CASCADABLE RESTORING DIGITAL OPTICAL LOGIC AND OPTICAL CIRCUITS USING BISTABLE ELEMENTS : PROSPECTS FOR SIGNIFICANT PROCESSING RATES

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CASCADABLE RESTORING DIGITAL OPTICAL LOGIC AND OPTICAL CIRCUITS USING BISTABLE ELEMENTS : PROSPECTS FOR SIGNIFICANT PROCESSING RATES

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Abstract - The use of bistable elements in optical circuits is described; developments in elements and arrays towards practically useful digital optical processing is reviewed.

From the starting point of mW-power infrared-driven digital optical logic element workin, from nonlinearity of electronic origin /1/; simple 2-element circuits were demonstrated /2/; with the capability of sub-microsecond cycle rates but with difficulties in fabrication of parallel arrays. Current work has therefore concentrated on devices made with thin-film coating techniques /3/ in which both conventional thermal evaporation and molecular beam deposited layers have been used. At comparable device diameter, operating powers are typically a few milliwatts, similar to the infrared electronic case. The early devices have shown sufficient stability to demonstrate 'hold and switch' circuits operating continuously so that the results of a processing operation can be stored /4/. Gain of up to 10 has been typically observed but the available output signal limits subsequent switching speeds. Off-axis address ensures standard logic levels and thus a 3-element 'optical classical finite state machine' has been demonstrated to show restoring logic operation over many cycles as well as the necessary inversion function /5/.

This 'proof of principle' experiment now requires development to substantial parallelism and speed to give practically competitive processing rates. As a first stage we are attempting the development of a 100 x 100 array with a cycle time in the range 1 - 10 µs. This would give a data rate of 100 - 1000 times faster than existing liquid crystal SLM's as well as providing logic functions and storage.

The trade-offs between opto-thermal and opto-electronic mechanisms are of interest. The use of thermal pixellation on a scale of a few µm and optimised interference design, suggests theoretical switching power limits for individual elements to be about 10 µW /6/. Present experiments confirm that sub-milliwatt element powers will certainly be practical. Recent results on reproducibility (including use of MBD films) also look encouraging.

A new device the e-beam controlled NLIF SLM has been developed /7/. Simple calculations suggest that a 10^4 bistable memory array could be written by this device in 10 µs and, by controlling the holding beam, the entire frame reset in the same time. This can be an important input and interrogation device for a parallel digital optical processing system.

The NLIF elements themselves can be designed for any wavelengths between the visible and the communications wavelengths at 1.55 µm and operation at 830 nm with GaAs diode lasers and 1.3 µm with Nd:YAG lasers has been demonstrated /8/.

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