New Products

Athermal AWG Module

1. INTRODUCTION

Arrayed waveguide grating (AWG) which handles the function of wavelength multiplexer/demultiplexer is extensively used in configuring optical communication networks that are becoming more diversified. Since the transmission wavelength of an AWG is temperature dependent, it was a common practice to control its temperature using heaters or Peltier elements. But this caused problems of power consumption increase in the whole system in addition to limiting the installation locations of AWGs, thus making it difficult to respond to various needs of the next-generation optical communication networks, despite the fact that system performance upgrading and function enhancement are required in recent years.

To solve these problems, Furukawa Electric has developed an athermal (temperature independent) AWG module of PS701 series that do not require, based on its proprietary structure and principle, any temperature control and power supply. The product will be introduced in this report.

2. FEATURES

The AWG consists of input waveguides, arrayed waveguide, slab waveguide and output waveguides, constituting a diffraction grating that takes advantage of the optical path difference in the arrayed waveguide. Figure 1 shows a schematic of AWG circuitry.

As ambient temperature changes, the phase front at each wavelength generated by the arrayed waveguide will tilt due to the change in the refractive index of the optical waveguide and the linear expansion of the silicon substrate, causing a shift of the focusing point on the output waveguide within the slab waveguide. This constitutes the main factor determining the temperature dependence of the transmission wavelength for an AWG, which is represented by Equation (1).

$$\frac{d\lambda}{dT} = \frac{\lambda}{n_c}\frac{dn_c}{dT} + \lambda\alpha_s \qquad (1)$$

where: n_c is the effective refractive index of the arrayed waveguide; and α_s is the thermal expansion coefficient of the silicon substrate.

Letting $dn_c/dT = 8\times10^{-6}/℃$ and $\alpha_s = 3\times10^{-6}/℃$, the temperature dependence of the AWG is estimated to be 0.011 nm/℃.

In order to solve such a problem of temperature dependence for the transmission wavelength, we have devised a structure in which the AWG circuit is cut at the slab waveguide.

The AWG circuit is cut at one of the slab waveguides into two pieces --one larger and one smaller, and these pieces are connected by a compensating plate made of copper. Figure 3 shows the slab waveguide, schematically illustrating the mechanism of temperature compensation.

In an ordinary AWG, when ambient temperature changes from the middle temperature, the focus point will shift as shown in Figure 3. In an athermal AWG, on the other hand, the focus point shift as the temperature changes, but the expansion or contraction of the copper plate

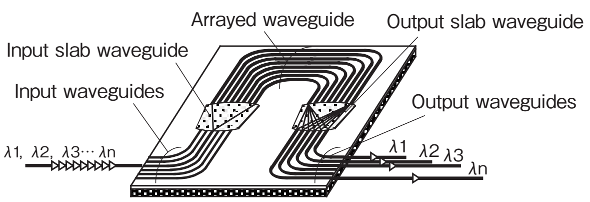

Figure 1 Structure of AWG circuitry.

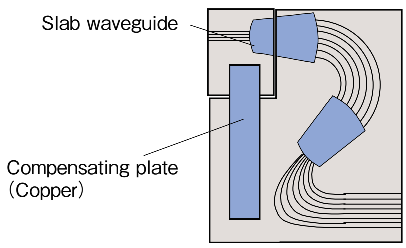

Figure 2 Structure of athermal AWG circuitry.

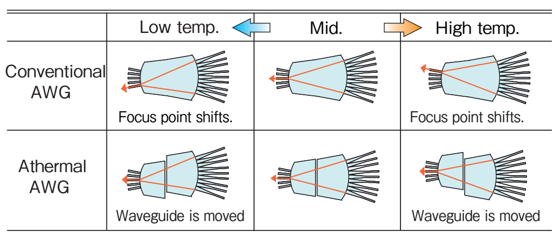

Figure 3 Principle of temperature compensation for athermal AWG.

moves the output waveguide to the new focus point, so that the same wavelength can be output.

3. CHARACTERISTICS

3.1 Optical Characteristics

Figure 4 shows a typical temperature dependence of the center transmission wavelength of the athermal AWG product based on Furukawa Electric's proprietary principle and structure, and Figure 5 a typical temperature dependence of the transmission spectrum. Both the center wavelength with respect to the ITU-T Grid wavelength and the transmission spectrum show no fluctuation and degradation against ambient temperature changes, achieving good results.

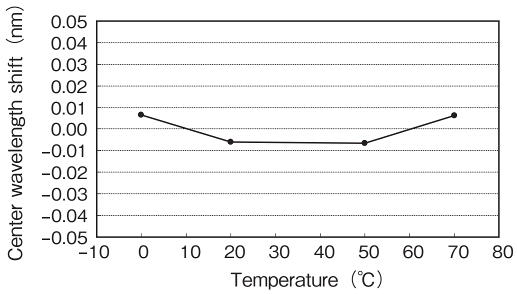

Figure 4 Temperature dependence of center wavelength.

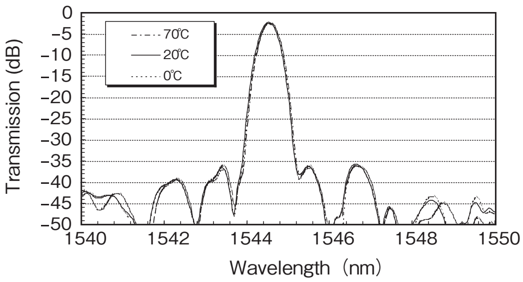

Figure 5 Temperature dependence of transmission spectrum.

Table 1 summarizes typical optical characteristics of the PS701 series athermal AWG module developed here. The insertion loss is 3.5 dB or less for the Gaussian type, 4.5 dB or less for the semi-flat type, and 6.5 dB or less for the flat-top type --excellent results, together with the other optical characteristics. The package measures 130 x 65 x 8.5 mm³, a very compact size. See Photo 1.

3.2 Reliability Tests

Reliability tests in conformity with Telcordia GR-1209 and 1221 were carried out, and the results are shown in Table 2. It can be seen that the changes in the insertion loss and in the center wavelength before and after the tests are 0.3 dB or less maximum and 0.022 nm or less, respectively, achieving a high level of reliability.

4. CONCLUSION

Based on its proprietary structure and principle, Furukawa Electric has launched an athermal AWG module of PS701 series that needs no temperature control and power sup-

Photo 1 Appearance of athermal AWG module, measuring 130 x 65 x 8.5 mm³.

Table 1 Typical optical characteristics of athermal AWG module.

Item \ Type	Gaussian			Semi-flat			Flat			Unit
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Number of channel		40			40			40		Ch
Channel spacing		100			100			100		GHz
ITU-grid frequency	C-band or L-band									…
Pass band	−0.1		0.1	−0.1		0.1	−0.1		0.1	nm
Center wavelength accuracy	−0.05		0.05	−0.05		0.05	−0.05		0.05	nm
1-dB bandwidth	0.2			0.3			0.4			nm
3-dB bandwidth	0.4			0.5			0.6			nm
Insertion loss at ITU-grid		2.0	3.5		4.0	4.5		5.5	6.5	dB
Uniformity of insertion loss			1.0			1.0			1.0	dB
Adjacent crosstalk			−25.0			−25.0			−25.0	dB
Non-adjacent crosstalk			−30.0			−30.0			−30.0	dB
Total crosstalk			−21.0			−21.0			−21.0	dB
Polarization dependent loss			0.5			0.5			0.5	dB
Polarization mode dispersion			0.5			0.5			0.5	ps
Chromatic dispersion	−15.0		15.0	−20.0		20.0	−20.0		20.0	ps/nm
Return loss	45.0			45.0			45.0			dB
Optical input power			24.0			24.0			24.0	dBm
Package size	130×65×8.5									mm

Table 2 Results of reliability tests.

Reliability Test	Condition	n	Result			
			Insertion loss change (dB)		Center wavelength change (nm)	
Vibration	20 G, 20~2000 Hz 4 min/cycles 4 cycles/axis	14	Ave Worst Std	0.00 −0.10 0.031	Ave Worst Std	0.002 −0.015 0.0056
Impact	500 G 5 times/direction 6 directions	14	Ave Worst Std	−0.01 0.11 0.025	Ave Worst Std	0.000 0.011 0.0046
Temperature cycling	−40~85℃ 500 cycles	14	Ave Worst Std	0.00 0.17 0.051	Ave Worst Std	−0.003 0.013 0.0060
Damp heat	85℃・85%RH 2000 hours	15	Ave Worst Std	0.10 0.30 0.087	Ave Worst Std	0.012 0.022 0.0050
Low temperature storage	−40℃ 2000 hours	3	Ave Worst Std	−0.06 −0.11 0.023	Ave Worst Std	−0.011 −0.018 0.0075
Temperature-humidity cycling	−40~85℃ 20~85%RH 42 cycles	3	Ave Worst Std	0.02 0.09 0.018	Ave Worst Std	−0.014 −0.020 0.0057
Cable retention	1.5, 0.45 kgf 60 sec	11	Ave Worst Std	0.00 0.00 0.000	− − −	
Side pull	0.23 kgf 5 sec 90° 2 directions	11	Ave Worst Std	0.00 0.00 0.000	− − −	

ply. In terms of transmission spectrum, the Gaussian, semi-flat and flat-top types are available, provided with excellent optical characteristics and reliability.

Hereafter, we plan to successively launch athermal AWG modules with outdoor specification for WDM-PON applications.

For more information, please contact:

New Business Promotion Unit, Optical Components Section, FITEL Products Department, Telecommunications Company.
TEL: +81-436-42-1676 FAX: +81-436-42-1789