ALL-OPTICAL 1x4 NETWORK SWITCHING AND SIMULTANEOUS WAVELENGTH CONVERSION USING AN INTEGRATED MULTI-WAVELENGTH LASER

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Abstract: For the first time a single monolithic integrated device is used to demonstrate 1x4 space switching at 2.488Gbits/s. Other novel network functions are demonstrated such as multi-wavelength conversion and WDM multiplexing.

Introduction

Wavelength division multiplexing is an important technique for utilising the enormous available bandwidth of optical fibre by the simultaneous transmission of numerous data signals on different wavelengths of light [1]. As WDM systems become more mature there is an increasing need to perform more complex functions in the network such as all-optical routing and space switching. For an *N* fibre or channel system this may be performed by an *NxN* all-optical crosspoint switch. However, the complexity of such a device increases as a function of N^2.

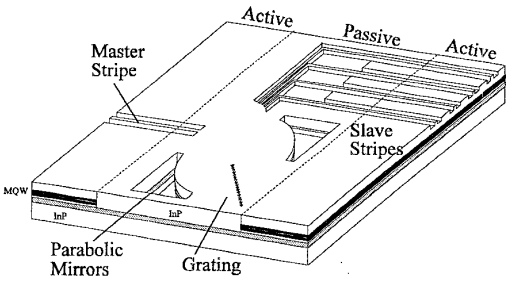
Alternatively, the use of tuneable wavelength conversion together with a passive demultiplexer has recently been highlighted by several authors as a method of achieving *NxN* space switching [2,3]. In this case the complexity of the space switches only increases linearly with *N*. However the integration and managing of the integrated components in such a switch is more challenging. As a result, here for the first time a single monolithically integrated device is used to demonstrate 1x4 space switching together with wavelength conversion. This affords a number of advantages for the network such as flexibility, reduced component count and potential cost reduction.

The Integrated Multi-Grating Cavity (MGC) Laser

The wavelength converter used in these experiments is an integrated InGaAs/InGaAsP/InP multi-wavelength laser (figure 1) fabricated by selective area regrowth. The device consists of an integrated InP passive transmission grating router [4] placed between two MQW active gain regions. The first implementation of the device uses one input (Master) and four output (Slave) waveguides. The grating section consists of parabolic collimating mirrors and a transmission grating etched into a passive slab waveguide. This introduces four wavelength selective paths between the master and slave waveguides, determined by the position of each slave. When biased at constant current, the laser can emit on up to four different wavelengths (3.7nm channel spacing) simultaneously, depending on which slaves are driven in conjunction with the master.

All-optical space switching may be achieved in the MGC laser by injecting an optical signal into the master stripe. Suppression of the lasing wavelength by gain saturation imprints an inverted copy of the input signal onto the MGC output. By monitoring each slave output, simultaneous conversion and space switching may be achieved.

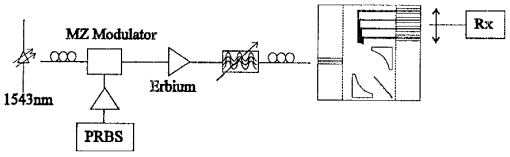
Fig. 1: Schematic Diagram of the Integrated Multi-Grating Cavity (MGC) Laser



1x4 Space Switching using the MGC Laser

The experimental set-up used to demonstrate a 1x4 space switch is outlined in figure 2. A 1543nm input signal is first patterned by a 2^7-1 PRBS NRZ (Pseudo Random Binary Sequence Non Return to Zero) using a Mach Zehnder Interferometer. The resulting input signal is then pre-amplified using an EDFA and filtered using a Fabry Perot tuneable bandpass filter to remove unwanted spontaneous emission. A fibre lens is addressed to the master facet of the MGC laser through which the input signal is injected via a polarisation controller. A second fibre lens is address to each of the output slave stripes in turn and the resulting optical output is detected on a 2.5Gbits/s receiver.

Fig. 2: Experimental Set-up used to demonstrate 1x4 Space Switching

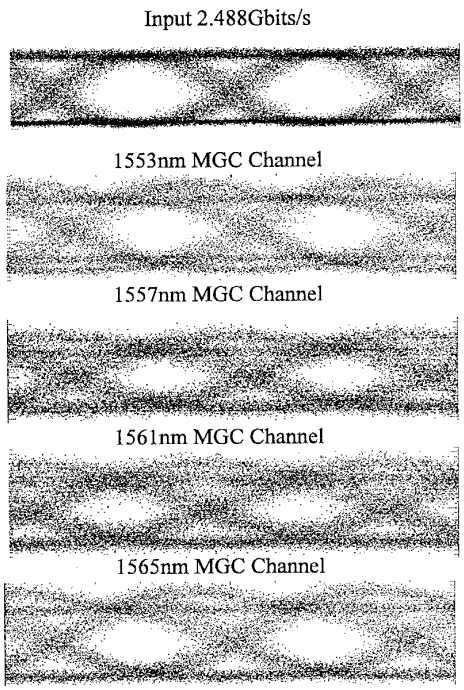


Experimental results

Figure 3 shows the converted eye diagrams on each of the four MGC wavelength channels biased independently with an input data rate of 2.488Gbits/s. An average extinction ratio of approximately 7dB is achieved on all the outputs for an averaged coupled input power of 6dBm when master and slave stripes are biased at 200mA. Also, owing to the optical isolation between master and slave stripes as a function of wavelength, no post filtering of the optical output is required. Indeed an optical isolation between input and output of approximately 20dB could be obtained on all channels at an input wavelength of 1543nm.

By biasing multiple slaves, simultaneous conversion to many outputs can also been achieved with a negligible loss of extinction ratio. Thus the device has also been used to demonstrate broadcast switching which will be presented at the conference.

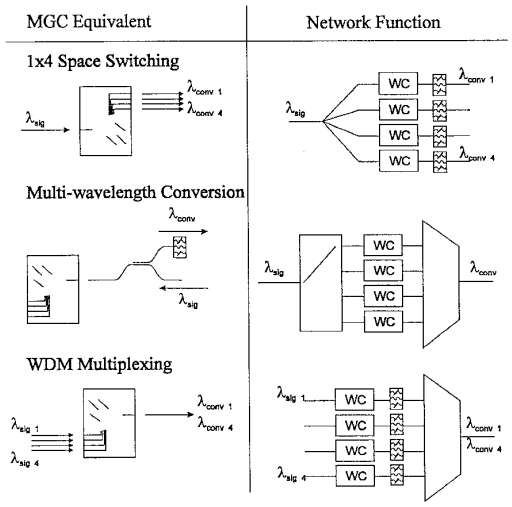
Fig. 3: Converted Eye Diagrams showing 1x4 Space Switching using the MGC Laser



Other Novel Network Configurations

By operating the MGC laser in other novel configurations the device has been used to demonstrate other high level functions. These are outlined in figure 4 and include firstly multi-wavelength conversion, whereby the optical input may be converted to any or all of the MGC lasing wavelengths. Secondly, by injecting an optical signal into each of the slave stripes, conversion can be achieved whilst simultaneously multiplexing the signal to the MGC master output. Experimental results which will be presented at the conference show approximately 7dB extinction ratios for similar drive conditions used to demonstrate 1x4 space switching.

Fig. 4: Novel Network Functions Demonstrated by the Integrated MGC Laser



Conclusions

For the first time, a single monolithically integrated device is used to demonstrate 1x4 space switching at 2.488Gbits/s. This has been achieved without the need for post filtering the optical output. We believe this is the highest modulation rate currently achieved by a monolithic integrated multi-wavelength laser. Other novel network functions have also been demonstrated simultaneously with wavelength conversion which include multi-wavelength conversion and WDM multiplexing. These will also be presented at the conference.

Acknowledgements

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