Packaging and Performance of an Ultra-Fast 1x4 Optical Switch

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Abstract: We report a packaged ultra-fast 1x4 fiber-optic switch obtained by cascading two electro-optic scanners. The resulting switch exhibits a fiber-to-fiber insertion loss of 3.2 dB and rise and fall times of 46ns and 8 ns, respectively.

OCIS codes: (060.1810) Couplers; switches and multiplexers; (230.2090) Electro-optical devices; (060.2340) Fiber optic components; (120.5800) Scanners

Bulk-effect based electro-optic (EO) devices have been used extensively for applications in scanning and switching [1, 2]. Attractive properties of this technology include modest fabrication requirements that lead to devices with low insertion losses. Previously, we demonstrated a packaged ultra-fast packaged 1x2 optic switch [3]. The switch design was based on a 500μm z-cut LiTaO3 single crystal wafer fabricated using the domain inversion method. This 1x2 switch had a deflection angle of 1.22° with an applied voltage of 1.1kV. The insertion loss and crosstalk figures were 2.36dB and -36dB, respectively.

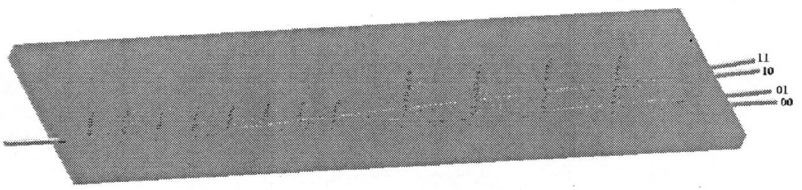

Fig. 1. The schematic of the two active regions and four outputs of the EO scanner

Based on these design concepts, we have extended our work to a 1x4 optical switch using a cascade of two 1x2 switches. The two active regions are fabricated on a contiguous substrate. Fig.1 is a schematic of the 2 element device. The first stage of the 1x4 operates in a manner similar to the 1x2 switch, whereas the second stage is designed to be wide enough to deflect both the original and the deflected beam coming from the first stage. Using this approach, four states can be obtained depending on the configuration of the electrical field applied to the EO device. Fig. 2 shows the four spots obtained from the deflector and Fig. 3 shows the deflection angle vs. applied voltage. In Fig. 3, we label the four spots as follows: 00, 01, 10, and 11. Using this notation, 00 indicates that no voltage is applied to either stage, 01 indicates a voltage is applied to the second stage, 10 indicates a voltage is applied to the first stage, and 11 indicates a voltage is applied to both stages simultaneously.

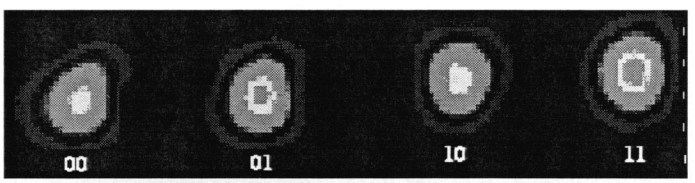

Fig. 2. Four output spots of the 1x4 optic switch.

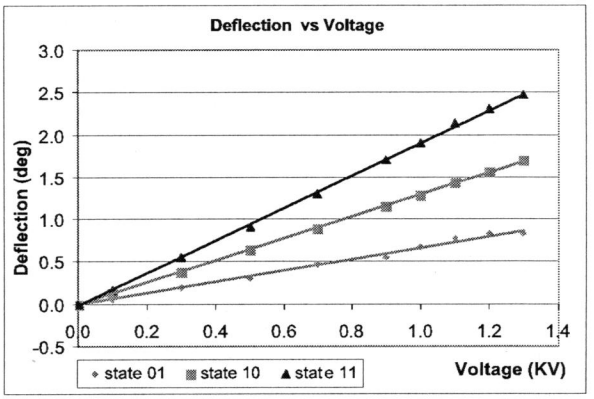

Fig. 3. Deflection Vs. Applied Voltage.

The EO device and the polarization maintaining (PM) fiber collimators, which connect the 1310nm linearly polarized fiber coupled laser source to the optical power detectors, were packaged on an acrylic mount. A special shaped prism was glued at the output end of the device to further separate the four beams. The electrical power is delivered from the high voltage supplies using two high-voltage SHV cable connectors. A real photo of the packaged switch and the schematic of the prism are shown in Fig. 4.

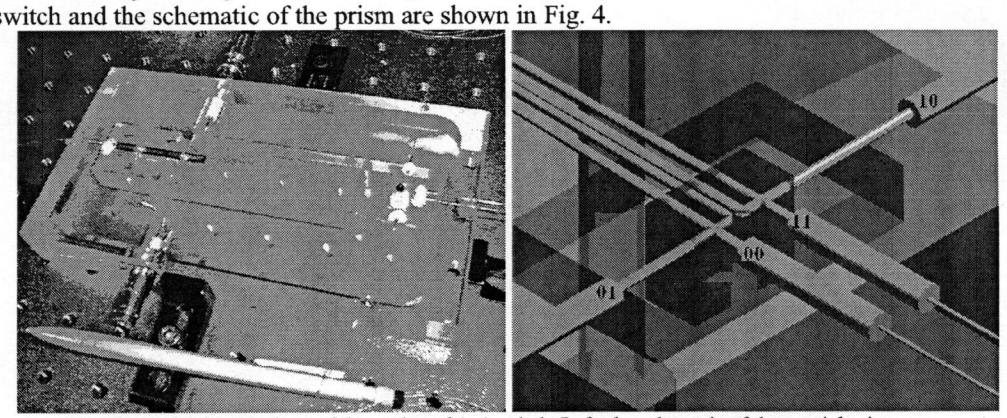

Fig. 4. Right: the photo of the packaged 1x4 switch; Left: the schematic of the special prism.

The insertion loss of the packaged switch includes the losses resulting from the fiber collimators, coupling loss into the crystal and the scanner loss. The facets of the scanner were not AR coated, and this source of loss was calculated and subtracted from the results. Deflection and power measurements for our packaged switch are shown in Table 1. With a high voltage pulse generator, pulse rise and fall times (10% to 90%) of 46nsec and 8nsec were measured respectively (shown in Fig. 5).

Table 1: Insertion loss, crosstalk and deflection angle of the packaged switch

	Switch Configuration (dB)	**Collimator Position**				**Deflection** (deg)
		"00"	**"01"**	**"10"**	**"11"**	
Collimator Position	**"00"**	2.90	-24.66	-32.86	-37.76	0
	"01"	-40.16	3.68	-36.96	-35.06	0.77
	"10"	-39.90	-40.16	2.80	-21.36	1.43
	"11"	-40.52	-40.55	-30.36	3.42	2.13

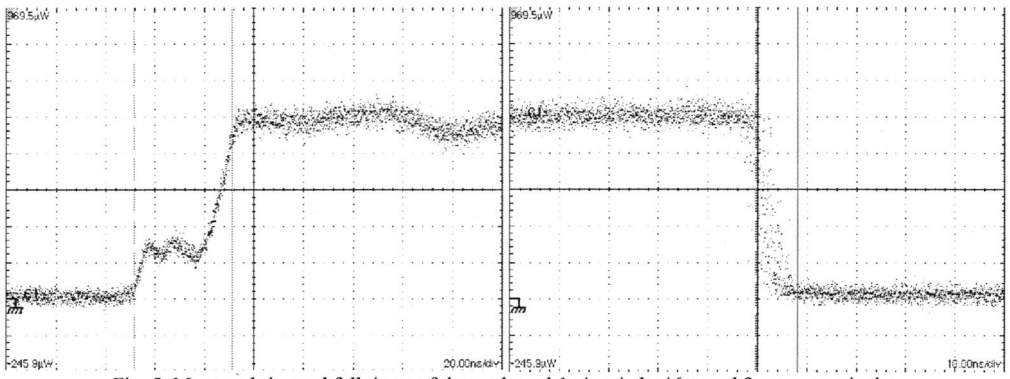

Fig. 5. Measured rise and fall times of the packaged 1x4 switch: 46ns and 8 ns, respectively.

Future work will investigate reducing the voltage requirements, reducing the insertion loss, increasing the crosstalk and the construction of a switch fabric.

References:

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