Design of Micro-scale Transmission Light Valve Arrays

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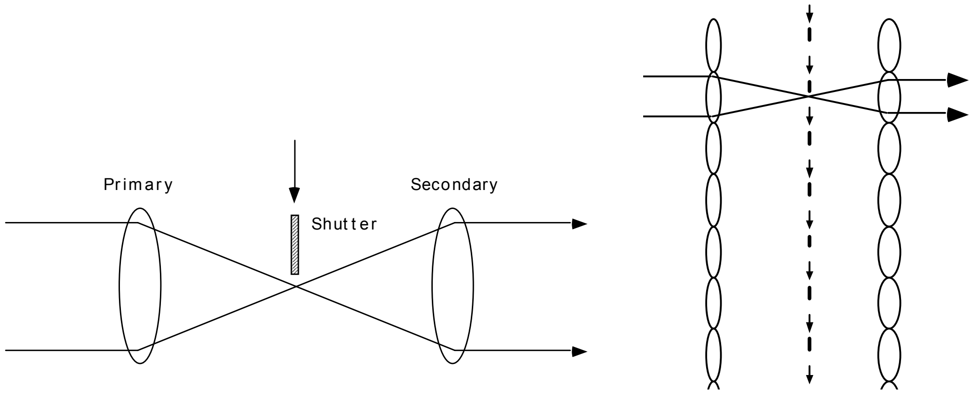
A two-dimensional array of light valves is described in which light is modulated at each pixel. The light is transmitted through the array. This function is important for certain instruments, such as the Near Infrared Spectrometer (NIRSpec) to be carried on the James Webb Space Telescope [1]. By selectively addressing particular pixels, the efficiency of that spectrometer can be improved by more than a factor of 100. Light valve (Microshutter) arrays [2, 3] have been developed at the NASA Goddard Space Flight Center for use with the NIRSpec instrument. This abstract provides an alternative design with significant advantages over the Goddard array.

Each pixel in the array contains two positive lenses, arranged as a 1:1 telescope (Figure 1). Light entering the pixel is assumed to be (nearly) parallel. It is brought to a focus by the first lens, and then re-collimated by the second lens. A shutter is positioned near the focus, so that it can be moved to block the focal image, thereby preventing the light from being transmitted through the pixel.

The shutter is driven by an electromechanical comb, which is a well known mechanism for moving parts in micro electromechanical systems (MEMS) (Figure 2a). Only a few microns of motion are needed to completely block the light, so the requirements on the comb are relatively modest. In addition, by pre-stressing the moving spring, the motion of the comb becomes mechanically bi-stable. The array becomes in effect a mechanical memory, in which each pixel remains either open or closed indefinitely, until it is further addressed (Figure 2b). Each pixel can be addressed without affecting any other pixels, and no voltages are required to keep it in either state. This is a major advantage of the present design compared to conventional transmission arrays, since there is zero power consumption until an address is changed.

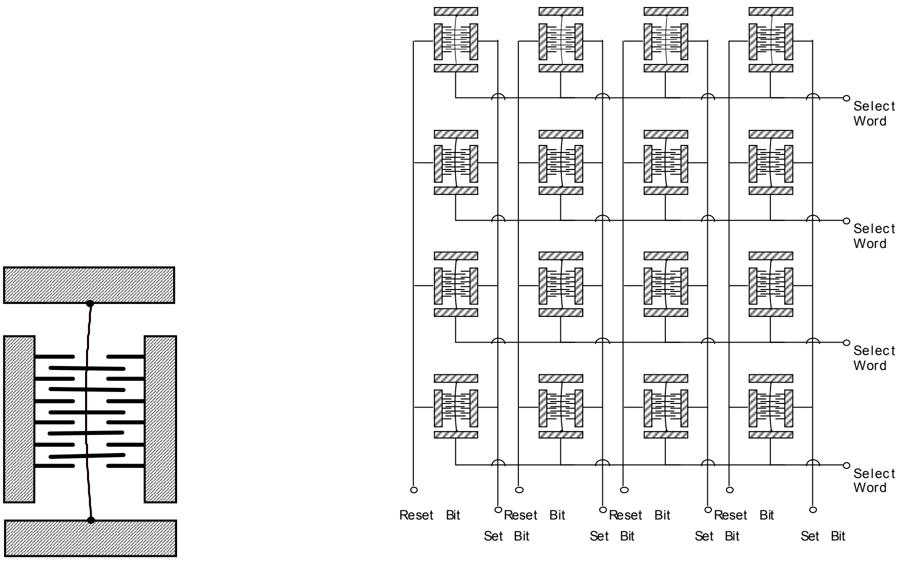
Almost no space is lost between the pixels. This is because the connecting wires, and the comb mechanism, lie in unused spaces adjacent to the focus. This is another major advantage of the present design compared to conventional transmission arrays, in which the entire light path must be kept clear and connecting wires and controls are located between the pixels.

[1] http://www.jwst.nasa.gov/microshutters.html
[2] M.J. Li et al, "Microshutter Array System for James Webb Space Telescope," *Proc. SPIE, Vol. 6687, pp.668-709* (2007)
[3] S.H. Moseley et al, "Microshutters Arrays for the JWST Near Infrared Spectrograph," lep694.gsfc.nasa.gov/gunther/gunther/moseleyetal.pdf, Retrieved June 11, 2010



(a) (b)

Figure 1: (a) A one to one telescope. The output contains all the light in the original beam, but it can be gated by a small motion of the shutter. (b) An array of telescopes. Each element in the array has its own moveable shutter which gates that individual element. For clarity, the light going through only one element is shown. If all the shutters are open, all of the input light goes through.



(a) (b)

Figure 2: (a) The bistabile mechanical arrangement used to drive the shutter. The comb structures on either side repel the central member when a drive voltage is applied to them. (b) Word lines and bit lines for a two dimensional array of shutters. Each bit line has two strings: one goes to the right-hand comb and one goes to the left-hand comb. These correspond to "set" and "reset" functions for the mechanical bi-stabile memory. When the right-hand string is at a voltage, +V, the left-hand string is at 0. This is defined as setting the selected pixel to logic "1." Similarly, when the left-hand string is at +V, the right-hand string is at 0. This sets the selected pixel to logic "0."