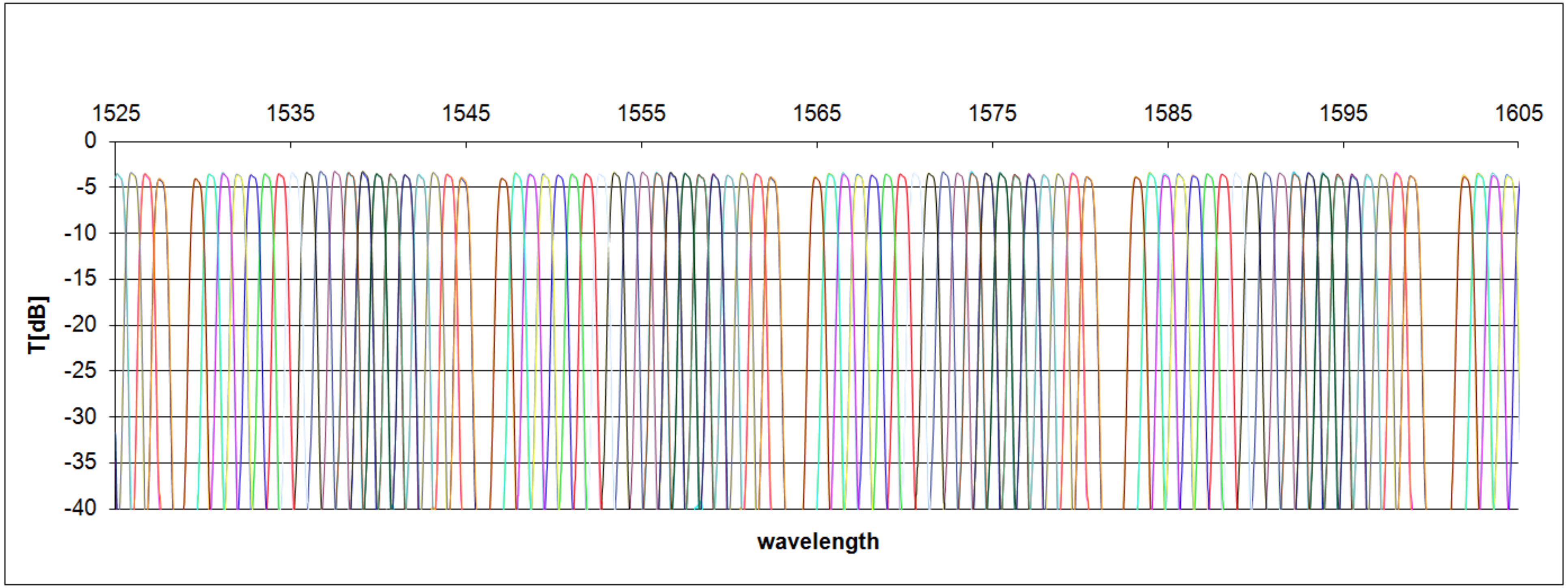
Low loss CAWG design for Super-PON systems

IEEE P802.3cs - July 17, 2019
Henk Bulthuis (Broadex Technologies)

References

- http://www.ieee802.org/3/cs/public/201903/20190312-CAWG_Router_for_Super-PON.pdf
- http://www.ieee802.org/3/cs/public/201903/20190312-CAWG_for_Super-PON.pdf

Super-PON spectral response from conventional technology



- Athermal AWG products operate over -40 to 65 degree C
  - -40 to 85 C is also possible
- 20 skip 2 cyclic configuration
- Tested for 4 bands at 3 temperatures (-40C, 25C, 65C).

BROADEX TECHNOLOGIES UK

Performance parameters from conventional technology

Package results over temperature for 20 channels, typical IL about 5.6dB

	Temperature	23				65				-40			
		C-band 2	C-band 1	L-band 2	L-band 1	C-band 2	C-band 1	L-band 2	L-band 1	C-band 2	C-band 1	L-band 2	L-band 1
Centre Wavelength(3dB, Avg.) Ch:10	Monitor	1538.136	1555.699	1573.665	1592.050	1538.172	1555.735	1573.702	1592.088	1538.161	1555.723	1573.690	1592.075
Bandwidth (1dB, Avg.)	> 0.4	0.486	0.487	0.495	0.498	0.491	0.495	0.500	0.503	0.473	0.477	0.485	0.488
Bandwidth (1dB, Min) GHz	> 30	51.986	48.496	44.695	40.282	60.716	57.220	53.677	47.276	56.727	53.506	49.956	44.477
Insertion loss(191.8THz;100GHz;0.24nm;FIXED)	< 6.8	5.481	5.321	5.211	5.214	5.613	5.379	5.253	5.216	5.441	5.291	5.160	5.166
Insertion Loss Uniformity(191.8THz;100GHz;0.24nm;FIXED)	Monitor	1.654	1.660	1.568	1.518	1.737	1.645	1.513	1.444	1.828	1.753	1.659	1.583
Peak to peak PDL (100GHz)	< 0.5	0.105	0.119	0.140	0.138	0.313	0.224	0.206	0.174	0.144	0.150	0.159	0.178
WDL-ave 0.24nm – dB	< 1	0.330	0.338	0.300	0.314	0.287	0.292	0.257	0.272	0.429	0.385	0.371	0.383
Adjacent Crosstalk(191.8THz;100GHz;0.24nm;FIXED)	> 23	28.730	27.600	26.056	24.882	31.064	30.752	29.810	29.296	29.451	29.571	28.261	27.678
Non-adjacent Crosstalk(191.8THz;100GHz;0.24nm;FIXED)	> 28	35.717	35.585	36.063	36.469	32.804	32.784	33.694	32.652	30.977	30.879	31.679	31.943
Max. Integrated Crosstalk(191.8THz;100GHz;0.24nm;FIXED)	Monitor	25.865	25.310	24.323	23.565	24.888	24.934	25.243	24.900	24.332	24.441	23.972	23.947
Wavelength accuracy	Monitor	5.232	6.483	8.050	9.267	0.620	1.947	3.798	4.557	2.464	3.638	5.081	6.582

Package results over temperature for 16 channels, typical IL about 4.8dB

	Temperature	23				65				-40			
		C-band 2	C-band 1	L-band 2	L-band 1	C-band 2	C-band 1	L-band 2	L-band 1	C-band 2	C-band 1	L-band 2	L-band 1
Insertion loss(191.8THz;100GHz;0.24nm;FIXED)	< 6.8	4.5831964	4.5486178	4.4545222	4.4981372	4.7640774	4.6930326	4.5534375	4.5678024	4.5309162	4.476459	4.43023	4.4897917
Insertion Loss Uniformity(191.8THz;100GHz;0.24nm;FIXED)	Monitor	0.454958	0.5338861	0.4434627	0.4256149	0.4829005	0.5769498	0.4912957	0.4887758	0.4521122	0.5081652	0.428174	0.4339087

BROADEX TECHNOLOGIES UK

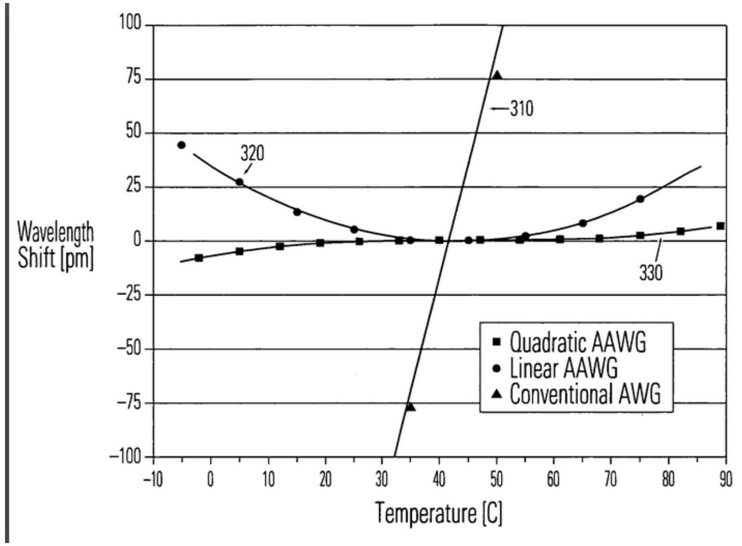
Loss contributions 16/20 channels

Mechanism	Loss 20 ch	Loss 16 ch
Flattening of passband	2.5 dB	2.5 dB
Athermalisation penalty	0.6 dB	0.6 dB
Ultra wide band for wavelength variation	0.5 dB	0.5 dB
Connector and attach loss	0.5 dB	0.5 dB
Insertion loss uniformity due to spectral coverage close to FSR	1.8 dB	1.0 dB
Excess loss	0.5 dB	0.5 dB
Margin for yield and test	0.4 dB	0.4 dB
Total Loss	6.8 dB	6.0 dB

Loss improvement options

Mechanism	Loss contribution	Solution	New loss
Flattening of passband	2.5 dB	MZI-AWG	1.0 dB
Athermalisation penalty	0.6 dB	Improve athermalisation penalty	0.3 dB
Ultra wide band for wavelength variation	0.5 dB	Improve wavelength accuracy	0.3 dB
Connector and attach loss	0.5 dB		0.5 dB
Insertion loss uniformity due to spectral coverage close to FSR	1.0 dB	Improve envelope function	0.5 dB
Excess loss	0.5 dB	Improve technology	0.4 dB
Margin for yield and test	0.4 dB	Volume manufacturing	0.2 dB
Total Loss	6.0 dB		3.2 dB

Improved wavelength accuracy over temperature



Using one polymer type in the slot one can eliminate linear wavelength variation over temperature

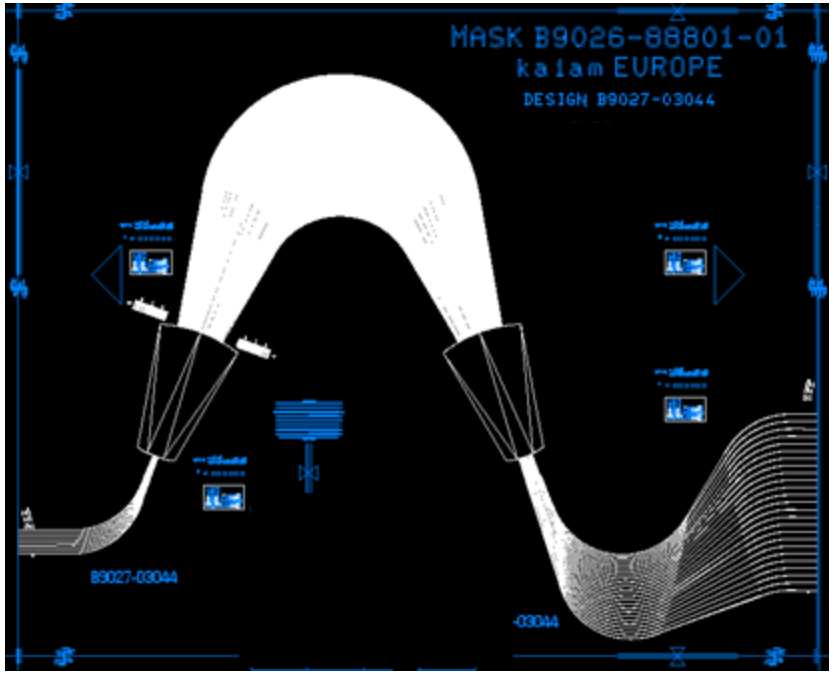
Using two polymer type in the slot one can eliminate the Parabolic wavelength over temperature.

See reference below:

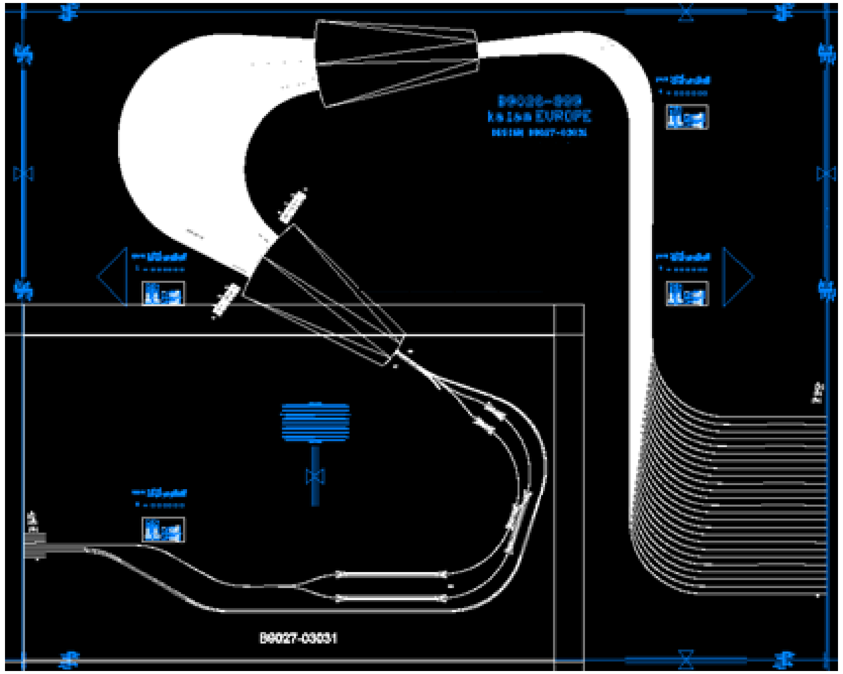
IEEEPHOTONICSTECHNOLOGYLETTERS,VOL.23,NO.11,JUNE1,2011

Reduction of Second-Order Temperature Dependence of Silica-Based Athermal AWG by Using Two Resin-Filled Grooves by Katsuhiko Hirabayashi, Nobutatsu Koshobu, Junya Kobayashi, Mikitaka Itoh, and Shin Kamei

Chip layout MZI-AWG

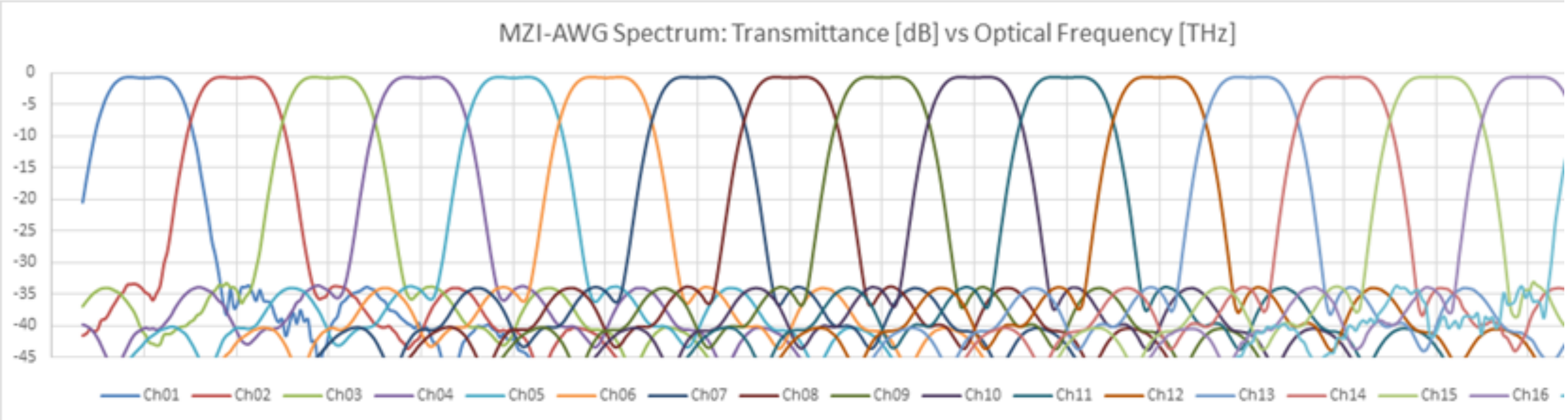


AAWG



MZ-AAWG

MZI-AWG simulated response



Conclusion

- Existing product can achieve IL of 6.0dB for 16 channels
- Same product can achieve IL of 4.7dB for 16 channels when deployed in volume
- An improved design with MZI AWG cascade could achieve IL of 3.2dB for 16 channels
- The outer 4 channels, when extending to 20 channel plan will have worse IL by about 0.8dB extra