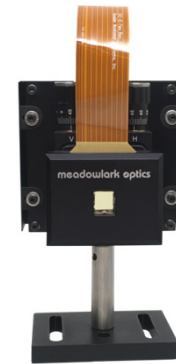
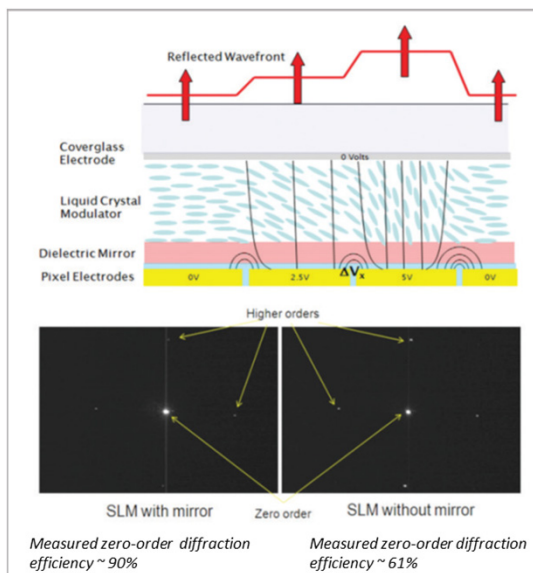


Spatial Light Modulator – 512 x 512

Meadowlark Optics Liquid Crystal on Silicon (LCoS) Spatial Light Modulators (SLMs) are uniquely designed for pure phase applications and incorporate analog data addressing with high refresh rates. This combination provides user's with the fastest response times and highest phase stabilities commercially available. Meadowlark offers both transmissive and reflective SLMs in either one or two dimensions. Phase-only SLMs can also be used for amplitude-only or a combination of both. The 512 x 512 SLM is good for applications requiring high speed, with synchronization / triggering capabilities. The optional dielectric mirror coating provides users with 100% fill factor, which increases optical efficiency.

High Efficiency

All of the light reflecting off of the SLM is modulated – including the light between the aluminum pixel electrodes. The reflective pixel structure associated with a Liquid Crystal (LC) on Silicon SLM backplane acts as an amplitude grating that diffracts some light into higher orders. To eliminate this loss of light, Meadowlark has developed a process for removing the grating effects due to the pixel structure. Optically, the active area of the backplane is converted into a flat dielectric mirror by depositing planar dielectric layers to eliminate the amplitude and optical path variations associated with the underlying aluminum pixel structure. The dielectric stack is kept thin to minimize any drop in electric field across the LC layer as shown in the figure below. In other words, there are no abrupt changes in phase modulation (such as dead zones) between pixels due to the smoothing (low pass spatial filtering) which results from separating the LC modulator from the driving electrodes.



Key Features

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- High speed
- Pure analog phase control
- High bit-depth controllers (high phase resolution)
- High reflectivity option
- High power handling
- Synchronization / Triggering
- Wavelengths from 400-1650 nm

Applications

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- Adaptive Optics
- Optical Trapping
- Multi-Spot Volumetric Beam Steering
- Optical Vortices
- Pulse Shaping
- Spectral Shaping
- Tunable Lens

SLM Family

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- 1920 x 1152
- 1 x 12,288
- E-Series 512 x 512
- 1 x 128
- Hex 127

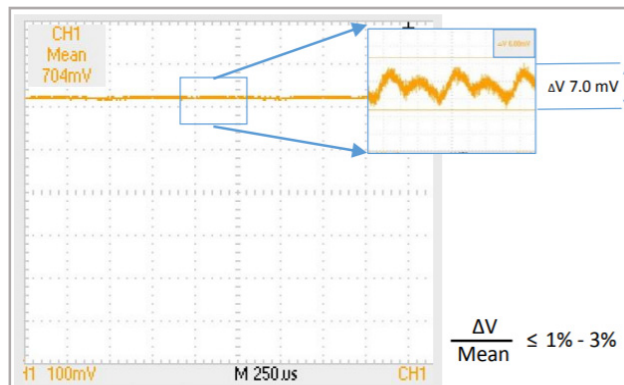


High Phase Resolution

Meadowlark offers the industry's only 16-bit controllers for LCoS SLMs. With 16-bit voltage resolution these controllers provide unsurpassed phase resolution. When properly calibrated the SLMs typically have more than 10,000 unique pixel values over a 2π phase stroke. This high resolution is necessary when working with broad wavelength ranges, or large phase stroke SLMs in order to accurately hit the desired retardance at the operating wavelength. High phase resolution is also necessary in applications where the SLM is combined with polarizers to achieve amplitude modulation. With this approach, achieving good contrast ratio requires hitting the exact phase value yielding the darkest "off" state.

Low Phase Ripple

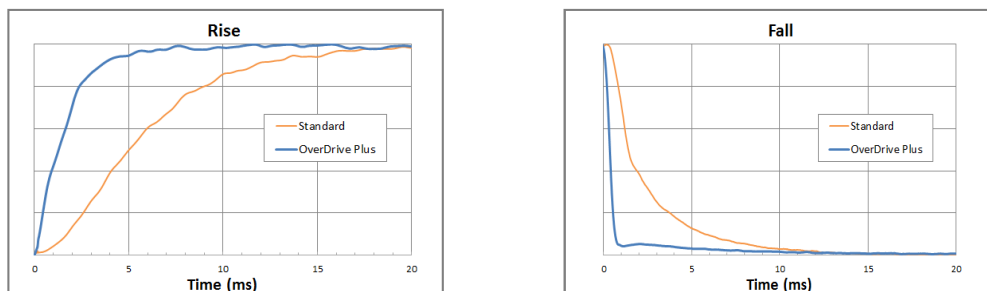
Meadowlark loads every pixel with 8-bit or 16-bit data several times per millisecond. This high speed addressing scheme eliminates phase ripple as demonstrated in the figure to the right. Meadowlark Optics' SLMs have been tested for compatibility with high power pulsed and CW lasers. In the measurements shown, the optical response of the 512 x 512 pixel SLM was measured as the incident power was incremented up to a peak power density of 112 MW/cm². Thermal effects resulted in a reversible reduction in modulation depth, and no permanent damage.



High Speed

The use of OverDrive Plus has shown reductions of the liquid crystal response times by a factor of up to 8x through use of the transient nematic effect, phase wrapping, and regional calibrations. The base technology is the transient nematic effect, utilizing intermediate transition voltages beyond the target voltage needed to achieve the desired phase value. The second technology development is the use of phase wrapping, which is based on the cyclical nature of light wherein adding or subtracting 2π from any phase value in a hologram results in an equivalent hologram. Often times it is faster to switch from phase1 \rightarrow phase2 $\pm 2\pi$ instead of switching from phase1 \rightarrow phase2. ODP automatically implements the faster of the two transitions, based on the calibration data. The third technology development is the utilization of regional calibrations of an SLM. Because most optical applications require precision on the order of a fraction of a wavelength, nearly all SLMs will have some inherent phase errors across the aperture that may impact the performance of the optical system. OverDrive Plus utilizes the phase modulation capabilities of the SLM to calibrate these errors out of the reflected wave, while also utilizing the regional calibrations when determining the length of time required for the transient nematic effect on a pixel by pixel basis.

OverDrive Plus for Ultra-High Speed Modulation





512 x 512 Analog Spatial Light Modulator Specifications

Resolution: 512 x 512
Fill Factor: 83.4 - 100%

Array Size: 7.68 x 7.68 mm
Pixel Pitch: 15 x 15 μ m

Zero-Order Diffraction Efficiency*: 61 - 95%
Controller: PCIe 8-bit, PCIe 16-bit, DVI 16-bit

Wavelength	Wavefront Distortion	Liquid Crystal Response Time (Standard Efficiency / High Efficiency)			AR Coatings (Ravg <1%)
		P512/PDM512	HSP512/HSPDM512	ODP512/ODPDM512	
405 nm	$\lambda/5$	25 ms / 33.3 ms	N/A	3 ms / 4 ms	400 – 850 nm
532 nm	$\lambda/7$	33.3 ms / 45 ms	7 ms / 10 ms	3.5 ms / 4.5 ms	400 – 850 nm
635 nm	$\lambda/8$	33.3 ms / 45 ms	12 ms / 16.7 ms	4 ms / 5 ms	400 – 850 nm
785 nm	$\lambda/10$	55.5 / 80 ms	17.2 ms / 22.2 ms	4.5 ms / 5.5 ms	600 – 1300 nm
1064 nm	$\lambda/10$	66.7 / 100 ms	10 ms / 16.7 ms	5 ms / 6 ms	600 – 1300 nm
1550 nm	$\lambda/12$	100 / 130 ms	20 ms / 28.5 ms	6 ms / 7 ms	850 – 1650 nm

*Silicon backplane, performance varies as a function of wavelength.

Hardware Interface Options - Meadowlark Optics' SLMs come with multiple hardware interface options. For customers that prefer the computer to view the SLM as a secondary monitor, we offer a 16 bit DVI controller. For customers that require high speed operation and 16 bit addressing, we offer a PCIe 16-bit controller. For customers that require low latency transfers for OverDrive Plus we offer a PCIe 8-bit controller.



DVI 16-bit



Pcie 16-bit



Pcie 8-bit

512 x 512 Controller Models

Model	PCIe 8-bit	PCIe 16-bit	DVI 16-bit
Controller Phase Levels	256 / 8-bits	65,536 / 16-bits	65,536 / 16-bits
CPU to Controller Transfer Time (Computer Dependent)	0.6 ms	2.1 ms	16.7 ms