simple and cyclical AWG
(Arrayed Wave-guide Grating)

its functional characteristics
and manufacturing approach

by Ilja Kopacek

“simple”
AWG

one center wavelength

“cyclical”
AWG
two or more center wavelengths
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**general AWG design**

- Phase shifting wave-guide (phaser)
- Input/output fan-out/fan-in slabs
- Input/output "grooming" wave-guide
- Axis of symmetry

**input/output wave-guide**

To interface fiber array with divergent/convergent elements...

- Fiber array input (center focused into wave-guide)
- Optimization
- Input "grooming" wave-guide
- Fiber array output
- Output "grooming" wave-guide

... so that the optical power losses are minimized

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fan-out/fan-in slabs

geometry

length and differences in length of $d_1$, $d_2$, $d_3$, and curvature of "surface IN" and "surface OUT" adjust to the shape of a "phaser"

fundamental calculations
and
experimental optimization

our approach

fan-out/fan-in slabs

... and phaser - materials $n(\chi)$

looking for optimum ratios among:

$n_1 : n_2 : n_3$

and a contrasting ratio

$n_3 : n_4$

antireflection coatings minimizes losses due to passage of light through arias of different refraction indexes $n(\chi)$
entrance of light into phazer and index of refraction (zoom in)

\[ n_1 \rightarrow n_2 \rightarrow \text{fan-out slab of refraction index } n_2 \rightarrow \text{antireflection coating} \rightarrow \text{phase shifting arrayed wave-guide } n(\chi) \rightarrow n_4 \rightarrow n_3 \]

**phazer**

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**entrance of light into phazer (zoom out)**

Gausses distribution of the intensity of light

\[ \lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5 \]

only three input (grooming output) channels are shown in the picture

in the case of "input" guide - there is only one optimized common guide

in the case of "output" guide - the number of them depends on number of channels

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function and geometry

OR

adjacent paths
(number of paths is in order of 100)

phase shifting arrayed wave guide "phaser" has
to be made so, that the difference in phase of the
passage of the central wavelength \( \lambda_c \) over
adjacent paths has to be a whole multiple of that
\( \lambda_c \) (so that the electrical field at the entrance of
the phaser is the same as at its end)

with simple AWG this difference is given mainly
by the geometry of the phaser (for other
wavelengths the phase difference is other then
the whole multiple of respective wavelengths)

passage of other than \( \lambda_c \) through the phaser and into the convergent slab

where \( \Delta \) is given mainly by geometry

while electrical field of \( \lambda_c \) will stay unaffected by
the passage through the phaser the fields
of \( \lambda_2 \) (or \( \lambda_4 \)) will be slightly tilted forward
(or backward) since the wave-guide
path will affect \( \lambda_2 \) (or \( \lambda_4 \)) slightly
more (or less) than \( \lambda_c \)

this tilting of the field
will then cause the shift
of focal point (basically the
distance from focal point of \( \lambda_c \) will
determine the selection of \( \lambda_2 \) (or \( \lambda_4 \)))

phase tilted electrical field of \( \lambda_2 \) or \( \lambda_4 \)
AWG and symmetry

from IN to OUT

**IN** to **OUT**

$\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5$

only $\chi_c$ will travel symmetrically as to the axis of symmetry

**IN**

or

**IN**

**OUT**

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cyclical AWG

material, geometry and function

if there are two or more central $\chi_c$ for which optical differences in passages over fiber are equal to the whole multiple of their respective central wavelengths then we get a cyclical AWG

$B_i = \text{base optical paths of central wavelengths}$

depends on differences between $n(\lambda)$ and $n(\lambda)$

$\chi_c$

refraction index $n(\lambda)$

decreases slightly and linearly with increasing $\lambda$ in the area of 1310nm to 1550nm and quite considerably with decreasing density of the material

note on $n(\lambda)$

$\chi_c$ increases by $\Delta$

$\chi_c$ decreases by $\Delta$

$\chi_c$ increases by $\Delta$

$\chi_c$ decreases by $\Delta$

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decreasing temperature from "T" to "t" contracts more longer optical paths of the phaser (strong effect) and slightly increases n(χ) (week effect)

B₁ and B₂ = base optical path of central wavelength χ

B₁ + n(χ+Δ)

B₁ + 2(χ+Δ)

B₁ + (χ+Δ)

B₁ + χ

length of metal stripe at "T" and "t"
target specifications
(athermal packaging from -5 to 70°C)

<table>
<thead>
<tr>
<th>parameter</th>
<th>target</th>
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<tbody>
<tr>
<td>band</td>
<td>C or L band</td>
</tr>
<tr>
<td>number of channels</td>
<td>32 (100GHz)</td>
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<tr>
<td>maximum insertion loss</td>
<td>&lt; 4dB</td>
</tr>
<tr>
<td>insertion loss uniforminty</td>
<td>&lt; 1dB</td>
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<tr>
<td>polarization dependent loss</td>
<td>&lt;0.5dB</td>
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<tr>
<td>adjacent isolation</td>
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<tr>
<td>total isolation</td>
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<tr>
<td>return loss</td>
<td>40dB</td>
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</tbody>
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