DATA TRANSMISSION THROUGH A 16 CHANNEL MICRO-OPTO-MECHANICAL WAVELENGTH ADD/DROP SWITCH

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ABSTRACT

We demonstrate operation of a 16 channel fiber optic wavelength add/drop switch using free space optical wavelength multiplexing and a column of MEMS tilt-mirror switches. 622 Mb/s data transmitted on 8 parallel wavelengths was switched between two input and two output ports without signal degradation.

INTRODUCTION

Wavelength division multiplexed (WDM) fiber optic transmission allows multiple signals on closely-spaced wavelengths to be carried on a single fiber more efficiently than using multiple fibers. The next step beyond simple point-to-point links is dynamic routing of individual data channels into and out of the WDM stream without detecting and retransmitting all of the wavelength channels. Network operators want to reallocate transmission bandwidth in milliseconds for fault protection and to meet changing demands.

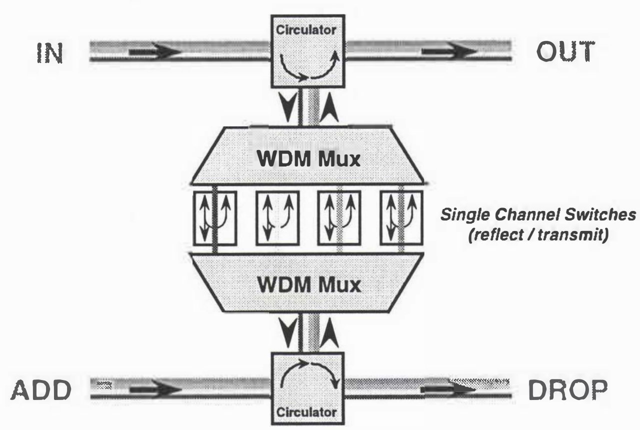

Figure 1. Wavelength add/drop switch layout.

Fig. 1 shows an multi-wavelength switch which demultiplexes the input by wavelength into individual reflect / transmit switches and re-multiplexes the transmitted output. This switch is placed between two optical circulators to separate the forward and backreflected signals and create a four-port component. Reflected signals flow from input to output, but any switch set to transmit routes one signal to the "drop" port and also opens a path from the "add" port to the output.

MICROMECHANICAL ADD/DROP SWITCH

This switch can be built using discrete components such as a waveguide router and individually packaged 1x1 switches. But our switch [1] uses free-space optical imaging through a planar diffraction grating to disperse the inputs onto a column of tilt-mirror switches. This approach offers low insertion loss and the potential to scale inexpensively to extremely large channel counts.

The active switching device (Figure 2) is a column of 16 micro-electro-mechanical tilt-mirrors which operates by electro-static deflection of a gold-coated polysilicon plate, similar to Texas Instruments' digital mirror display. Our design was fabricated in MCNC's MUMPS foundry [2]. Approximately 20 volts was required to switch between the two mirror positions, which differed by about 4.5 degrees. Switching time was 20 microseconds.

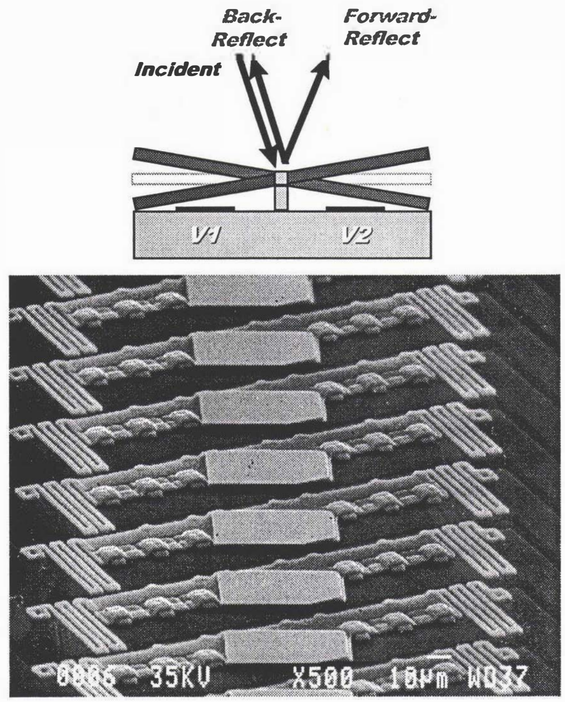

Figure 2. Tilt-mirror switch operation and fabricated device.

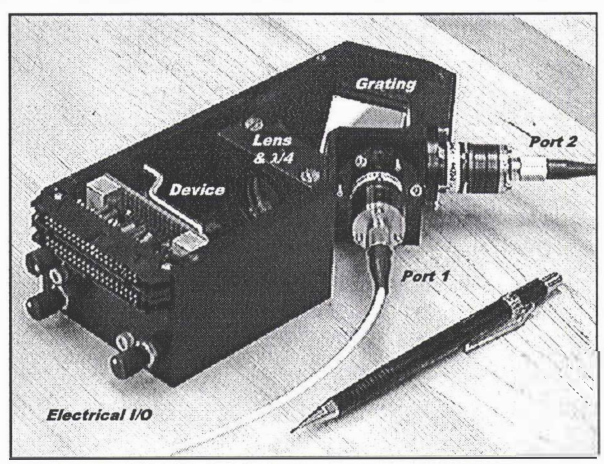

Figure 3. Wavelength multiplexing package.

The free space optomechanical package is shown in Figure 3. A single mode fiber input at port 1 is collimated, then diffracted by a 600 lp/mm grating and imaged onto the micromirror array. Depending on the mirror state, the light is either retroreflected back into the original input port, or tilted by about 9 degrees and carried into a second output port. A λ/4 plate between the lens and grating rotates the reflected light polarization to compensate for any grating polarization dependence. The packaged component, between two commercial circulators, has 5 dB total fiber-to-fiber insertion loss and 0.2 dB polarization dependence, measured with a gold mirror at the device plane and single mode fiber.

With the device in place, the mirror edges define 16 allowed passbands spaced at 1.6 nm intervals.. Figure 4 shows the total fiber-to-fiber insertion loss of the passed and dropped outputs for both switch states measured using a broad spectrum (white light) source at the input. The switching contrast ratio was more than 20 dB for the pass output, and 30 dB (1000:1) for the dropped output. There was no detectable crosstalk between adjacent switches. The maximum insertion loss of 8 dB is better by more than a factor of two compared to our preliminary results previously reported [1].

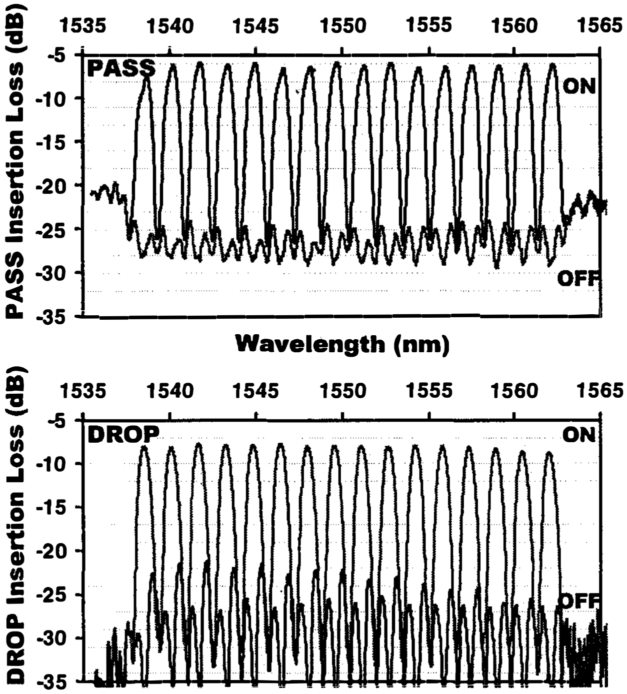

Figure 4: Switching for pass (top) and drop outputs

PARALLEL DATA TRANSMISSION

To operate the add/drop with multiple high-speed inputs, we used a pair of 8 channel x 200 GHz (1.6 nm) multi-frequency lasers [3] to produce multiple superimposed continuous output, then transmitted each fiber through optical modulators driven by two independent data generators to apply 622 Mb/s (OC-12) data patterns. The signals were connected to the input and add ports of the switch, and all the switches were set in either the "pass" or "drop" states, and the routed outputs were directed without demultiplexing into receivers. With this arrangement, crosstalk on any of the 8 channels will show up as closure of the detected transmission eye.

Figure 5 shows the eye diagrams for three cases: transmission from the input to the output, from the input to the drop port, and from the add port to the output. The left column shows the eye for a single data source, while the column on the right shows the same case but with the second signal (a potential source of crosstalk) applied to the switched-off port. In each case, the crosstalk source has no perceptible impact on the eye.

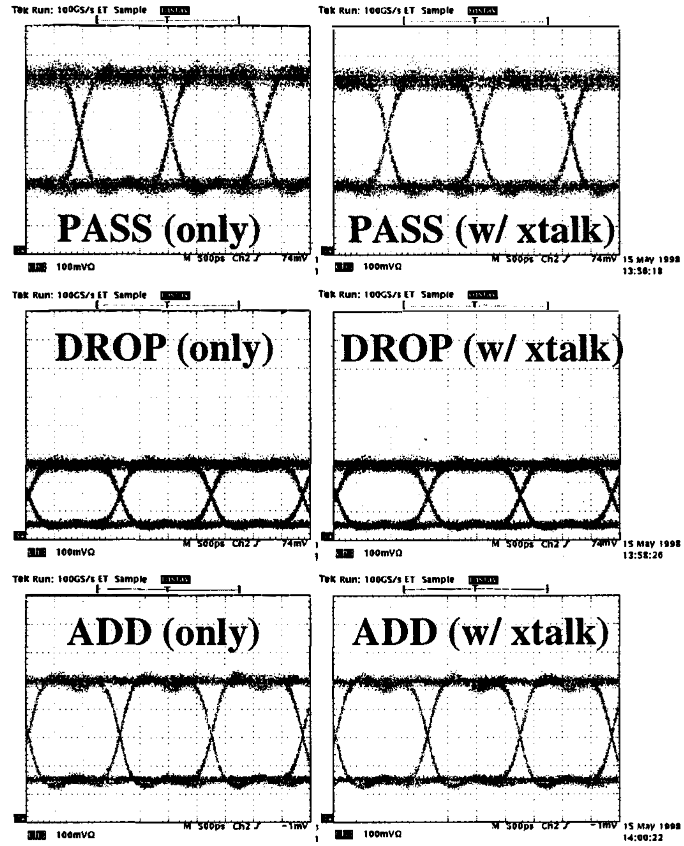

Figure 5. Transmission at 622 Mb/s for 8 summed wavelengths

It is important to note that in a complex optical network, where large numbers of passive components are cascaded, the effects of coherent noise will accumulate and the switching crosstalk performance required to achieve reliable transmission will increase. However, this first demonstration of transmission is encouraging for further development of micromechanically switched passive fiber-optic components

CONCLUSIONS

We have demonstrated parallel operation of the micro-mechanical wavelength-selectable add/drop, showing high-contrast (20 to 30 dB) switching of 8 simultaneous wavelengths channels carrying data at 622 Mb/s.

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