the chromatic dispersion and the transmission spectrums of 3 samples for the center channel using the novel design, respectively. In Figure 3, we

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also describe a designed transmission spectrum and chromatic dispersion. From these results, we can see an effect of the phase correction waveguides. Next, the transmission spectrum of all 88 channels is shown in Figure 3 (d). As a result, we can obtain good performances such as a 1 dB band width: > 0.22 nm, a 3 dB band width: > 0.32 nm, an adjacent crosstalk within $+/-8$ GHz: < -23 dB and an insertion loss within $+/-8$ GHz: 4.5~5.1 dB.

4 Conclusion

We have successfully improved a property of the flat-top 50 GHz-88 ch AWG using the novel circuit design with the phase correction waveguides in part of the arrayed waveguides. We confirmed the property of the fabricated AWG almost corresponds to the design and obtained a good performance for all 88 channels. We believe this technique will contribute to reducing the cost of a future dense WDM with a narrow spacing and a large channel count.

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