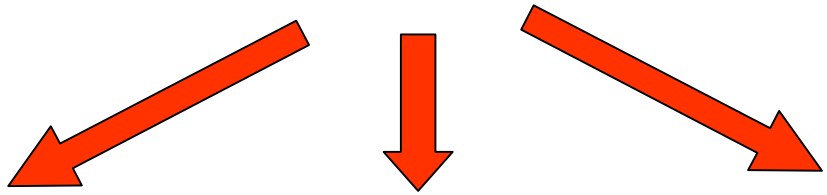
Wavelength Sensitive Photonic Modules for Signal Conditioning

Nabeel A. Riza, Ph.D.

Associate Professor of Optics and Electrical & Computer Engineering

and

Head,
Photonic Information Processing Systems (PIPS) Laboratory
The School of Optics and
Center for Research and Education in Optics and Lasers (CREOL)
University of Central Florida
Orlando, Florida, USA.



All-Optical

e.g., CDMA Optical Pulse, Multiwavelength Pulse

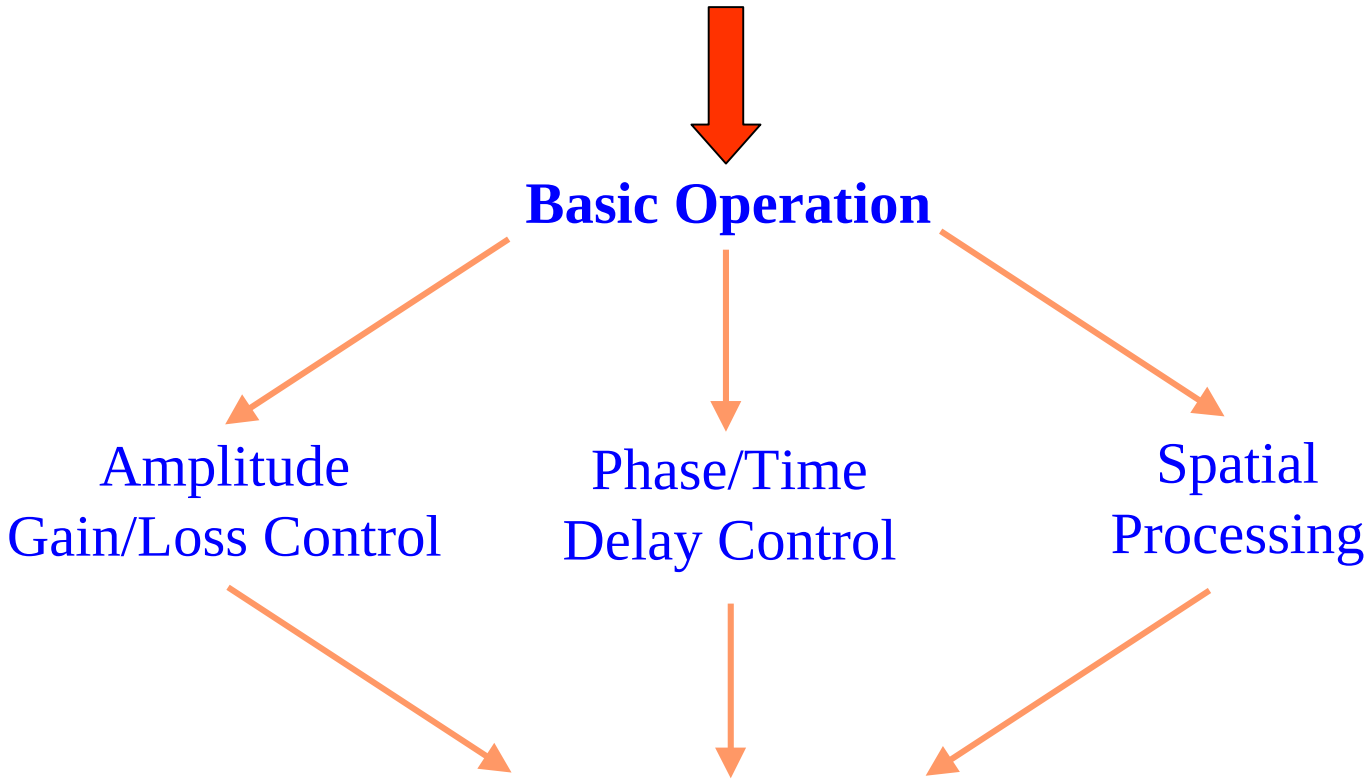
RF-Optical

e.g., Microwave Radar Modulation on Optical Carrier

Digital Electronic-Optical

e.g., Pseudo-random Electronic Binary Code on Optical Carrier

Signal Conditioning



Advantages of Wavelength Sensitive Photonic Modules

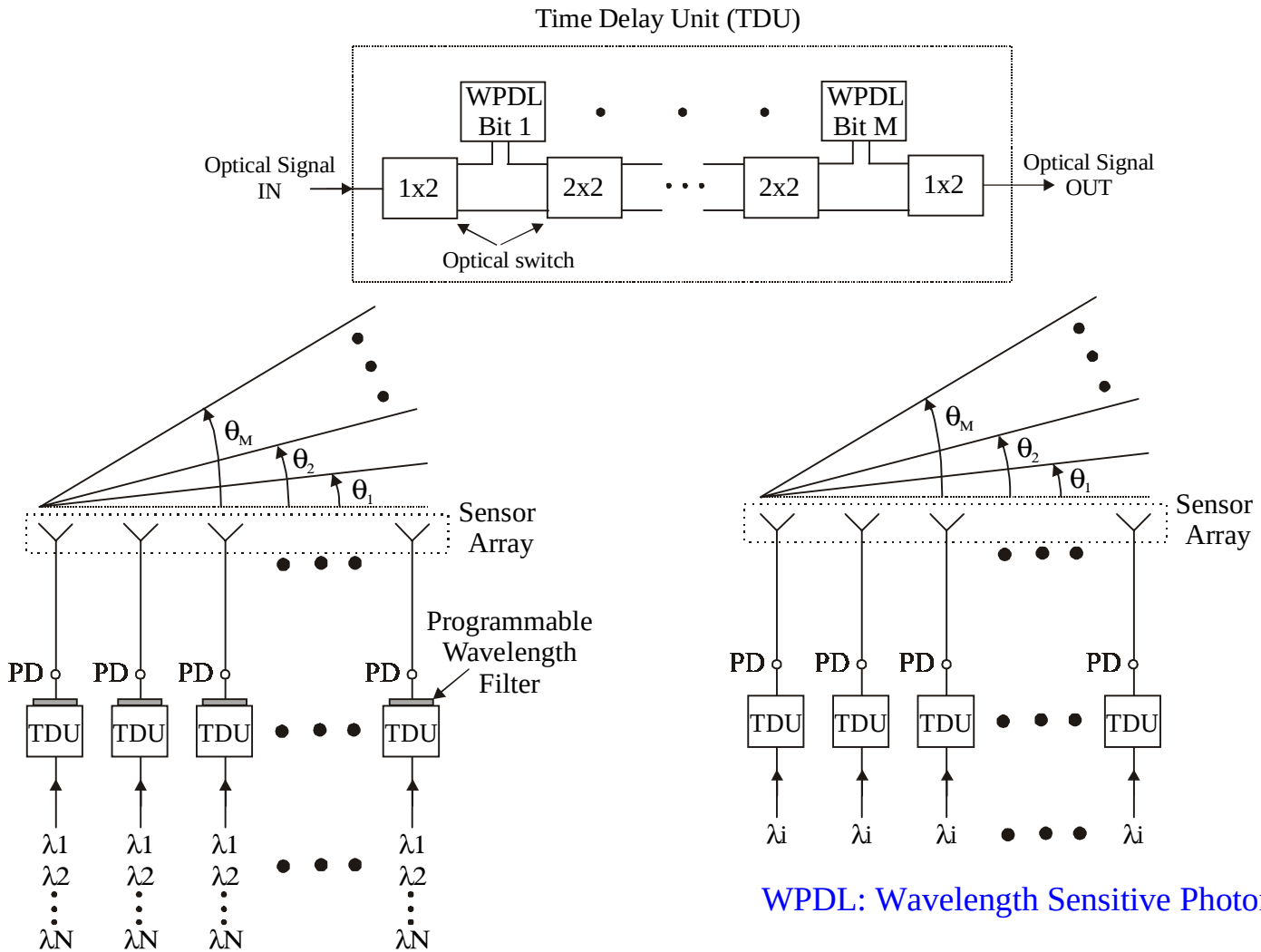
- Reduction in Hardware Complexity
- Enhancement in Signal Conditioning/Processing Power
- Multi-function Distributed Network Capacity
- Flexible Secure Communications

Applications of Our Wavelength Sensitive Photonic Modules

Wavelength Sensitive Photonic Modules

Phased Array Radars	Secure Communications	Parallel Computing
• **Beamformers**	• **Pulse Shapers**	• **Parallel Processors**
• **Transversal Filters**	• **Space-Time CDMA**	• **A/D Converters**

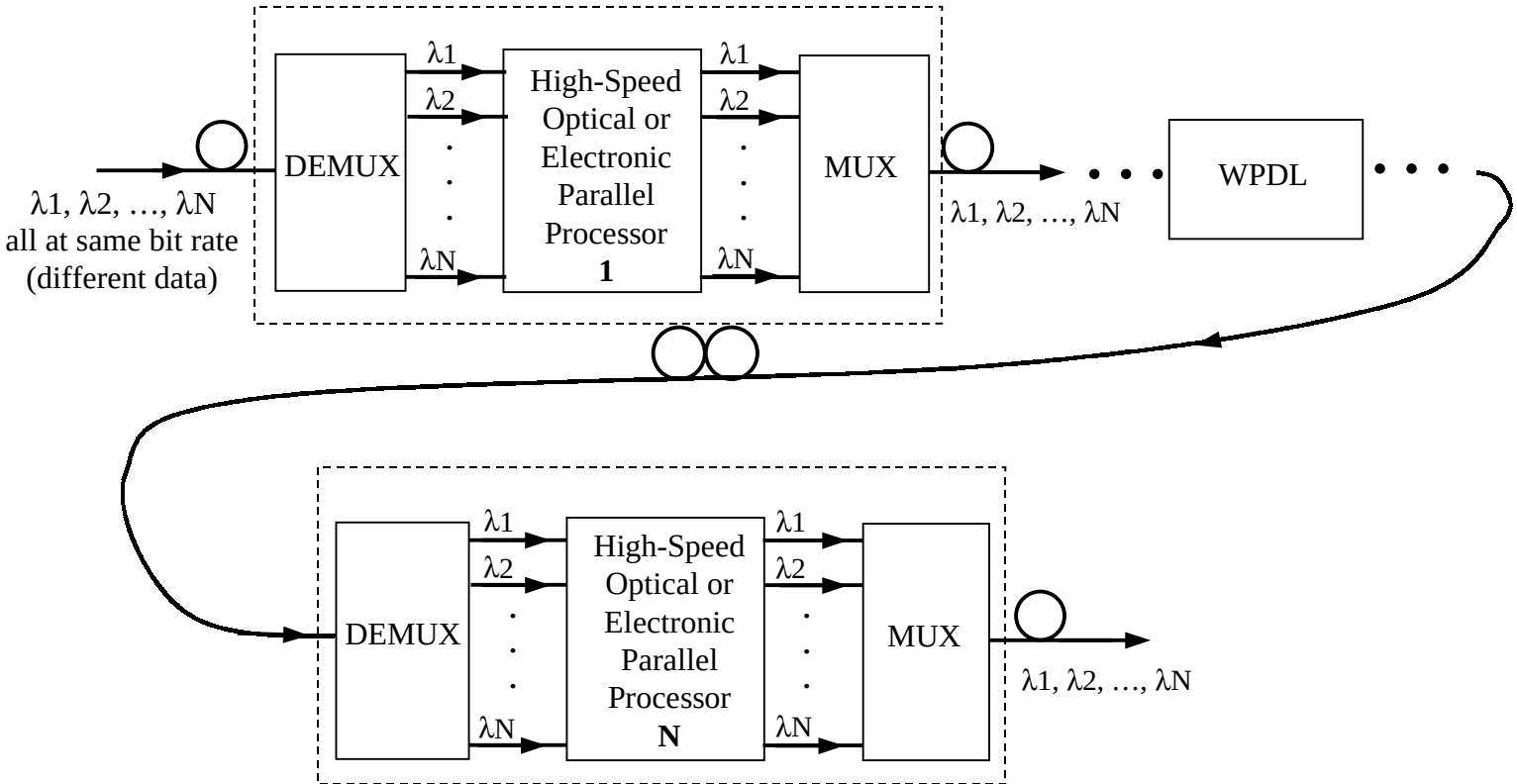
Photonic Beamforming for Phased Array Control



WPDL: Wavelength Sensitive Photonic Delay Line

N. A. Riza and N. Madamopoulos, "Phased-array antenna, maximum-compression, reversible photonic beam former with ternary designs and multiple wavelengths," *Applied Optics*, V. 36, No. 5, pp. 983-996, Feb. 1997.

Timing Jitter Controls in High Speed Optical Interconnections and A-D Convertors



Fiber optically Interconnected Parallel Processor (FIPP)

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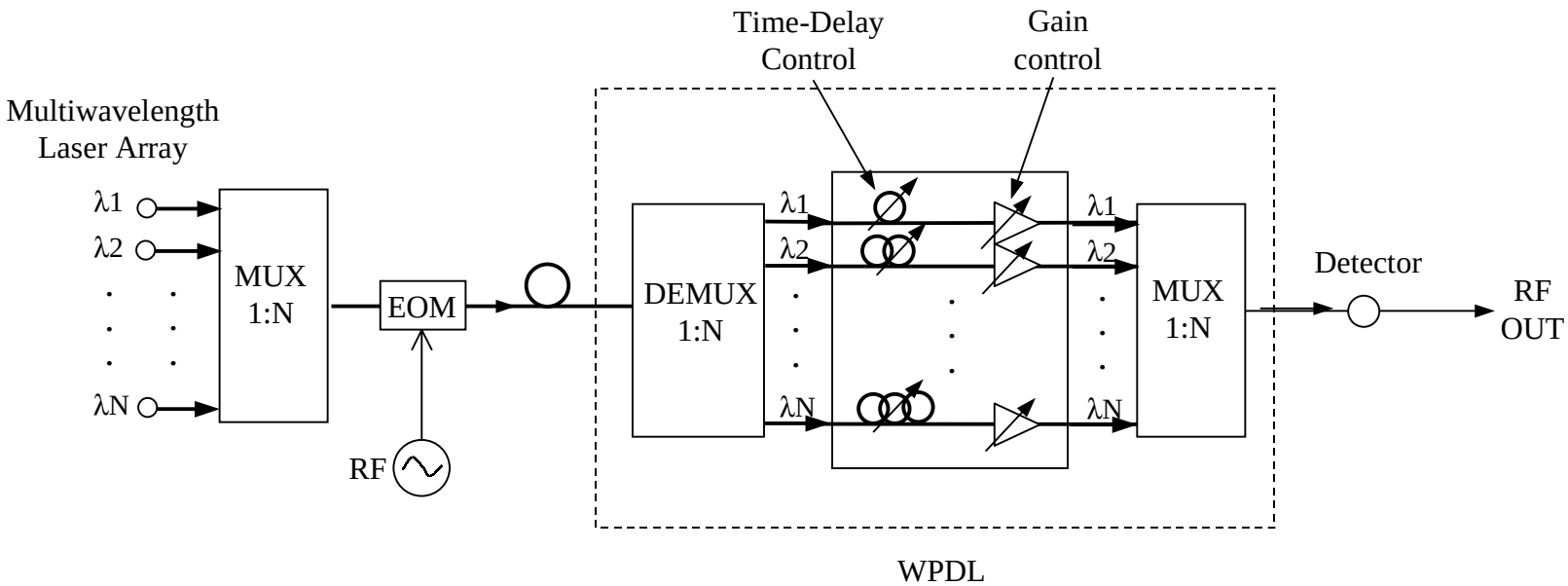
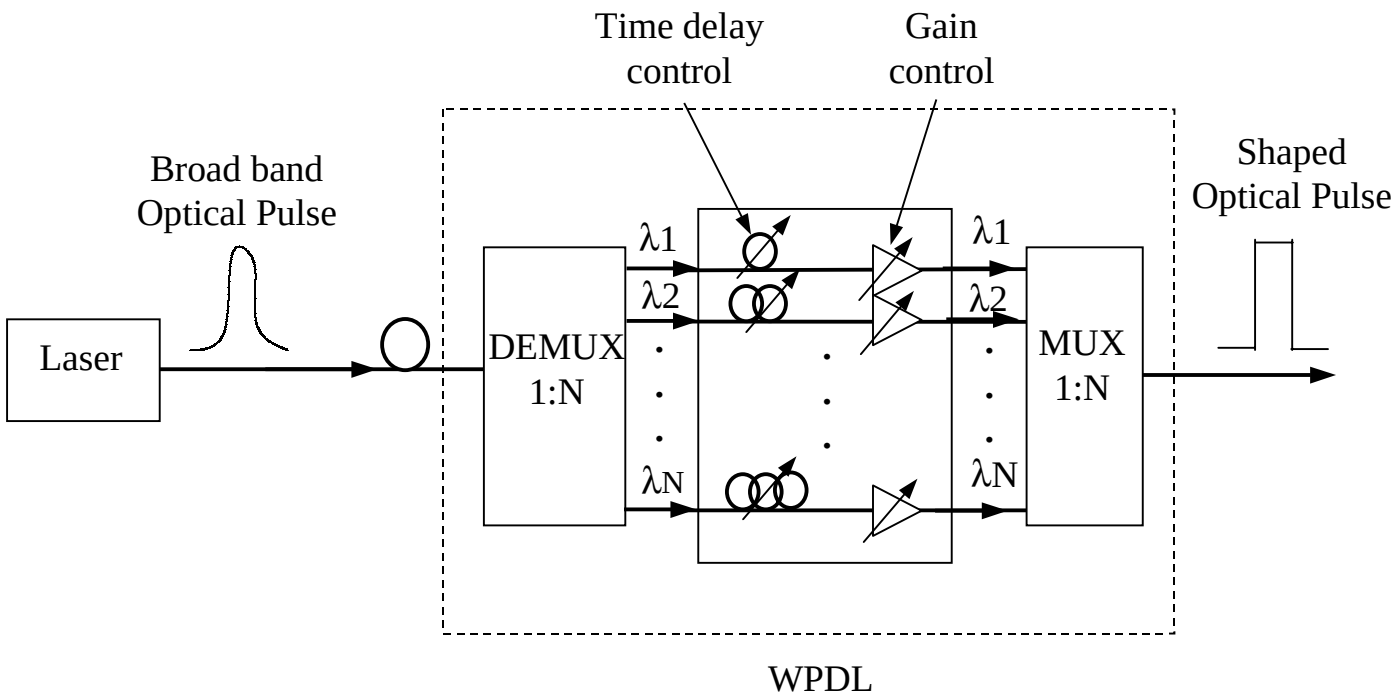
N. A. Riza and S. Sumriddetchkajorn, "Micromechanics-based wavelength sensitive photonic beam control architectures and applications," *Applied Optics*, V. 39, No. 6, pp. 919-932, Feb. 2000.

Basic Block Diagram of a RF Transversal Filter Architecture



N. A. Riza and S. Sumriddetchkajorn, "Micromechanics-based wavelength sensitive photonic beam control architectures and applications," *Applied Optics*, V. 39, No. 6, pp. 919-932, Feb. 2000.

Dispersion Compensation and Equalization in Ultrafast WDM Links



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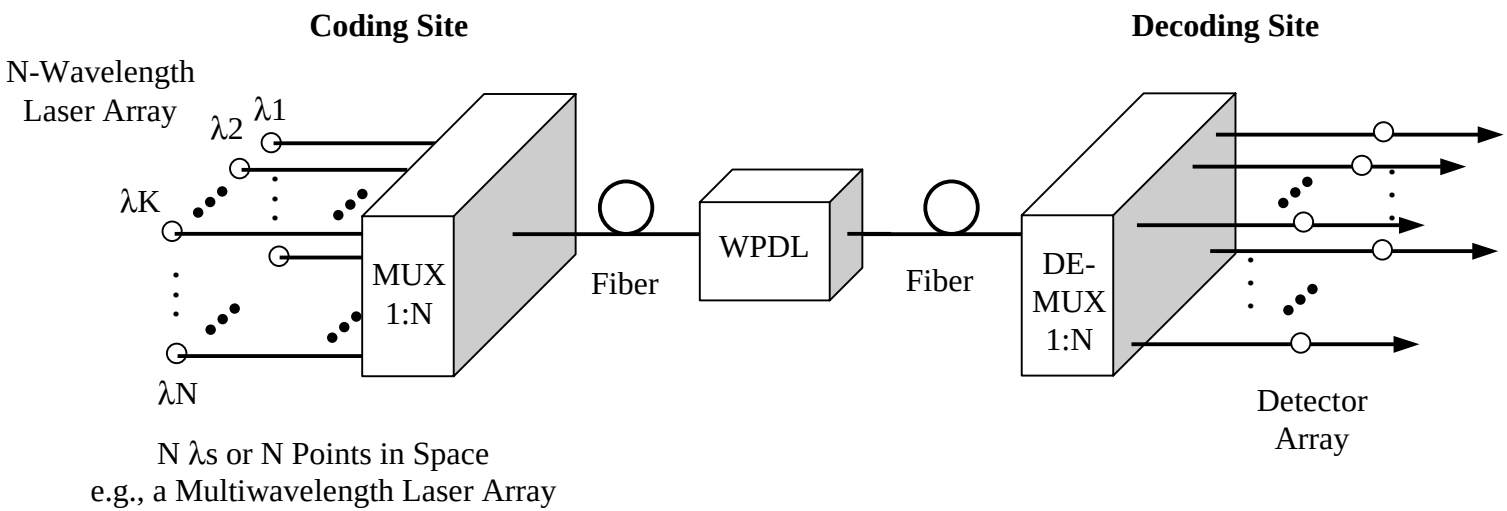
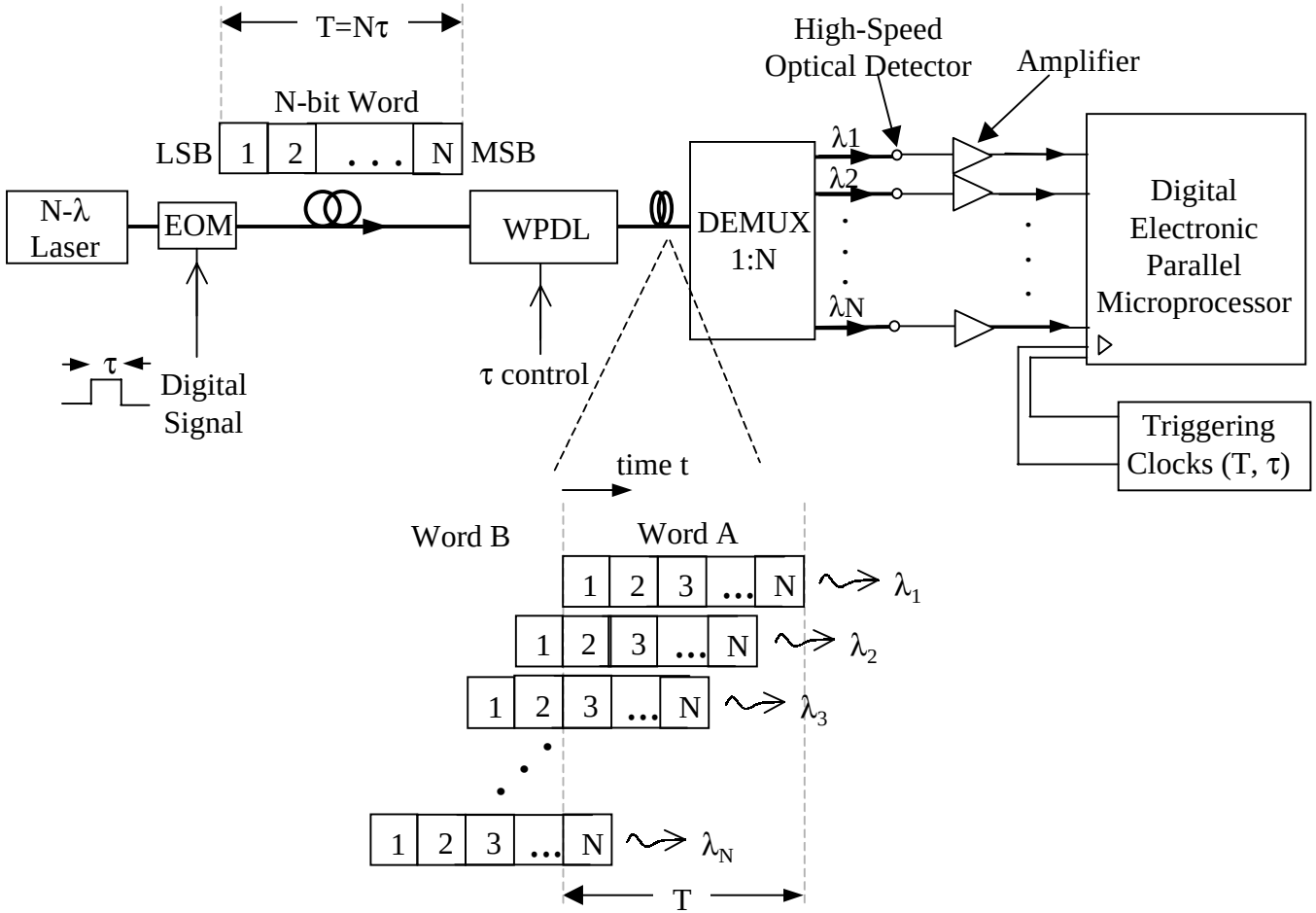
Space-Time WDM Optical CDMA Link Structure



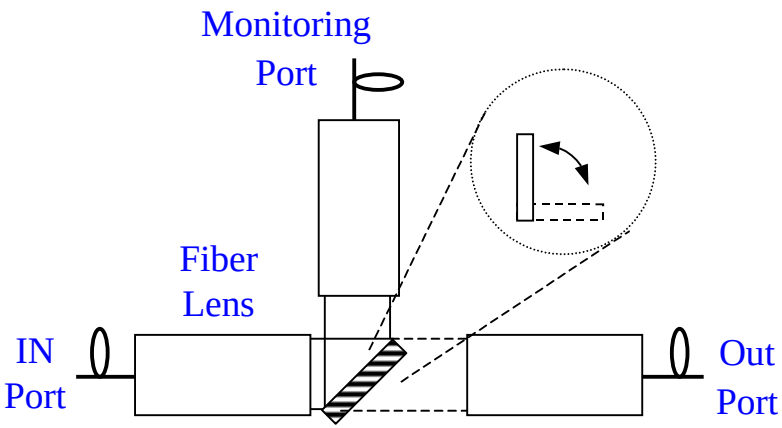
N. A. Riza and S. Sumriddetchkajorn, "Micromechanics-based wavelength sensitive photonic beam control architectures and applications," *Applied Optics*, V. 39, No. 6, pp. 919-932, Feb. 2000.

Basic Block Diagram of the Photonic Bit Serial-to-Parallel Word Converter

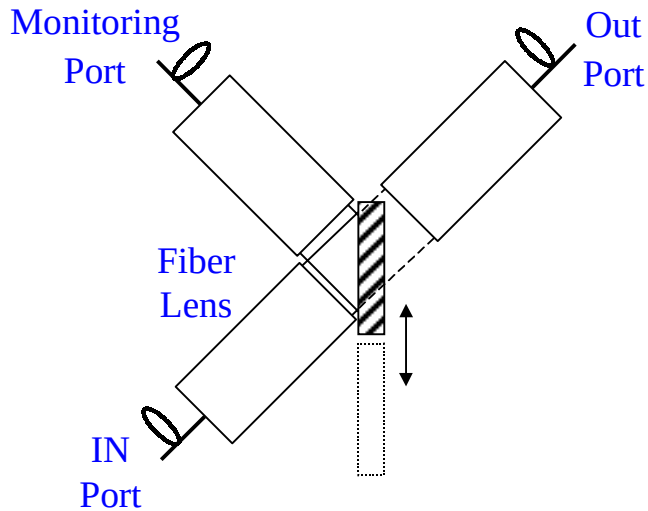


N. A. Riza and S. Sumriddetchkajorn, "Micromechanics-based wavelength sensitive photonic beam control architectures and applications," *Applied Optics*, V. 39, No. 6, pp. 919-932, Feb. 2000.

Non-Robust Approaches to make a Variable Fiber-Optic Attenuator



Big Rotating Mirror



Big Translational Mirror

Large micromirror sizes ➡ Slow Response Speed

Solution for Faster Speed ➡ Use One Small Micromirror ➡ Problems

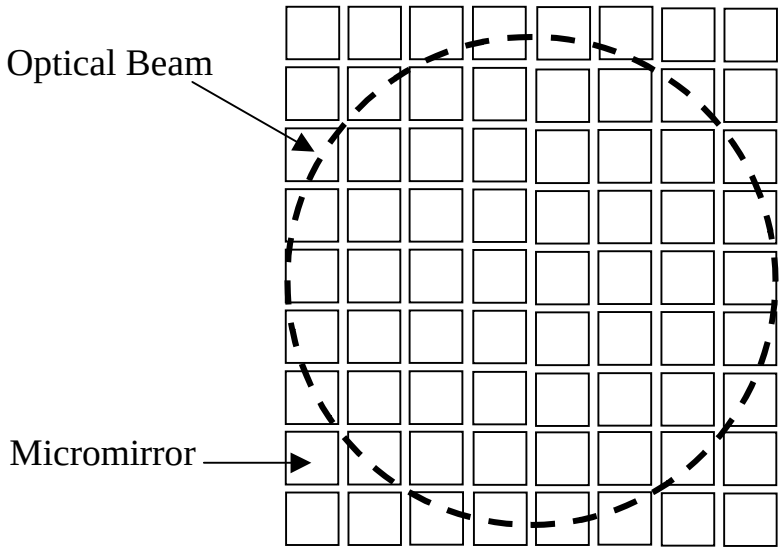
- Alignment Sensitivity
- Catastrophic Failure

Design Dilemma

Alignment Sensitivity vs Speed

One Mirror  Catastrophic Attenuator Malfunction

Solution

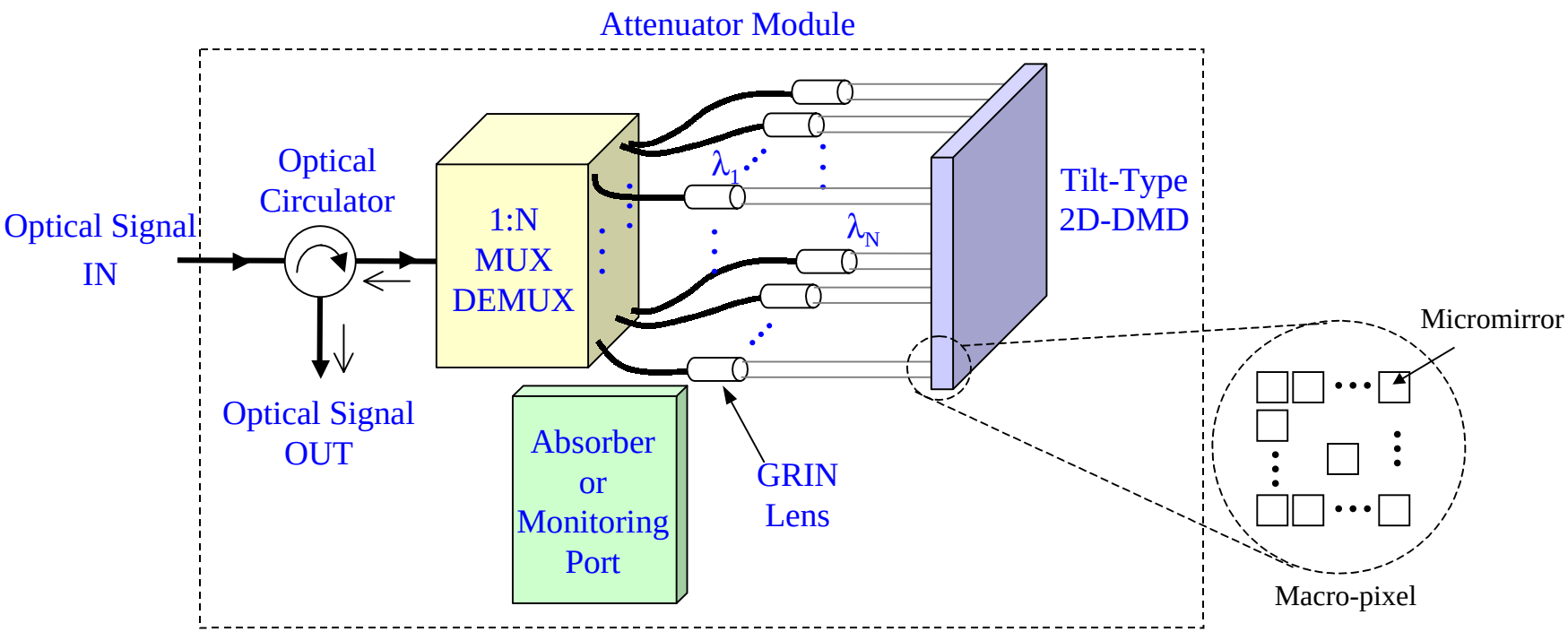


Use a Macro-pixel

Fault Tolerance and High Speed

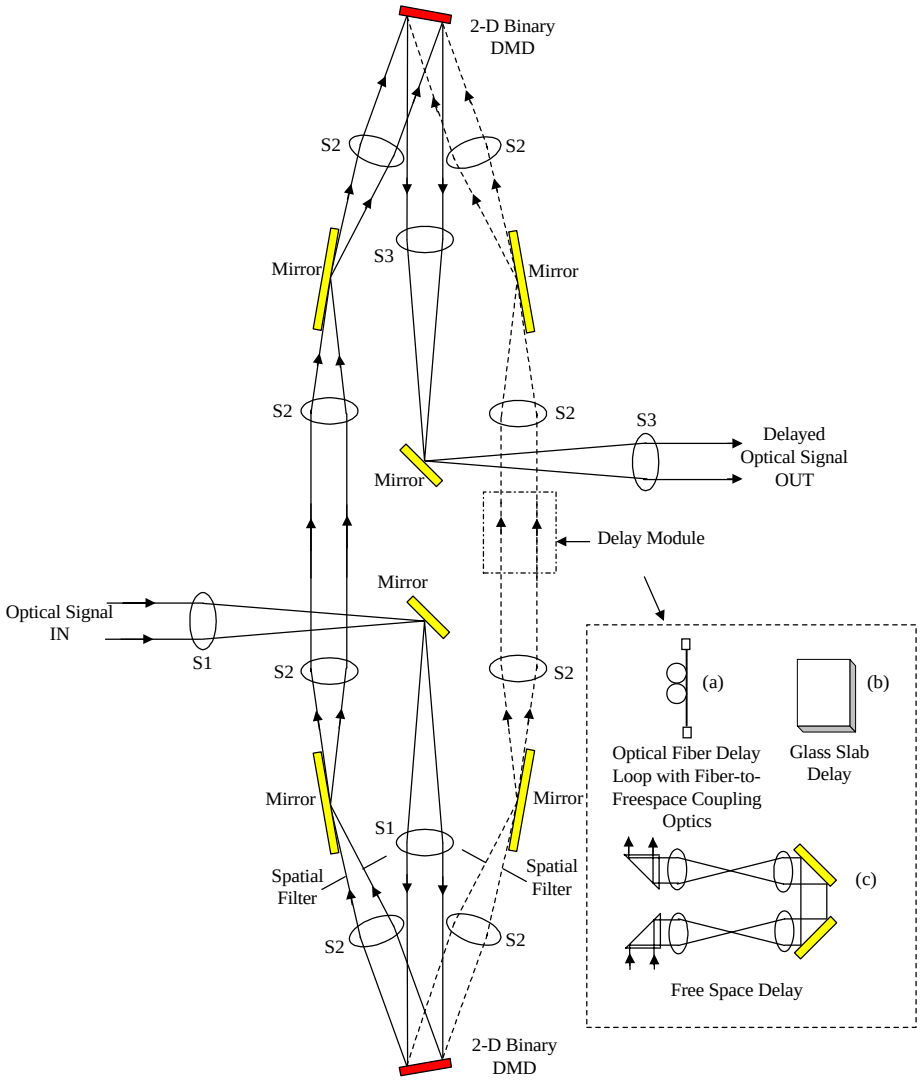
Ref: N. A. Riza and S. Sumriddetchkajorn, "Fault tolerant dense multiwavelength add-drop filter with a two dimensional digital micromirror device," *Applied Optics*, Vol. 37, No. 27, pp. 6355-6361, September, 1998.

Retro-Reflective Multi-Wavelength Programmable Fiber-Optic Attenuator using Small Tilt Digital Micromirror



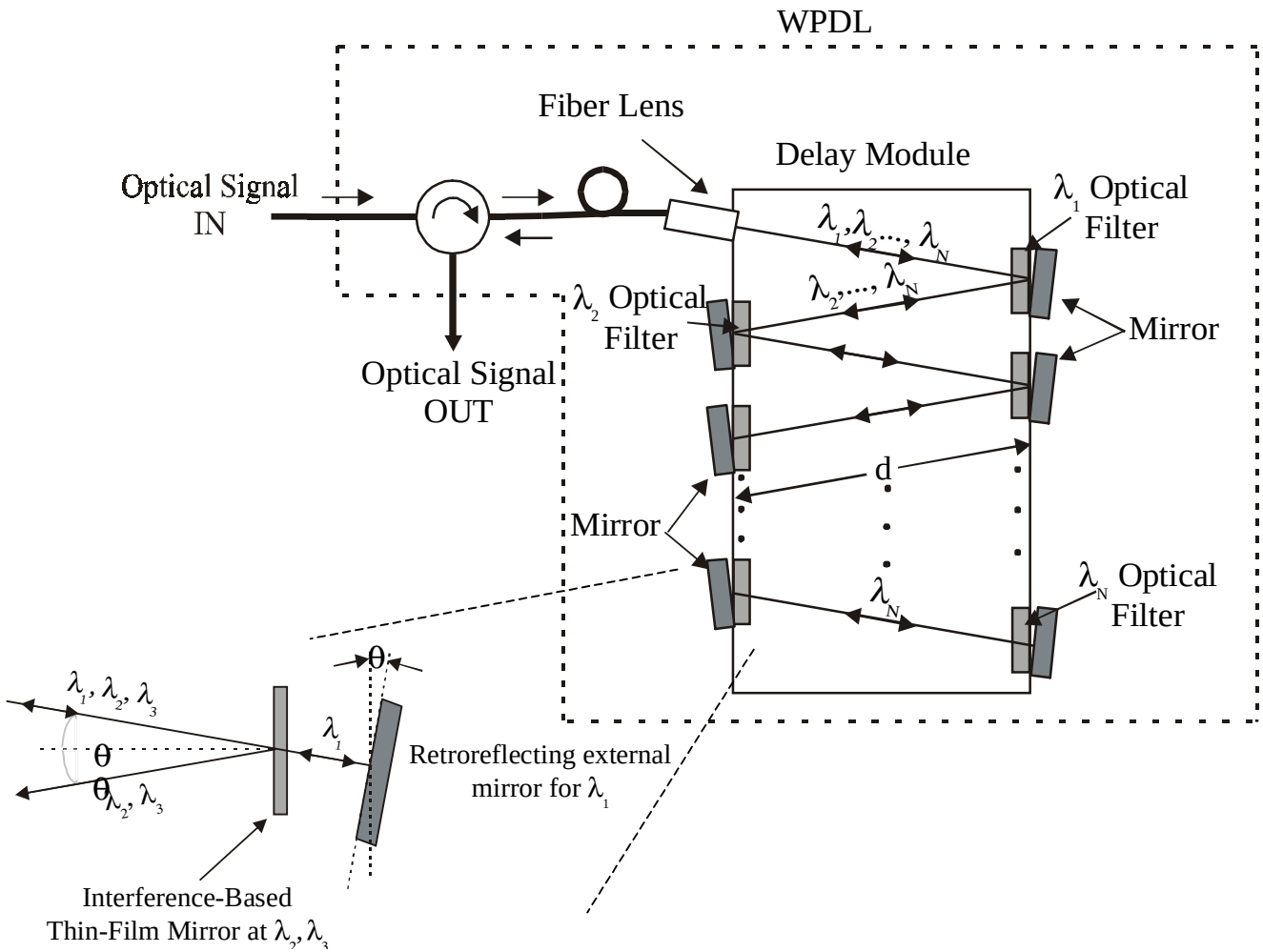
N. A. Riza and S. Sumriddetchkajorn, "Digitally controlled fault-tolerant multiwavelength programmable fiber-optic attenuator using a two dimensional digital micromirror device," *Optics Letters*, Vol. 24, No. 5, pp. 282-284, March 1, 1999.

Variable Photonic Delay Line using Small Tilt Digital Micromirror



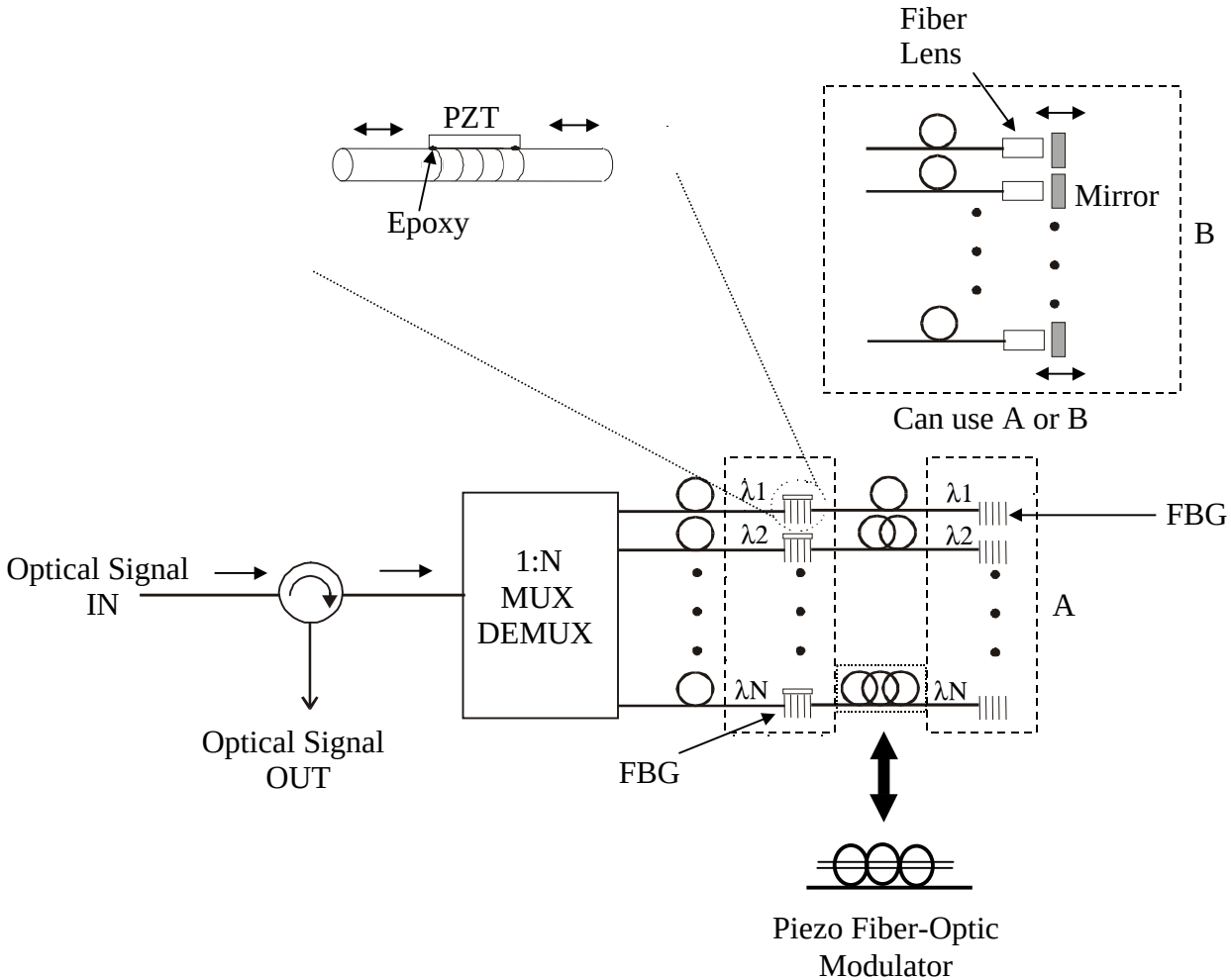
N. A. Riza and S. Sumriddetchkajorn, "Fault tolerant polarization-insensitive photonic delay line architectures using two dimensional digital micromirror devices," *Optics Communications*, Vol. 160, pp. 311-320, 15 Feb. 1999.

Our Proposed Basic Wavelength Sensitive Photonic Delay Line (WPDL) Architecture



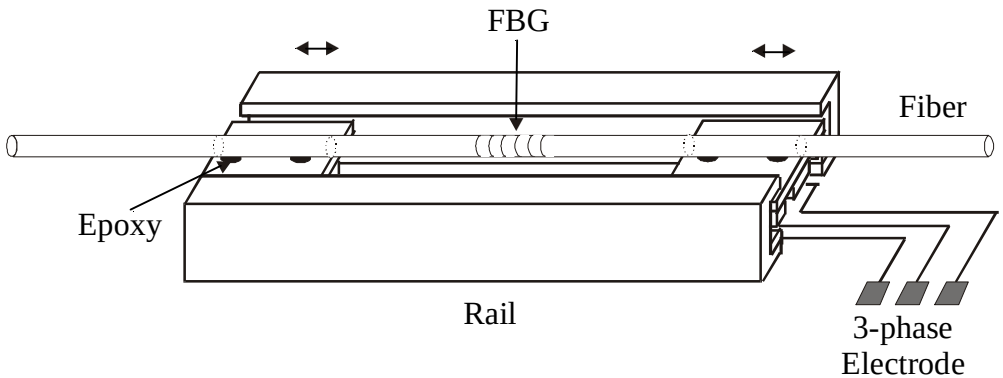
N. A. Riza and S. Sumriddetchkajorn, "Micromechanics-based wavelength sensitive photonic beam control architectures and applications," *Applied Optics*, V. 39, No. 6, pp. 919-932, Feb. 2000.

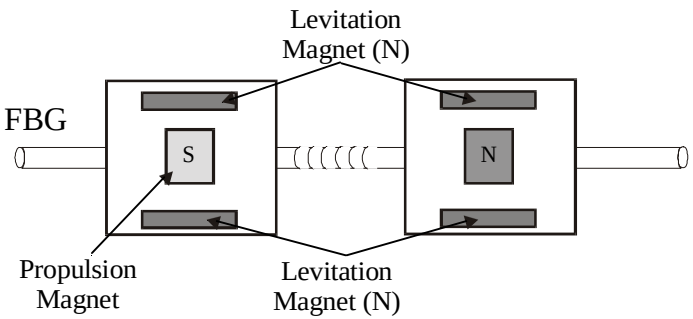
Proposed Tunable WPDL Architecture using FBG-based Serial-Parallel Approach



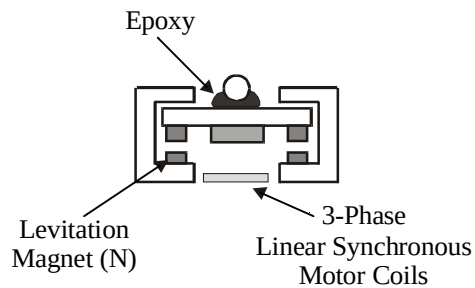
N. A. Riza and S. Sumriddetchkajorn, "Micromechanics-based wavelength sensitive photonic beam control architectures and applications," *Applied Optics*, V. 39, No. 6, pp. 919-932, Feb. 2000.

MEMS-based Fiber Bragg Grating Compressor using Magnetic Levitation (MAGLAV) and Propulsion Method





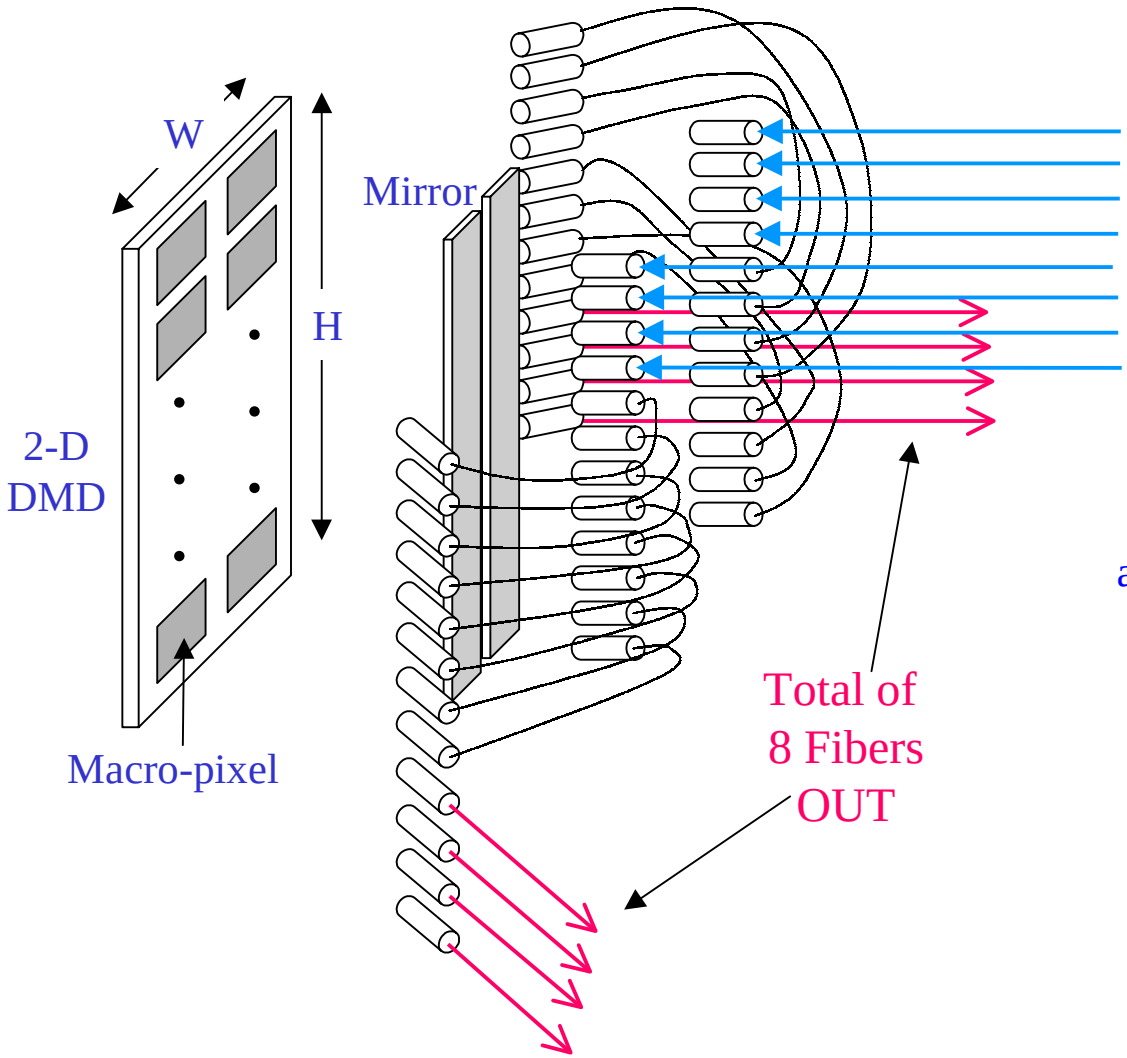
BOTTOM VIEW



SIDE VIEW

N. A. Riza and S. Sumriddetchkajorn, "Micromechanics-based wavelength sensitive photonic beam control architectures and applications," *Applied Optics*, V. 39, No. 6, pp. 919-932, Feb. 2000.

8 × 8 3-D Switch Matrix Package



Using a SXGA format DMD
(W × H = 17mm × 22mm)
and tightly packed GRIN lenses

12 Compact Switch Modules

8-IN 8-OUT Banyan Network

N. A. Riza and S. Sumriddetchkajorn, "Small tilt micromirror-based multiwavelength three-dimensional 2 x 2 fiber-optic switch structures," *Optical Engineering*, Vol. 39, No. 2, pp. 379-386, Feb. 2000.

Conclusion

- Introduced Powerful Wavelength Sensitive Photonic Modules and Applications
- Introduced Versatile Approach to MEMS-based Optical Component Design

Macro-pixel Approach

- High Speed
- Fault Tolerance to Mechanical/Electronic Failures
- High Optical Alignment Tolerance
- Inherently Robust Digital Controls

- Our Dual-Use Module Applications Include:

Military

- RF Signal Processing
- Phased Array Radars
- Secure Communication Systems

Commercial (Telecom.)

- WDM Add/Drop Filters
- Optical Crossconnects
- Variable Fiber-Optic Attenuators