UV trimming of arrayed waveguide gratings

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- Objective

- Influence of phase errors

- Measurement of phase distributions

- Compensation of phase errors with UV trimming

- Results

- Conclusion/Prospect
Objective 1

N = 25 ... 250

input waveguide

output waveguides

Focussing slab regions
Objective II

- Used for:
  multiplexer/demultiplexer
  channel equalizer
  channel switching

- important characteristics:
  crosstalk
  chromatic dispersion
  birefringence
  PDL
  PMD
Crosstalk: 27dB
Influence of phase errors I

- Full characterization of a device by the complex transfer function
- Amplitude spectrum is given by the focusing slab regions
- More critical: phase spectrum
- Fast fluctuations responsible for crosstalk
- Slow fluctuations responsible for chromatic dispersion

Influence of phase errors II

Compensation techniques I

- thin film heaters

- α-Si strip loaded waveguides

- phase compensating plates

problems:

permanent power consumption
additional clean room processes
increased insertion losses
Compensation techniques II

- most AWG’s are based on silica on silicon
- refractive index can be increased (or decreased) by UV illumination
  - $\delta \phi = 2 \frac{\pi}{\lambda} \Delta n L$
  - required phase changes: $\sim 0.5$ rad
  - realistic values for $\Delta n$: $5 \times 10^{-4} \ldots 1 \times 10^{-3}$
  - required trimming length: $\sim 250 \, \mu m$
- Why no $\text{H}_2$ loading?
- AWG’s + attached fibers to big for loading chamber
- no $\text{H}_2$-induced shift of central wavelength
- no $\text{H}_2$ outdiffusion to take into account
- Problem: such values for $\Delta n$ also possible without $\text{H}_2$ loading?
Compensation techniques IV

Graph showing the refractive index as a function of micrometers (µm) with data points for UV illuminated, non-UV illuminated, and UV-illuminated conditions. The graph indicates a change in refractive index, denoted as $\Delta n \sim 10^{-3}$. The y-axis represents the refractive index ranging from 1.45 to 1.47, and the x-axis represents the micrometers ranging from 57 to 65.

J. Gehler and K. Lösch, "Dispersion measurement of AWG’s by Fourier-transform spectroscopy", ECOC’99, Nice, P2.30, 1999
Aim

![Graph showing phase distribution.](image-url)

- Phase as fabricated
- Desired phase distribution

Arrayed waveguide number vs. Phase [rad]

0 1 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70
Experimental Setup
Experimental procedure I

Arrayed waveguide number

Phase [rad]

- trimming step 1
- trimming step 2
- trimming step 3

0 1 2 3 4 5 6 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60
Experimental procedure II

Arrayed waveguide number

Phase [rad]

trimming step 1
trimming step 2
trimming step 3

0 1 2 3 4 5 6

0 0,05 0,1 0,15 0,2 0,25 0,3 0,35 0,4 0,45 0,5

0 10 20 30 40 50 60
Results I

Arrayed waveguide number

Phase [rad]

- before UV-trimming
- after UV-trimming
Results II

![Graph showing transmission vs wavelength before and after UV-trimming. The graph compares the transmission in dB as a function of wavelength in nm. The data points are marked with red circles and the trend lines are shown in blue. The wavelengths range from 1542 nm to 1562 nm.](image-url)
Conclusion

- UV trimming using frequency doubled Ar-laser
  Power: 35 mW @ $\lambda=244$ nm, trimming speed: 0.5 $\mu$m/s

- UV-induced index change: $\Delta n =10^{-3}$

- Reduction of crosstalk level by 8 dB to below -35 dB

- residual crosstalk mainly caused by amplitude errors in the waveguide grating

- phase correction up to 5 rad without perceptible additional losses

- chromatic dispersion reduced from -0.7ps/nm to 0.1ps/nm
Prospect

- faster trimming
- main requirement: On-line phase measurement
- computer controlled trimming
- UV-written AWG’s?