Integrated Optic and Fiber Optic Devices for Communication and Sensor Networks

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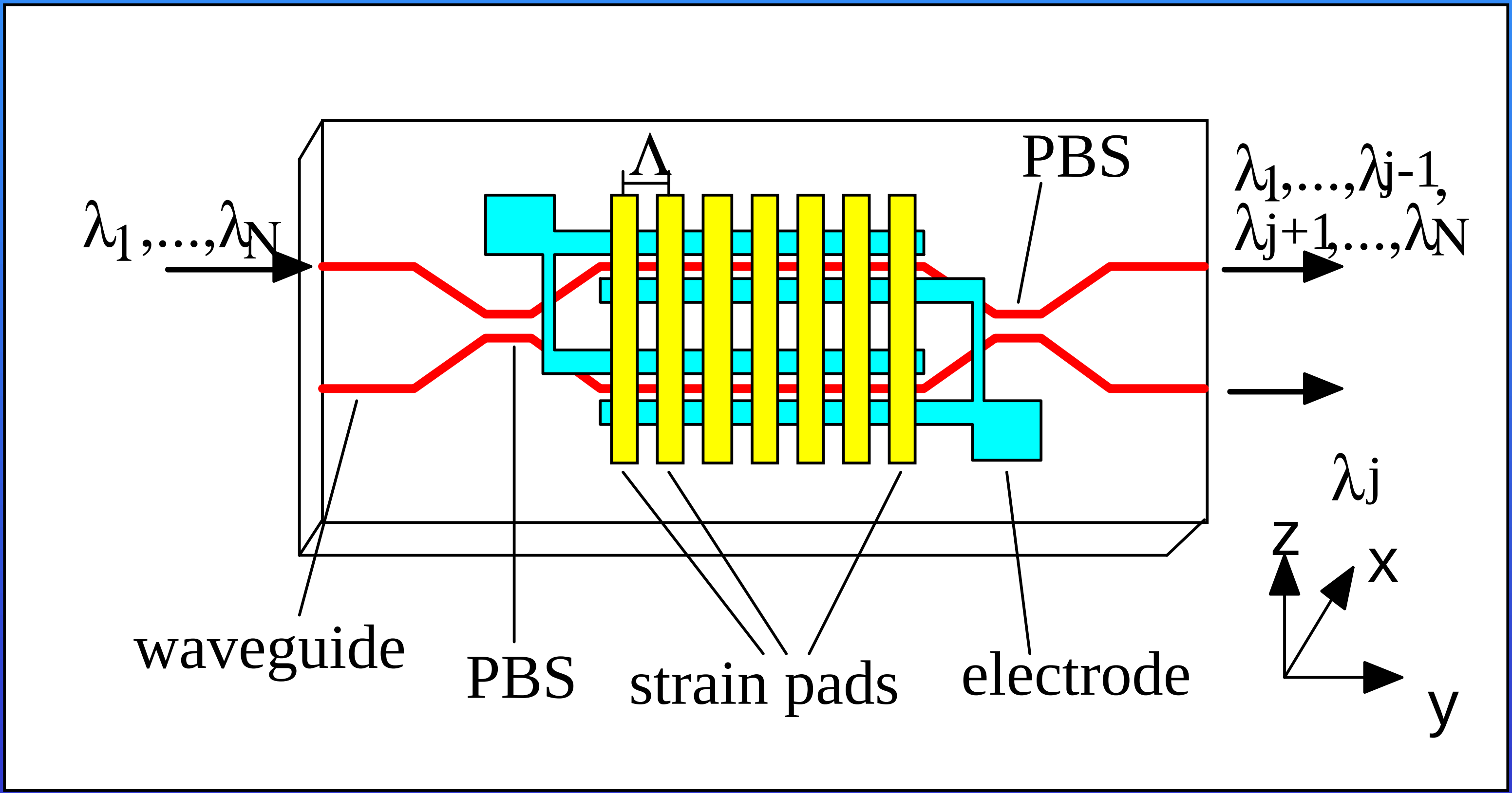
WDM-Related Research at Texas A&M University

- Electrooptic Tunable Filters for Fiber Optic Networks
- Slow Wave Electrooptic Modulators for Reduced Microwave Drive Power and Improved Response Linearity
- Fiber Fabry-Perot Interferometer Sensors for Measuring Pressure, Temperature, and Strain

Electrooptic Tunable Filter (EOTF)



Electrooptic Tunable Filter Development Objective

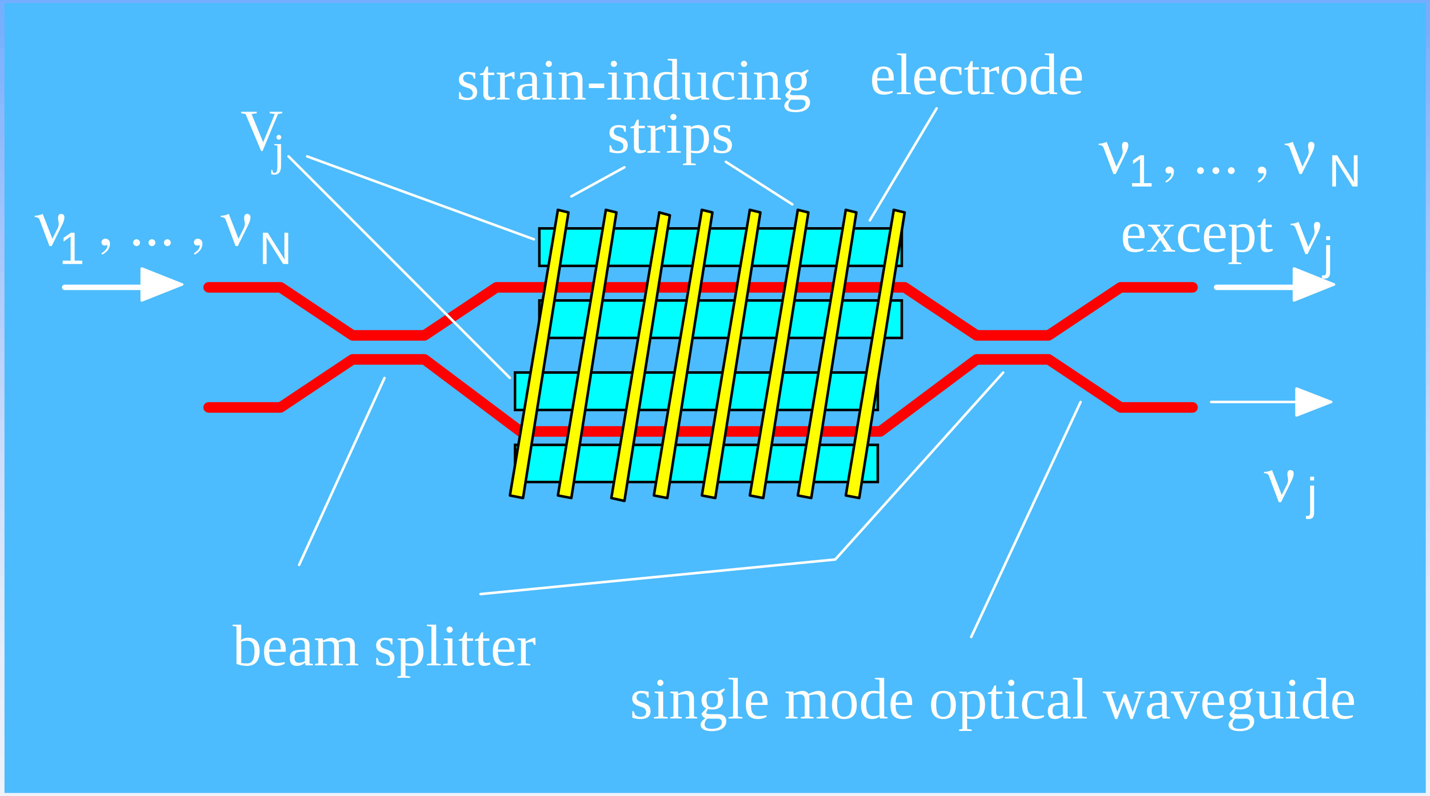
Develop filter to meet requirements of dense wavelength multiplexing:

- Polarization independence
- 50 or 100 GHz channel spacing
- Submicrosecond tuning
- < 3 dB insertion loss
- < - 25 dB interchannel crosstalk

Electrooptic Tunable Filter Development
Technical Approach

- Substrate: lithium niobate
- Waveguide structure: Mach-Zehnder interferometer; polarizing beam splitters not required
- Polarization coupling: periodic, strain-inducing silicon dioxide film

New 4- Port EOTF Design



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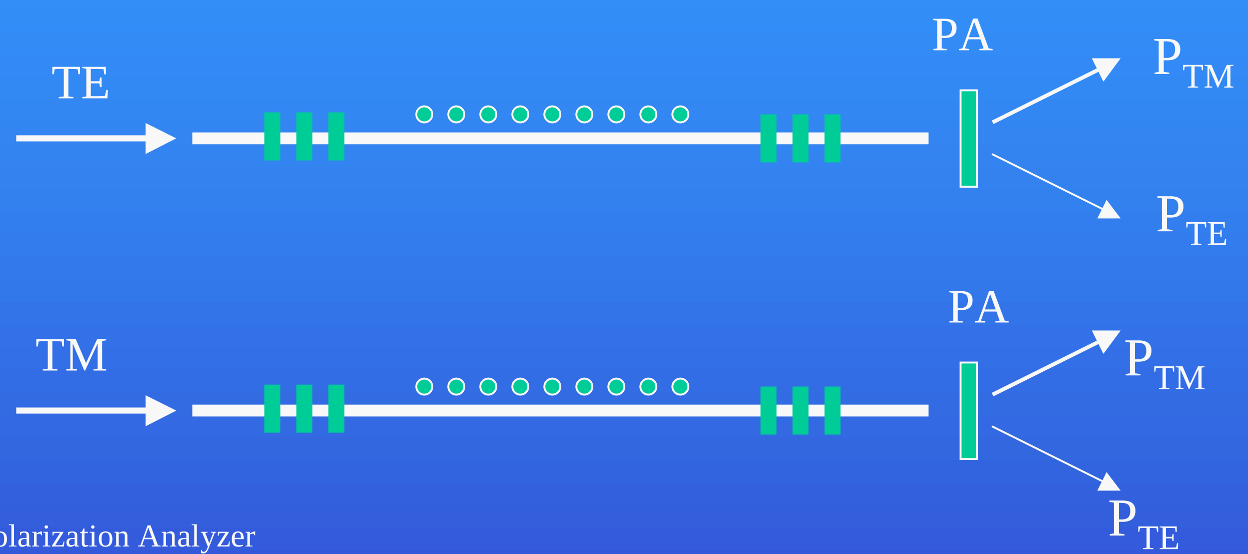
TE/TM Mode Conversion

Channel Waveguides with Grating



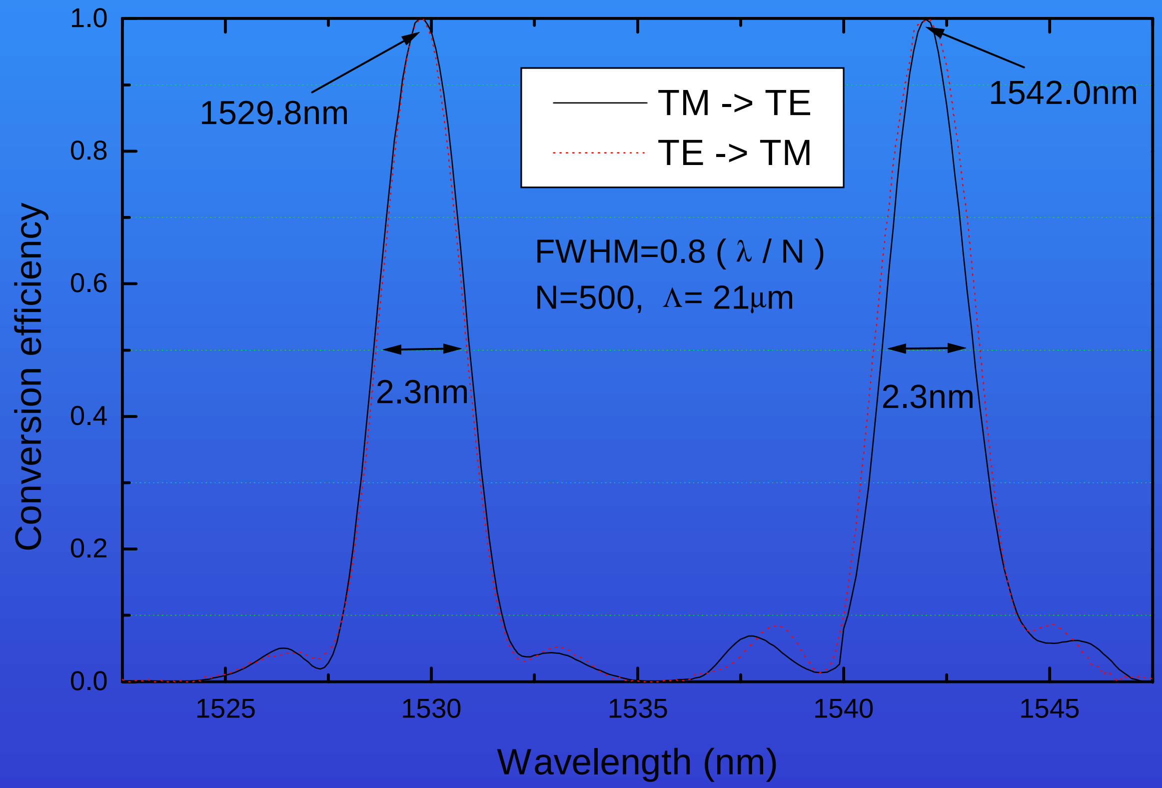
PA: Polarization Analyzer

Conversion Efficiency $$\eta_{TE(TM)} = \frac{P_{TM(TE)}}{P_{TM} + P_{TE}}$$

Conversion Bandwidth $$FWHM = 0.8\frac{\lambda}{N}$$

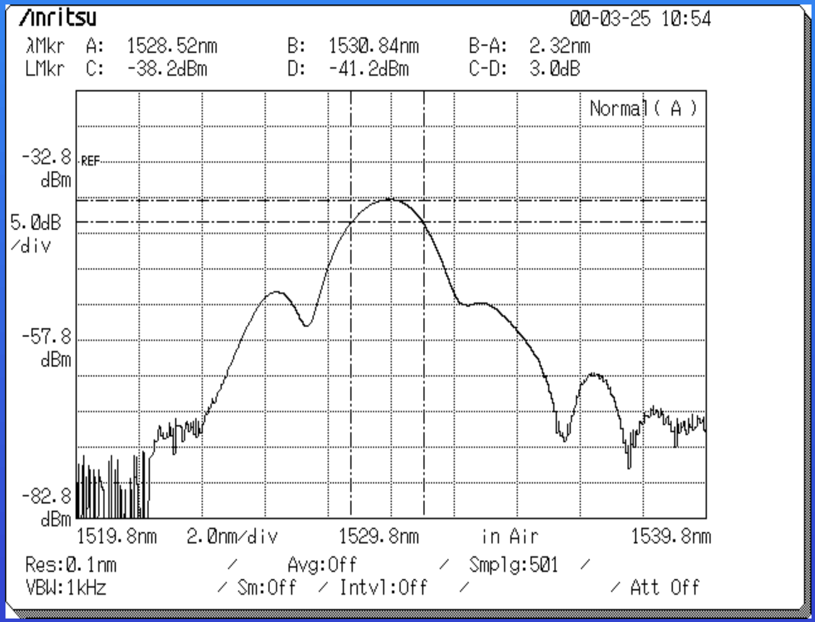
N: number of grating periods

Mode Conversion Efficiency and Thermal Tuning

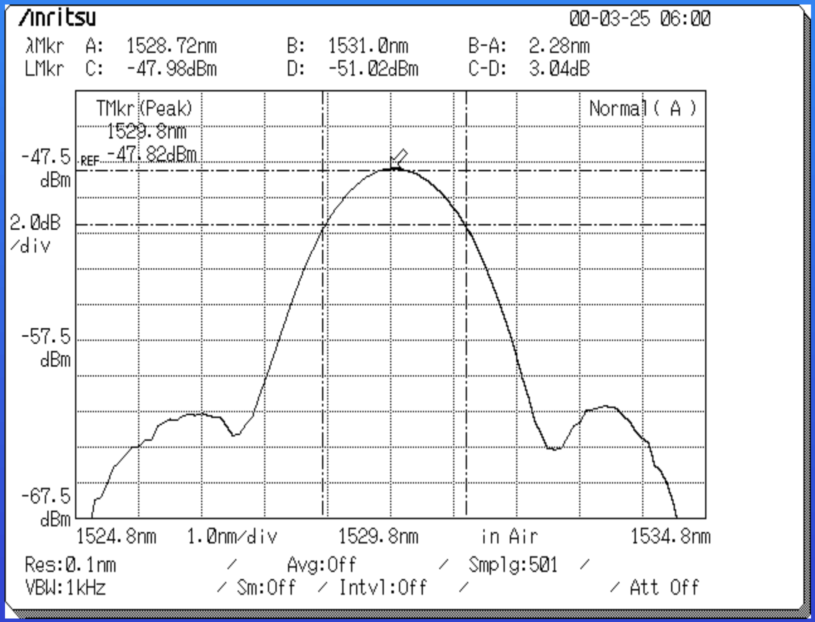


FWHM of Filter

TM to TE, FWHM=2.32nm

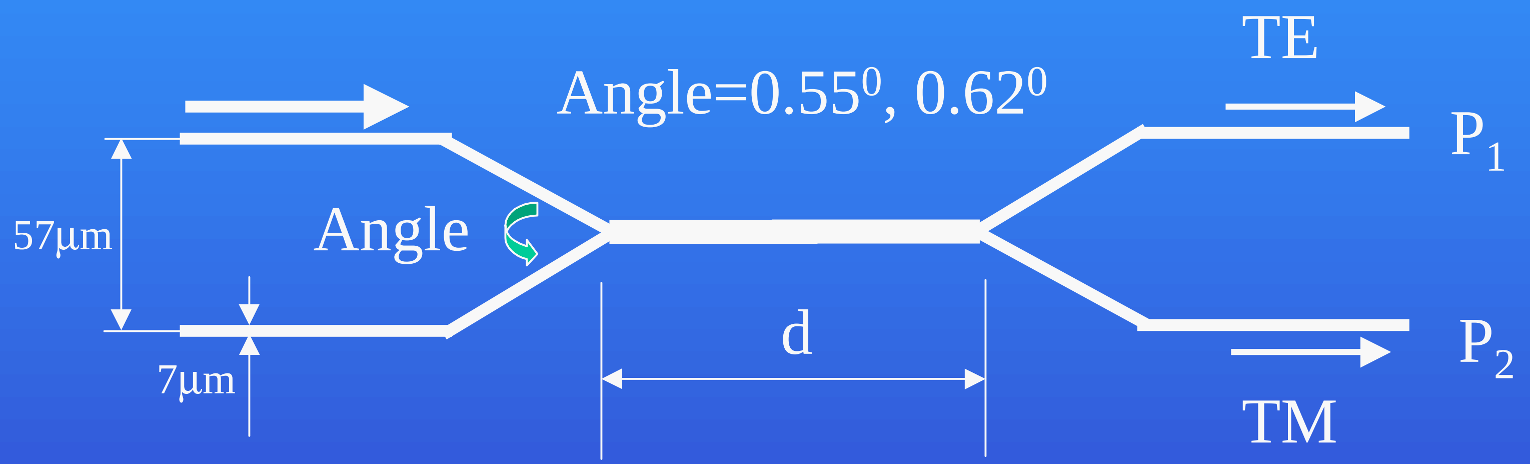


TE to TM, FWHM=2.28nm



Polarization Splitter(TE/TM splitter) ($Ti: LiNbO_3$)

Principle: Two Mode Interference (TMI)

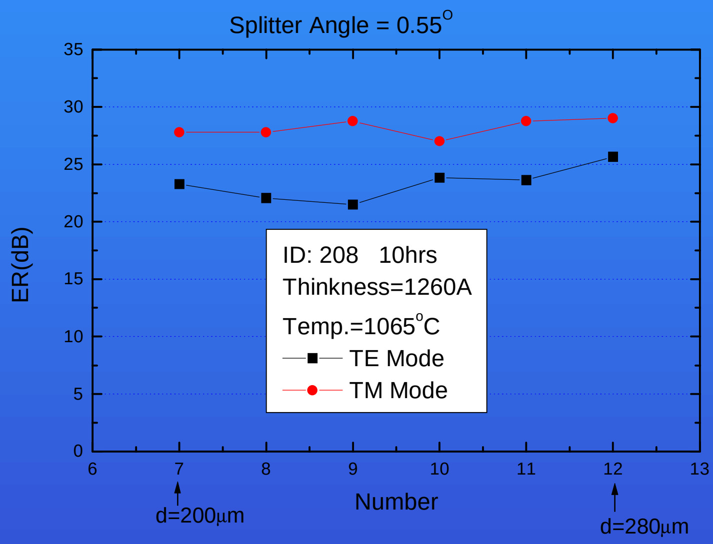


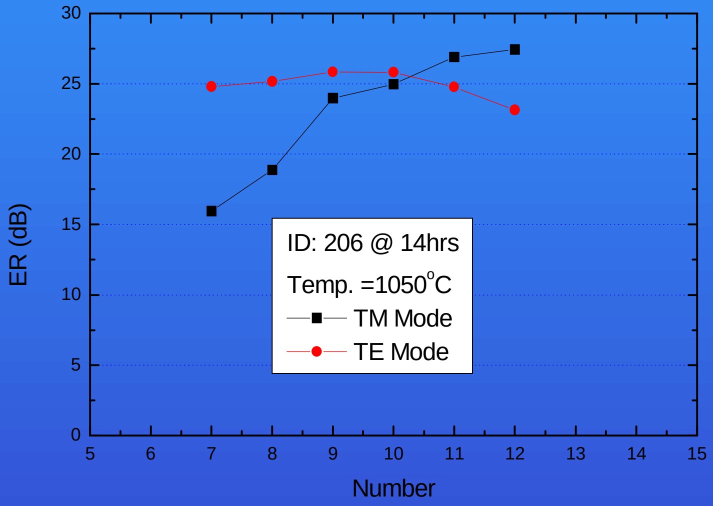
ER: Extinction Ratio

TM Mode: $$ER = -10\log\left(\frac{P_1^{TM}}{P_1^{TM} + P_2^{TM}}\right)$$

TE Mode: $$ER = -10\log\left(\frac{P_2^{TE}}{P_1^{TE} + P_2^{TE}}\right)$$

Experimental Results of Splitter



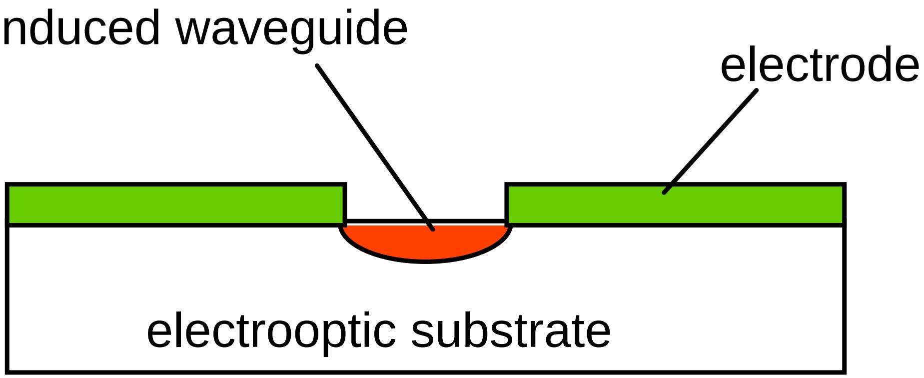


$$ER[dB] = 10\log\left(\frac{P_{TE(TM)}}{P_{TM(TE)}}\right)$$

EOTF Summary

- High (>99.5%) polarization conversion was achieved in channel waveguides.
- High (> 25 dB) extinction ratio has been obtained in polarizing beam splitters.
- New EOTF design with relaxed beam splitter requirements has been proposed.
- Completion of first four-port EOTFs is planned for Dec. 2000.

Low-Voltage SBN Modulator



substrate material: SBN:60

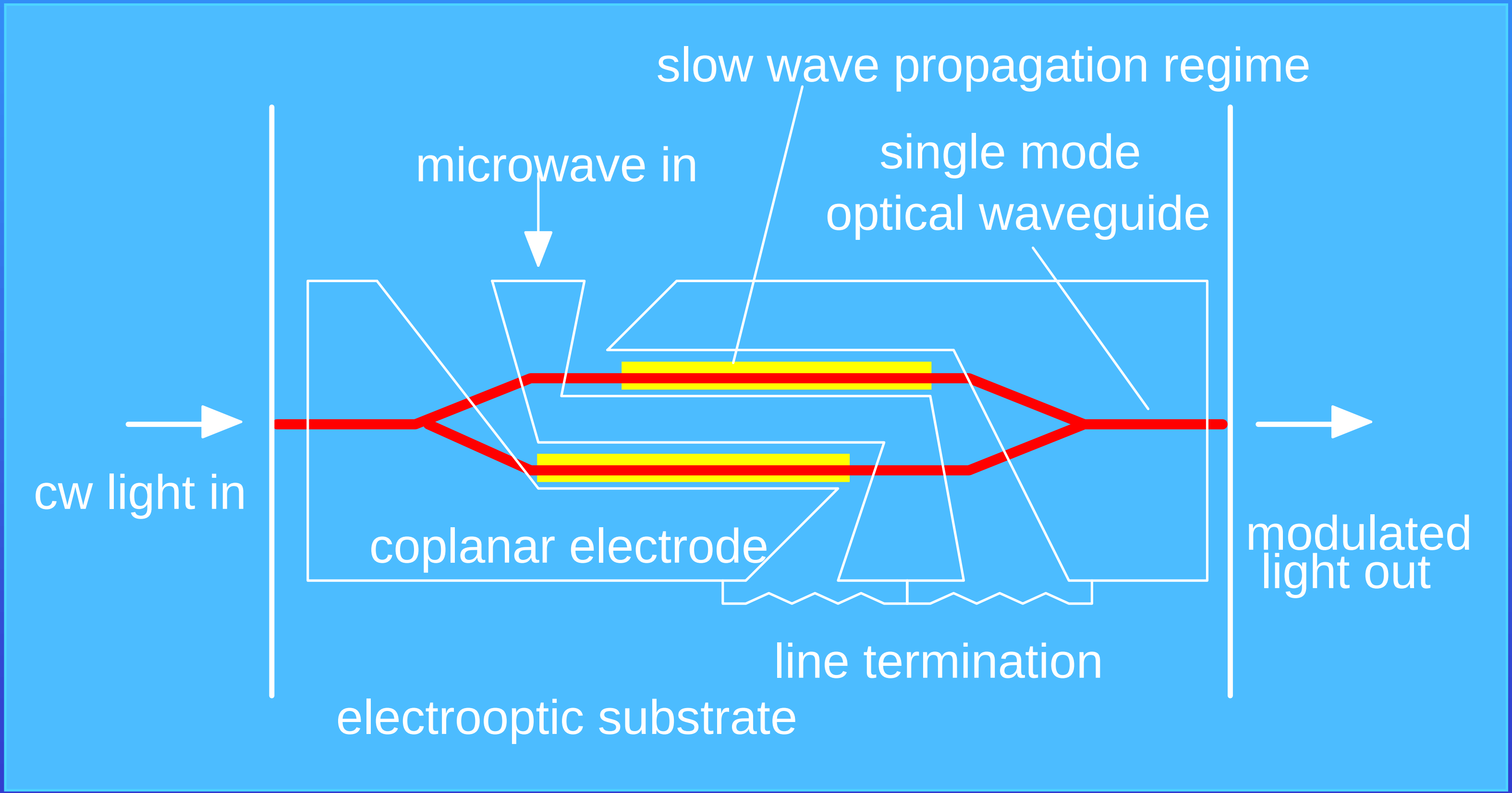
waveguide loss: < 0.3 dB/cm

voltage-length product: 0.25 V-cm

Summary of SBN Results

- Low-loss (0.3 dB/cm) strain-induced waveguides
- Low optical damage susceptibility (<< lithium niobate, < lithium tantalate)
- GHz modulation demonstrated
- Record low voltage-length product (0.25 V-cm)

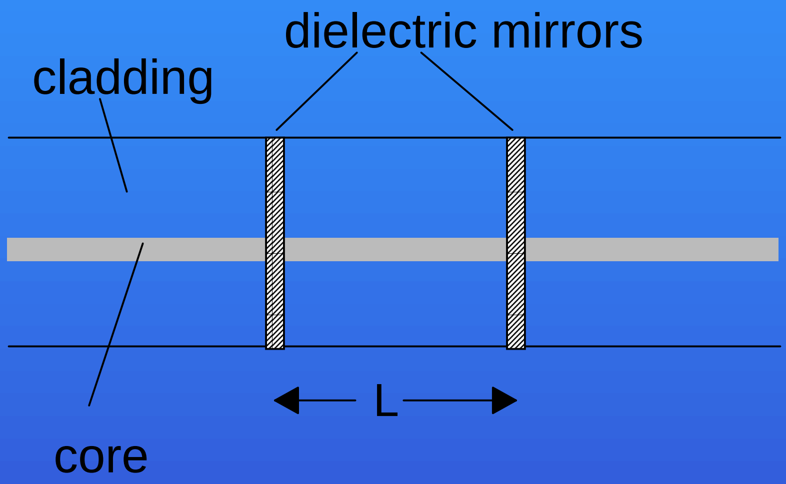
Slow Wave Electrooptic Light Modulator



Slow Wave Electrooptic Modulator Potential Benefits

- Orders-of-magnitude reduction in electrical drive power
- Improved response linearity and SFDR

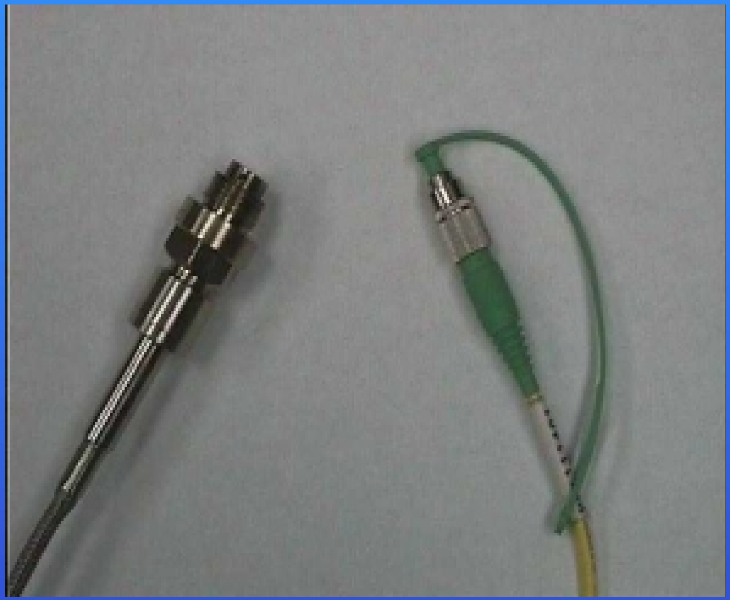
Fiber Sensors for WDM Networks



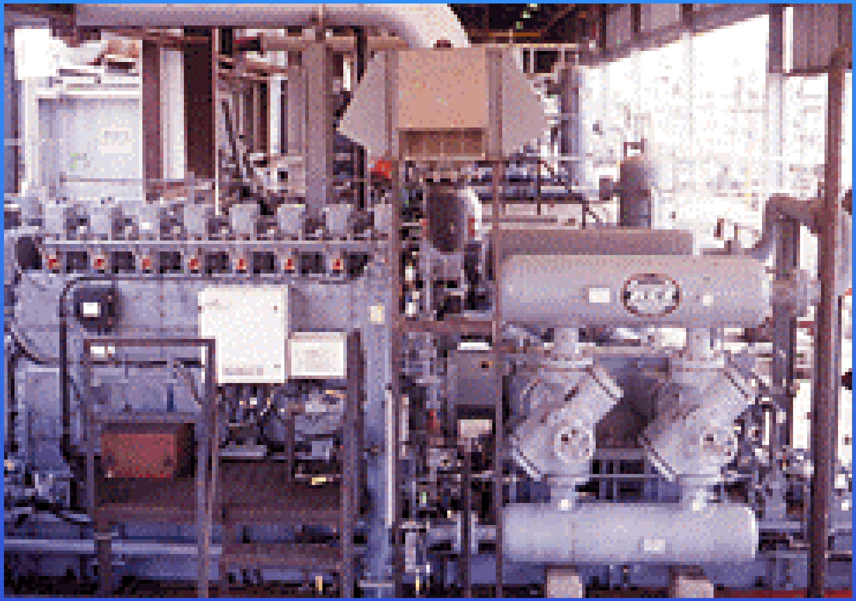
Fiber Fabry Perot Interferometer (FFPI)

FFPI Strain Sensor

Fiber Sensors for WDM Networks



FFPI Pressure Sensor



Engine Instrumented with FFPI Pressure Sensors

Demonstrated FFPI Sensor Measurands

- Pressure (static, acoustic, ultrasonic)
- Temperature
- Strain
- Magnetic field
- Acceleration
- Flow rate

FFPI Sensors for WDM Networks

- FFPI sensors can operate at high temperatures (to 1200 K), high pressures (> 10 kpsi) and high speeds (> 50 kHz)
- Readout using white light interferometry (WLI) provides absolute parameter measurement (dc performance) and multiplexing of many sensors on one fiber
- FFPI sensors are produced by Fiber Dynamics, Bryan, TX

Conclusion

Electrooptic tunable filters, slow wave modulators, and FFPI sensors are emerging technologies with considerable potential for application in military and commercial WDM networks.