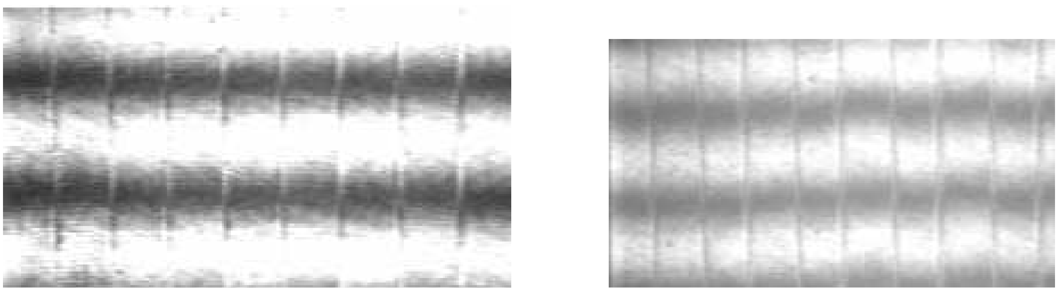
Why Choose BNS?

BNS has been continuously developing liquid crystal spatial light modulators for over 15 years. Through this development process, there has been an advancement of SLM performance not matched by other SLM manufacturers.
Such performance enhancement includes:

1) Sub-millisecond frame loading to prevent phase droop and addressing latency;
2) 100% fill factor to reduce higher-order diffraction;
3) Intra-pixel-pair modulo-2π transitions to maximize space bandwidth product;
4) Unique LC modulators.

High Optical Resolution

The optical resolution of a modulo-2π phase modulator is related to its ability to produce phase wraps (i.e. transition 2π radians) over a small distance - preferably within a pixel pair. That is, the full resolution capability of the SLM is realized by producing phase wraps within the line-pair resolution of the LCoS backplane. As discussed above, there is a spatial smoothing that depends on the thickness of the modulator and the voltage potential between the pixels and the coverglass electrode. This smoothing eliminates inter-pixel dead zones, but it increases pixel-to-pixel influence. Therefore, the distance from pixel pad to coverglass electrode needs to be small in relation to the LCoS pixel pitch to maximize spatial resolution (note: pixel pitch is center-to-center spacing of the pixel pads and is not the electrode gap distance shown in Figure 2).
There are a variety of parameters that affect the thickness of the modulator such as wavelength, phase stroke, optical throughput and power handling. The first two parameters affect the LC layer thickness and are a strong function of LC birefringence. Throughput and power handing are improved by using mirror-covered backplanes, increasing reflectivity.



1.064 micron device without mirror **1.064 micron device with mirror**

Figure 1 ~ Interferometer images of two 512 x 512 SLMs (left – without mirror, right - with mirror) operating at 1064 nm. The pattern written to the SLM has 15 pixels set to zero phase and 16 pixels set to 2π phase. The discontinuities in the horizontal fringe pattern show the relative width of the 2π transitions.

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However, mirror reflectivity is related to the thickness of the dielectric stack. Fortunately,narrowband designs with reflectivities ranging from 80% to 95% keep the mirror to a reasonable thickness out into the near IR. By understanding the tradeoffs, BNS maintains high resolution, usually limited by backplane resolution, using designs optimized for a particular wavelength. This capability is demonstrated in Figure 3, where a 1064 nm interferometer is used to measure the transition period of two SLMs (one with a dielectric mirror and one without). A binary pattern of 15 pixels set to 0 phase and 16 pixels set to 2π phase is written to the SLM. Since the relative phase difference between the phase levels of 0 and 2π is zero, a horizontal fringe pattern remains a set of horizontal lines except at the 0-to-2π and 2π-to-0 transitions. These transitions (vertical fringe lines) are approximately 2 pixels wide for both devices as shown in Figure 1. We verified this further by using higher magnification and higher frequency patterns. Unfortunately, the resulting images do not reproduce well.

For shorter wavelengths, the transition periods sharpens since the modulator gets thinner. This improves diffraction efficiency. Further improvement is possible by overdriving the modulator at the 2π transitions. With a pixellated active-matrix backplane, sufficient drive voltage, some modulation overhead and adequate pixel pitch, the system converts digital data into the desired high-resolution phase pattern with precise pinpoint control across the whole. This discrete control prevents the pattern data from being smeared through sampling, as happens when video signals (such as RS-170) are used to drive a display.

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