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Wavelength-Selective Switch for Space-Division Multiplex Systems

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WESORAM

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Outline

1. Introduction
2. Applications
3. Device setup
4. Summary

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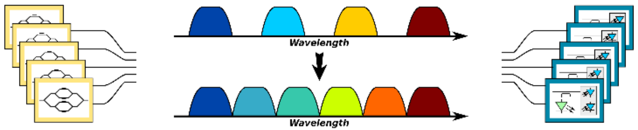
Introduction

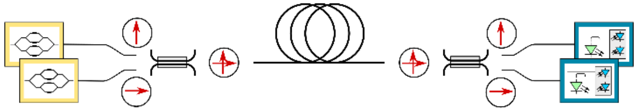
Paths to increased capacity

Increase of spectral efficiency



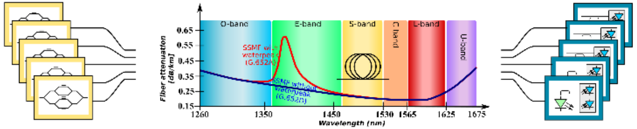
Almost exhausted

Polarization multiplexing



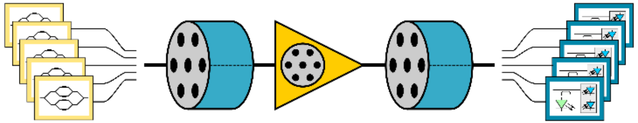
Exhausted

Multiband transmission



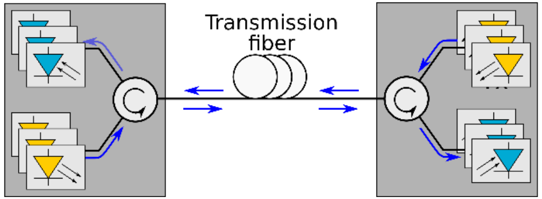
Compatible with existing fiber infrastructure

Space division multiplexing



Requires in most cases new fibers

Single-fiber bidirectional system



Only short distances possible

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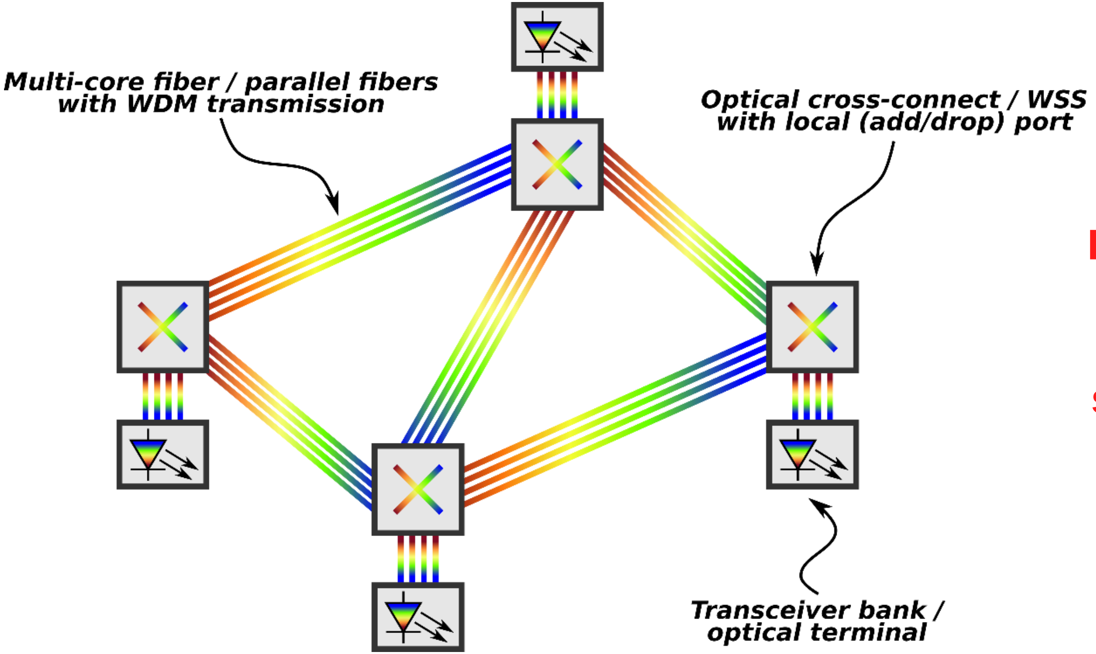
WESORAM – Project overview

Goal: Demonstration of feasibility of a low loss, compact and low cost wavelength selective switch for space division multiplexing applications

Main tasks:

- Optical architecture
- Spatial light modulator (SLM) with driver electronics
- System integration, control software and electronics

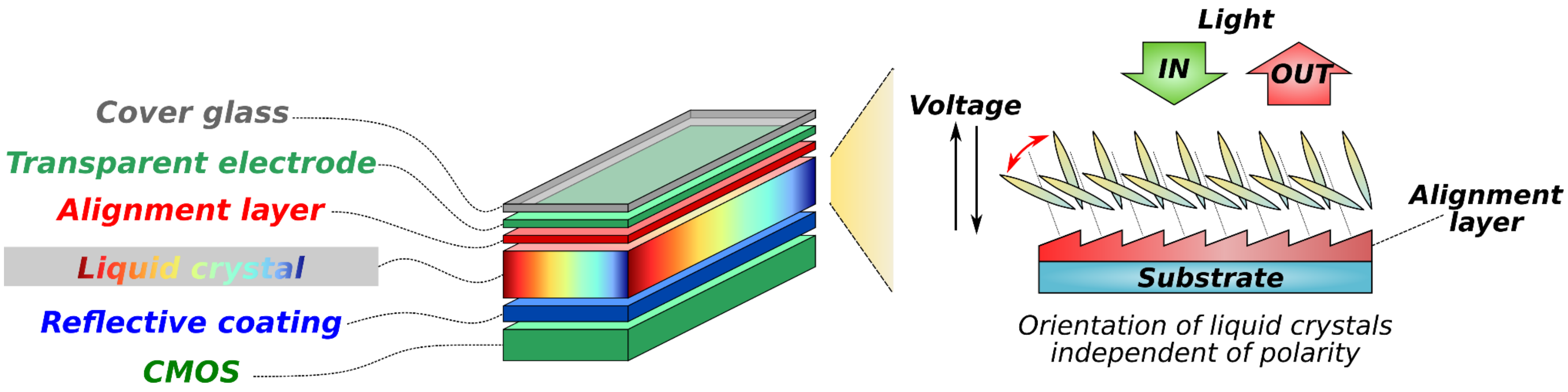
Transparent optical network



Free assignment of wavelength channels and spatial channels to different connections

Transparent routing of wavelength and spatial channels

Liquid crystal on silicon



Control of the phase of light at each pixel produces beam-steering

Large number of pixels allow a near continuous addressing capability

Liquid crystal on silicon (LCoS): Dynamic control of center frequency and bandwidth

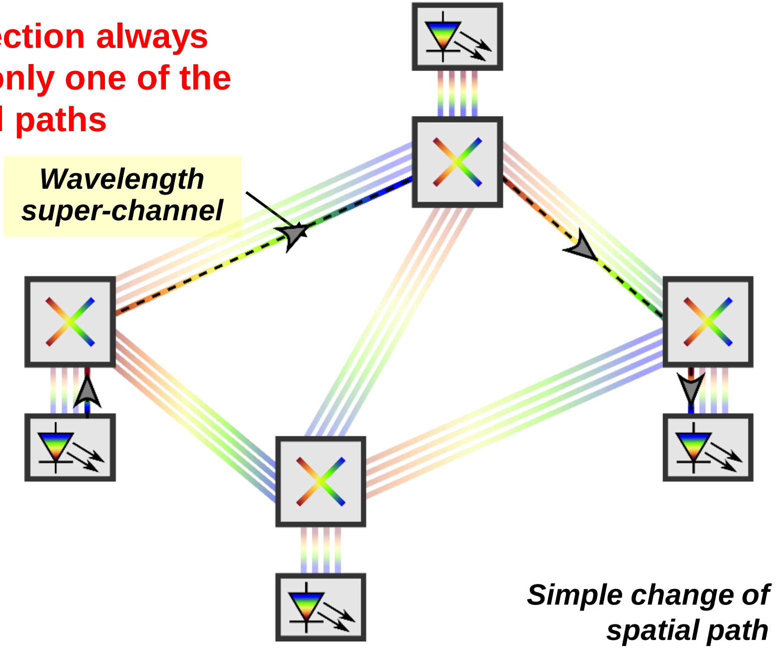
Applications

Simplified connection management

Single spatial path per connection

Connection always uses only one of the spatial paths

Wavelength super-channel

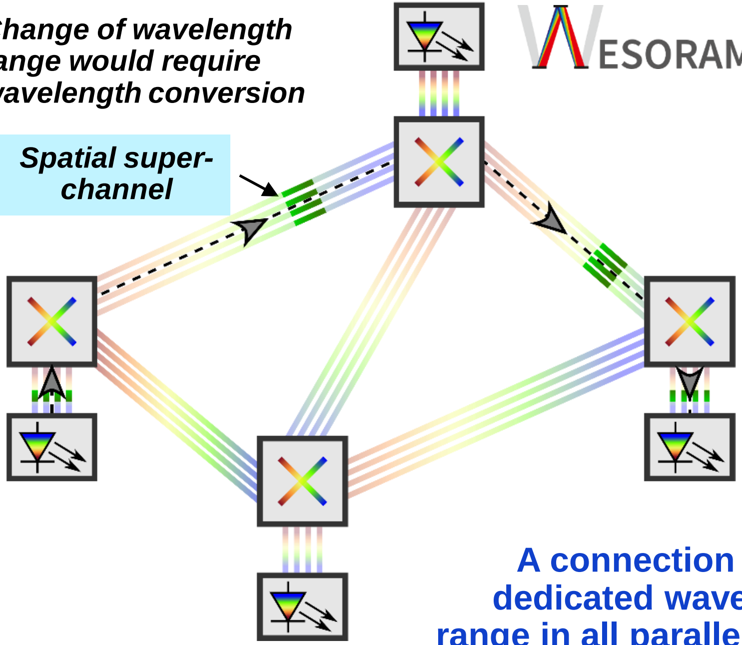


Simple change of spatial path

Single wavelength range per connection

Change of wavelength range would require wavelength conversion

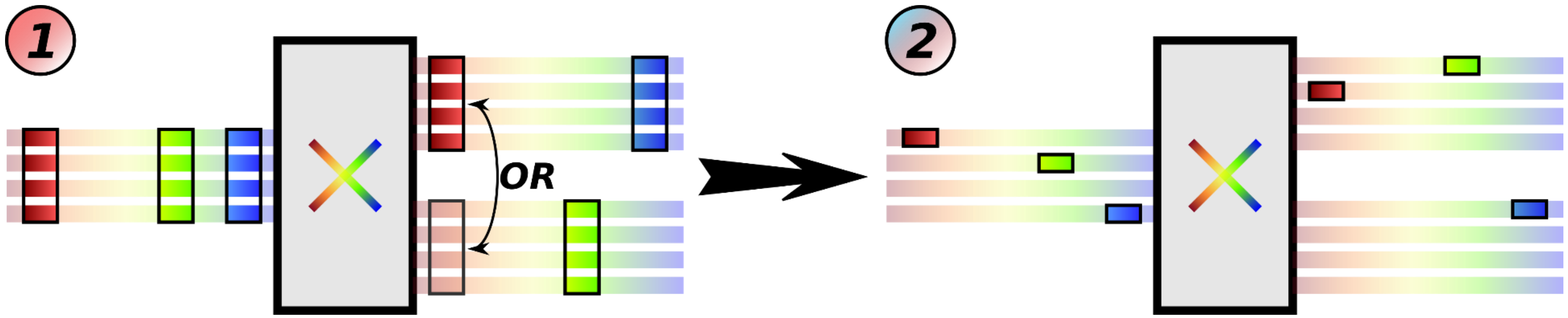
Spatial super-channel



A connection uses a dedicated wavelength range in all parallel paths

Assigning fixed paths or wavelength ranges to a connection

Cross-connection modes



Switching of SDM superchannels:

- Parallel switching of a wavelength from all input fibers to output ports
- No cross-connection between SDM lanes

Switching of individual wavelengths:

- Switching between SDM lanes and ports

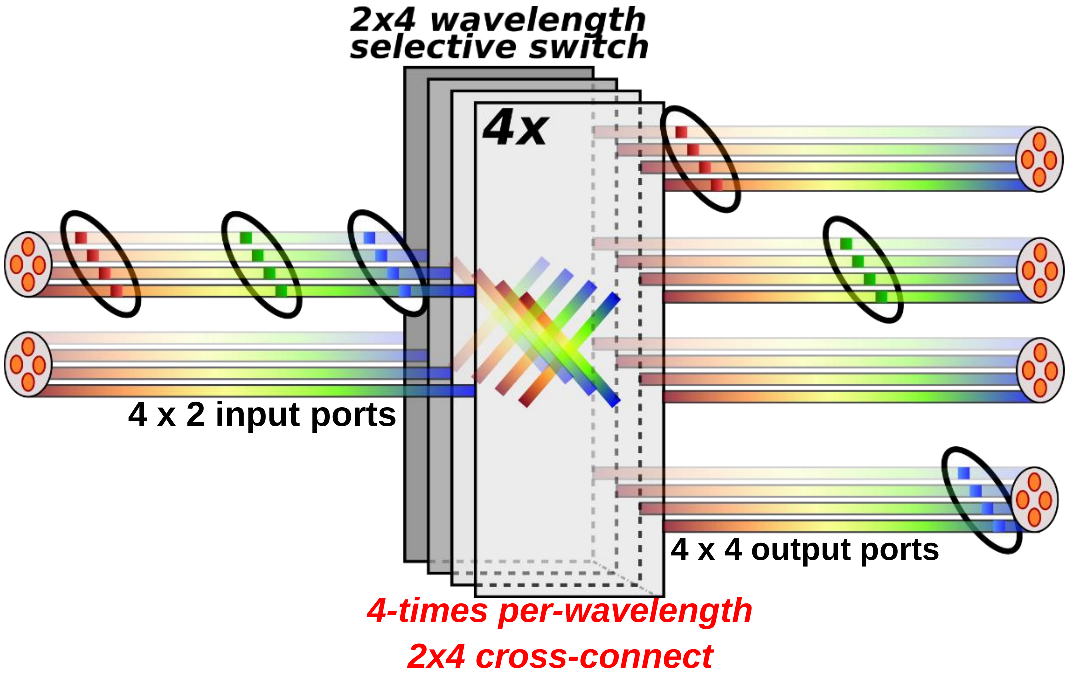
Device setup

Wavelength selective switch – first setup

Simplified first step:

Common routing of all 4 cores (lanes) of an SDM fiber

4 parallel planes of **2x4 wavelength selective switches**



Suitable for parallel switching of SDM superchannels

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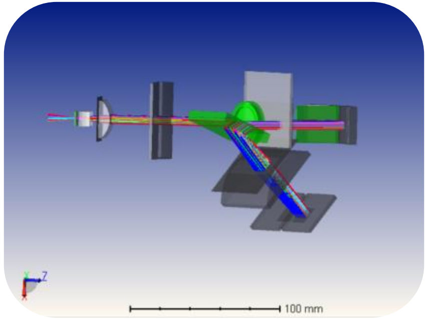
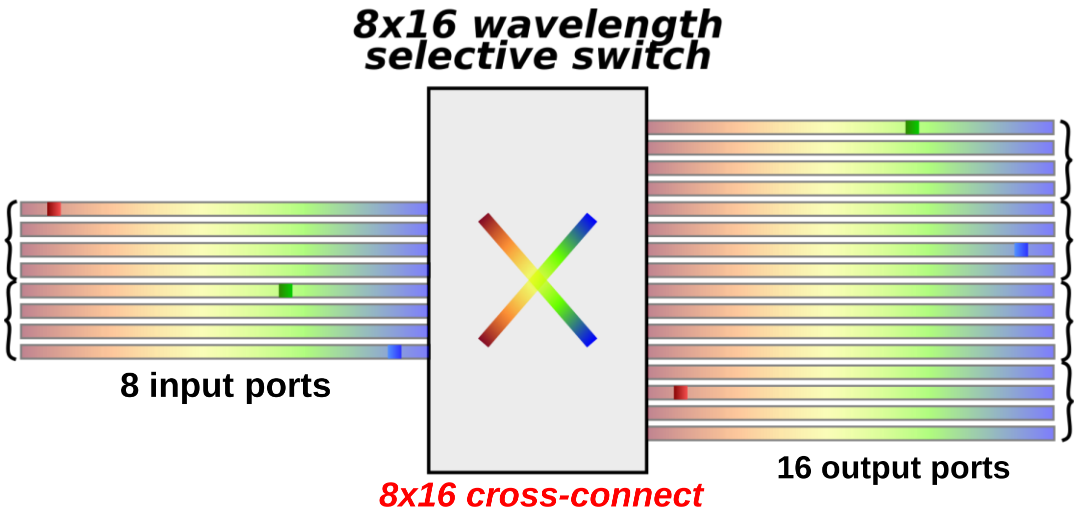
Wavelength selective switch – objective

Final setup:



Full flexibility



- ***full C-band: 1529.5 nm – 1568 nm***
- ***12.5 GHz channel spacing***
- ***polarization diversity***

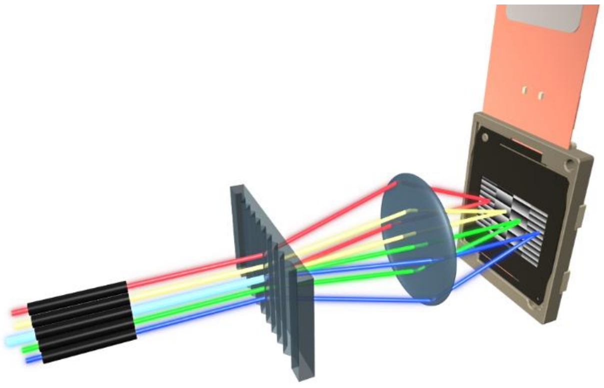
- each wavelength
- from each input fiber

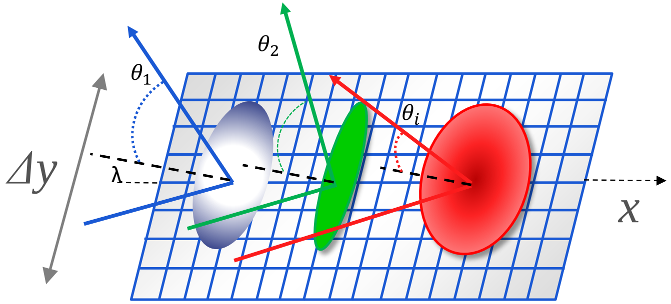
can be routed to

- each output fiber

Suitable for parallel switching of WDM and SDM superchannels

Control of the LCoS





Micro controller

Required connectivity
↓
Reflection angle
↓
Conversion into phase slope over LCoS matrix

Calculate and command the necessary movements

HDMI ↓ i^2C ↑ Status

FPGA

Gray scale of LCoS pixel
↓
Generation of bit seq.
↓
average phase of pixel due to slow reaction

Low-level control of pixels on LCoS matrix

Control split between microcontroller and FPGA

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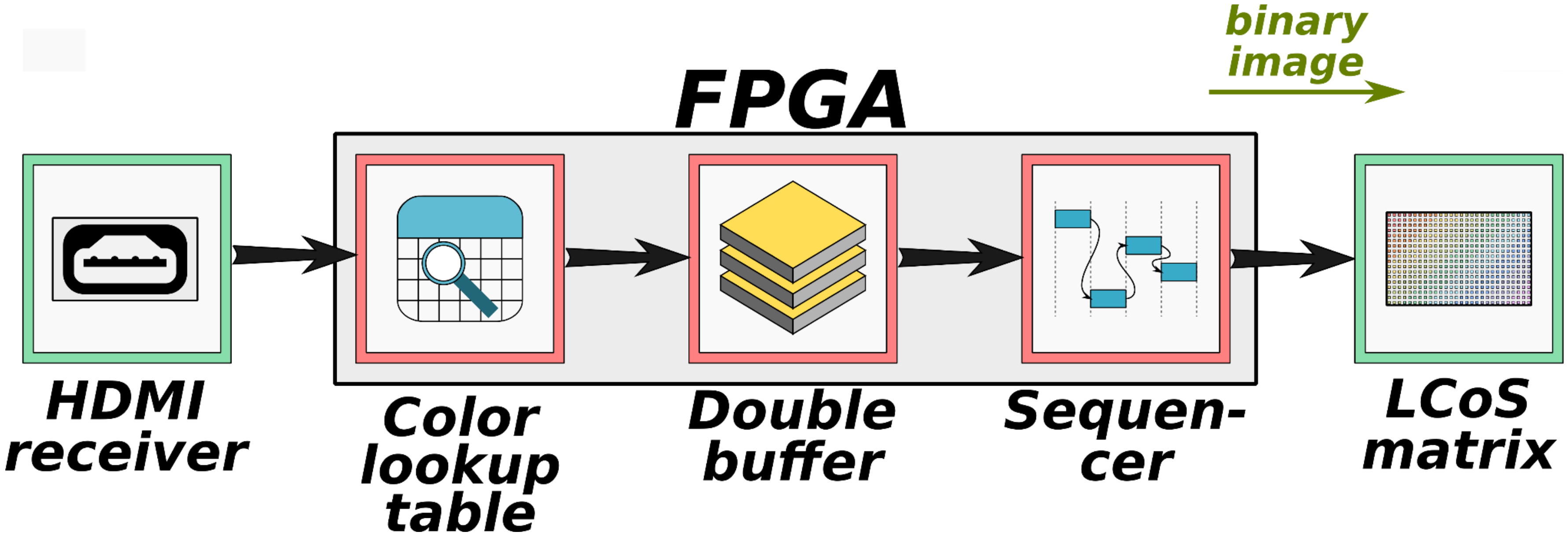
Signal flow in FPGA



FPGA converts HDMI input into drive signals for SLM

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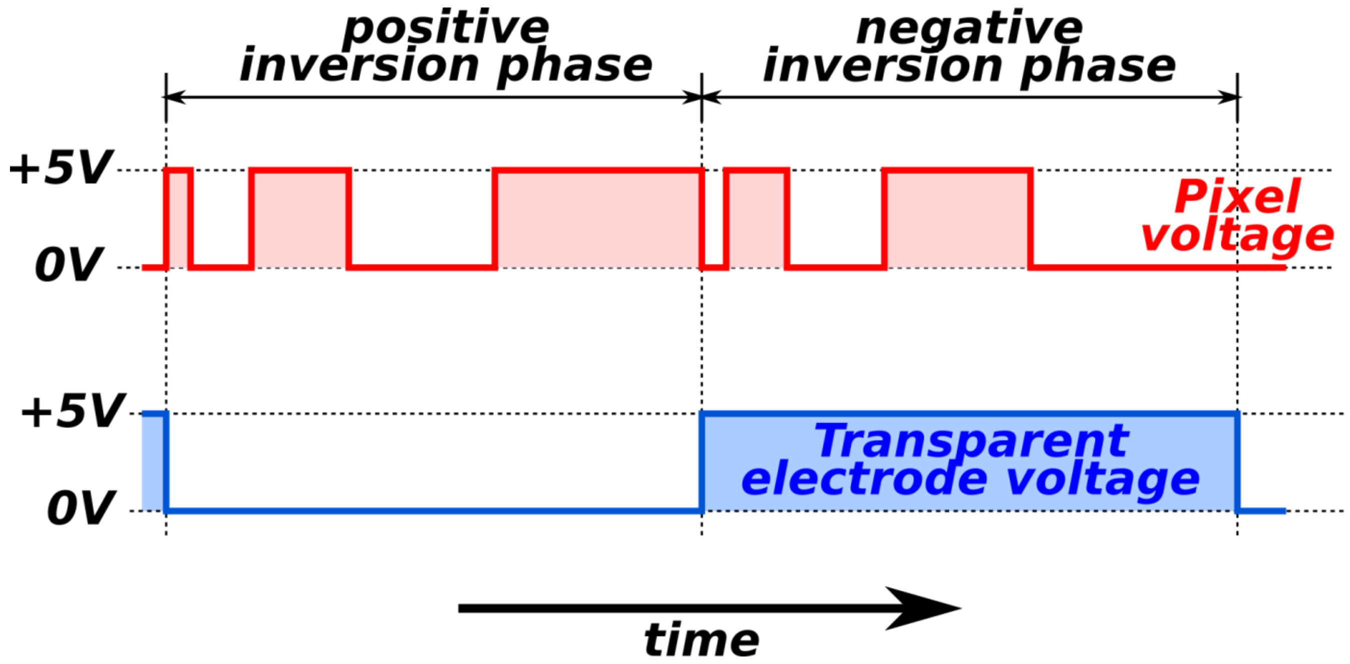
Pulse code modulation



Changing polarity of drive signal gives better chemical stability and avoids drift

Pulse code modulation used to control gray scale value of an LCoS pixel

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SLM demonstrator

Double cell for polarization management

2 times 2048 x 2048 pixels

6.4 µm pixel size

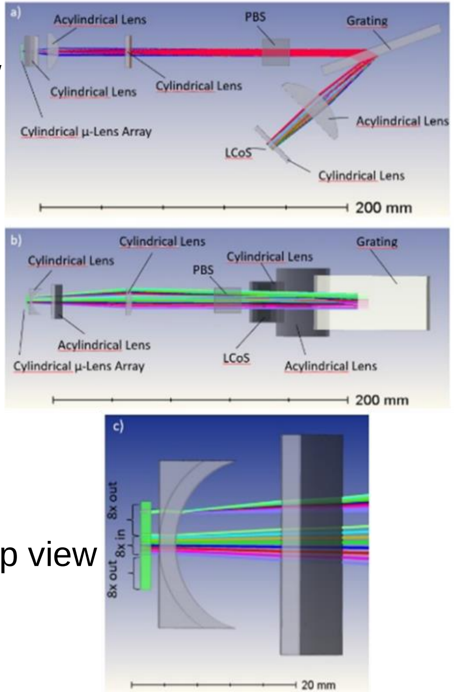
Design of the 8x16 WSS

Design of wavelength-dispersive optical system

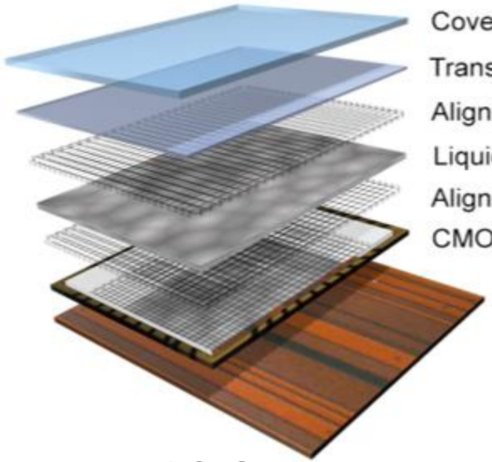
Side view

Top view

Magnified top view



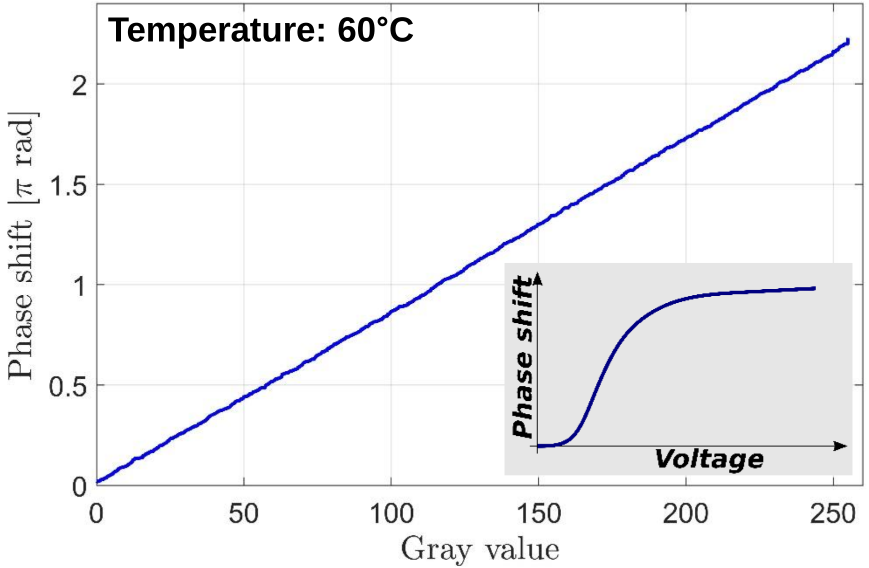
Design of spatial light modulator

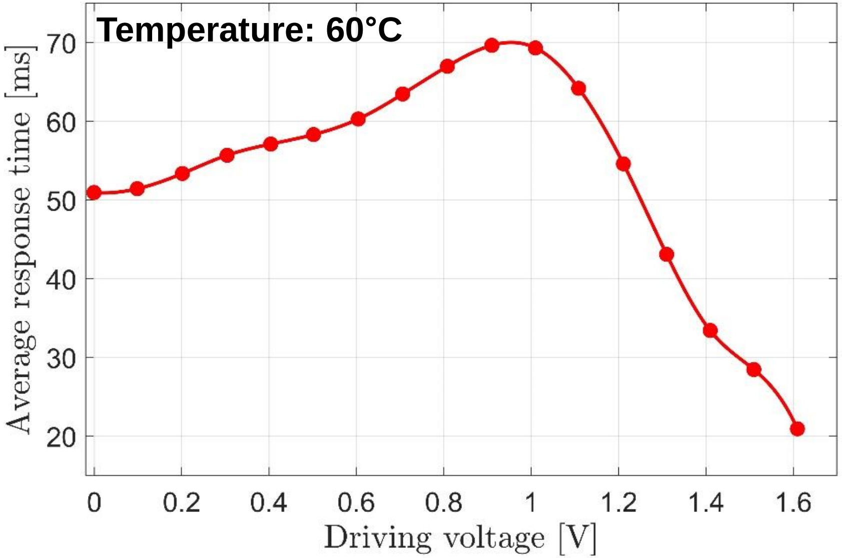


LCoS structure

Current tasks: Design of optical path and spatial light modulator

Performance data





Diffraction efficiency (16-Pixel blazed grating):

- Up to 88% in the 1st order
- Max 1,7% in the 0th order

Summary

Summary

Report on the development of a wavelength-selective switch that enables **switching** of wavelength channels

- from **multiple input ports**
- to **multiple output ports** with the
- option of **changing the spatial channel** (e.g. fiber core)

Module will support the switching of **spatial** and **wavelength super-channels** as well as a combination thereof.

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