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## DIGITAL MICROMIRROR DEVICE IN HIGH RESOLUTION LAMP

### Abstract

Systems and method described herein are directed a digital micromirror device high resolution lamp system. The system can include an optical module. The optical module can be configured to dispose inside a headlamp. The optical module can include an array of micromirrors. The system can include one or more processors coupled with memory. The one or more processors can be configured to provide a beam of light. The beam of light can include an origin. The one or more processors can be configured to control a zone within the beam of light, using the array of micromirrors. The zone can be configured to project a graphic within the beam of light. The zone can include at least a 400:1 contrast ratio within at least a 20 degree by 10-degree field of view from the origin.

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## Background/Summary

CROSS REFERENCE TO RELATED PATENT APPLICATION [0001] The present application claims the benefit of and priority to U.S. Provisional Patent Application No. 63/553,336, filed Feb. 14, 2024, the disclosure of which is incorporated herein by reference in its entirety.

INTRODUCTION
[0002] Electric vehicles (EVs) can be powered using batteries that store energy to reduce greenhouse gas emissions. The batteries can include different components facilitating energy storage and distribution.
SUMMARY
[0003] At least one aspect can be directed to a digital micromirror device high resolution lamp system. The system can include an optical module. The optical module can be configured to dispose inside a lamp such as a headlamp, rear lamp, a signal lamp, fog lamp or other lamp. The optical module can include an array of micromirrors. The system can include one or more processors coupled with memory. The one or more processors can be configured to provide a beam of light. The beam of light can include an origin. The one or more processors can be configured to control a zone within the beam of light, using the array of micromirrors. The zone can be configured to project a graphic within the beam of light. The zone can include, for example, at least a 400:1 contrast ratio within at least a 20 degree by 10-degree field of view from the origin.
[0004] At least one aspect can be directed to a method. The method can include providing a beam of a light. The beam of light can include an origin. The method can include controlling a zone within the beam of light to project a graphic within the beam of light, using an array of micromirrors disposed within an optical module. The zone can include at least a 400:1 contrast ratio within at least a 20 degree by 10-degree field of view from the origin.
[0005] At least one aspect can be directed to an electric vehicle. The electric vehicle include a digital micromirror device high resolution lamp system. The system can include an optical module. The optical module can be configured to dispose inside a headlamp. The optical module can include an array of micromirrors. The system can include one or more processors coupled with memory. The one or more processors can be configured to provide a beam of light. The beam of light can include an origin. The one or more processors can be configured to control a zone within the beam of light, using the array of micromirrors. The zone can be configured to project a graphic within the beam of light. The zone can include at least a 400:1 contrast ratio within at least a 20 degree by 10-degree field of view from the origin.
[0006] These and other aspects and implementations are discussed in detail below. The foregoing information and the following detailed description include illustrative examples of various aspects and implementations and provide an overview or framework for understanding the nature and character of the claimed aspects and implementations. The drawings provide illustration and a further understanding of the various aspects and implementations and are incorporated in and constitute a part of this specification. The foregoing information and the following detailed description and drawings include illustrative examples and should not be considered as limiting.

## Description

## BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The accompanying drawings are not intended to be drawn to scale. Like reference numbers and designations in the various drawings indicate like elements. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

[0008] FIG. **1**A depicts an example of a system for a digital micromirror device (DMD) high resolution lamp;

[0009] FIG. **1**B depicts an example of an array of micromirrors for the DMD high resolution lamp;

[0010] FIG. **1**C depicts another example of the array of micromirrors for the DMD high resolution lamp;

[0011] FIG. **2**A depicts an example cross-sectional view of an electric vehicle;

[0012] FIG. **2**B depicts an example of the DMD high resolution lamp;

[0013] FIG. **2**C depicts another example of the DMD high resolution lamp;

[0014] FIG. **3** depicts an example of a high-definition area of the electric vehicle;

[0015] FIG. **4** is a flow diagram illustrating an example method of executing the DMD high resolution lamp; and

[0016] FIG. **5** depicts an example of a computer system within the electric vehicle.

## DETAILED DESCRIPTION

[0017] Following below are more detailed descriptions of various concepts related to, and implementations of, methods, apparatuses, and systems of integrating a digital micromirror device into a high-resolution lamp of an electric vehicle. The various concepts introduced above and discussed in greater detail below may be implemented in any of numerous ways.

[0018] This disclosure is generally directed to a digital micromirror device (DMD) high resolution lamp. Vehicles configured to produce a high-resolution light beam from a headlamp can be limited in a size or ratio of the high-definition light beam due to insufficient quantities of micromirrors and challenges associated with adding additional micromirrors. Adding additional micromirrors to a headlamp configuration can face technical and other challenges associated with size constraints of a headlamp enclosure and excessive heat output by the micromirrors. The headlamp enclosure can define a form factor for an array of micromirrors which is difficult to achieve with large amounts of micromirrors. Furthermore, excessive heat generated by controlling large amounts of micromirrors can harm the operation of the micromirror array by causing dielectrics of the micromirrors to become sticky, preventing the micromirrors from flipping states.

[0019] This technical solution provides a system that can emit a light beam including a high-definition area greater than a threshold size or resolution from a headlamp of a vehicle. The system can project images through the high-definition area to display on a surface. To perform these functionalities, the system can control subsets of an array including 1.2-1.5 million micromirrors. The array can include different examples of micromirrors, for example greater than 1.5 million micromirrors. By controlling the subsets of the array as pixels, the system can enable a projection of a high-definition area within a light beam from a headlamp of a vehicle in a greater ratio or size than conventional systems. The system can include advanced optical components designed to sustain the area of micromirrors, such as a particular lens, light absorber, and light-emitting diode to enable the projection of the high-definition area within the light beam.

[0020] Thus, this technical solution can provide a high-definition light beam above a certain size without compromising resolution, generating excessive heat, or wasting power. Furthermore, the high-definition light beam can be configured to project from a headlamp of a vehicle, thereby conforming to a smaller form factor which can further reduce wasted resources.

[0021] FIG. **1** depicts an example of a system **100** for a digital micromirror device (DMD) high resolution lamp. The system **100** can include a data processing system **102**, a vehicle **116** (sometimes referred to as "electric vehicle **116**" herein), and an optical module **120**. The above-mentioned components may be connected to each other through a network **101**. The examples of the network **101** may include, but are not limited to, private or public LAN, WLAN, MAN, WAN, and the Internet. The network **101** may include both wired and wireless communications according to one or more standards and/or via one or more transport mediums.

[0022] The communication over the network **101** may be performed in accordance with various communication protocols such as Transmission Control Protocol and Internet Protocol (TCP/IP), User Datagram Protocol (UDP), and IEEE communication protocols. In one example, the network **101** may include wireless communications according to Bluetooth specification sets, or another standard or proprietary wireless communication protocol. In another example, the network **101** may also include communications over a cellular network, including, e.g., a GSM (Global System for Mobile Communications), CDMA (Code Division Multiple Access), EDGE (Enhanced Data for Global Evolution) network.

[0023] The system **100** is not confined to the components described herein and may include additional or alternate components, not shown for brevity, which are to be considered within the scope of the embodiments described herein.

[0024] The system **100** can include at least one optical module **120**. The optical module **120** can be disposed in a headlamp **118**. The headlamp **118** may illuminate a road ahead of a driver of the vehicle **116**. The headlamp **118** can be located at the front of the vehicle **116**. For example, a headlamp **118** can be located at the front of a vehicle **116**. The headlamp **118** can include at least a low beam and a high beam setting. For example, a headlamp **118** with a low beam setting may illuminate a road in front of a vehicle **116**, whereas a high beam setting can produce a brighter illumination of the road in front of the vehicle **116**. The headlamp **118** can automatically turn on while the vehicle **116** is in motion during the day. For example, a headlamp **118** can automatically turn on while a vehicle **116** is in motion.

[0025] Referring to FIG. **1** and FIG. **2**A. FIG. **2**A depicts an example cross-sectional view **200** of an electric vehicle **116** installed with at least one battery pack **202**. Electric vehicles **116** can include electric trucks, electric sport utility vehicles (SUVs), electric delivery vans, electric automobiles, electric cars, electric motorcycles, electric scooters, electric passenger vehicles, electric passenger or commercial trucks, hybrid vehicles, or other vehicles such as sea or air transport vehicles, planes, helicopters, submarines, boats, or drones, among other possibilities. The battery pack **202** can also be used as an energy storage system to power a building, such as a residential home or commercial building. Electric vehicles **116** can be fully electric or partially electric (e.g., plug-in hybrid) and further, electric vehicles **116** can be fully autonomous, partially autonomous, or unmanned.

[0026] Electric vehicles **116** can also be human operated or non-autonomous. Electric vehicles **116** such as electric trucks or automobiles can include on-board battery packs **202**, battery modules **204**, or battery cells **206** to power the electric vehicles **116**. The electric vehicle **116** can include a chassis **208** (e.g., a frame, internal frame, or support structure). The chassis **208** can support various components of the electric vehicle **116**. The chassis **208** can span a front portion **210** (e.g., a hood or bonnet portion), a body portion **212**, and a rear portion **214** (e.g., a trunk, payload, or boot portion) of the electric vehicle **116**. The battery pack **202** can be installed or placed within the electric vehicle **116**. For example, the battery pack **202** can be installed on the chassis **208** of the electric vehicle **116** within one or more of the front portions **210**, the body portion **212**, or the rear portion **214**.

[0027] The battery pack **202** can include or connect with at least one busbar, e.g., a current collector element. The first busbar **216** and the second busbar **218** can include electrically conductive material to connect or otherwise electrically couple the battery modules **204** or the battery cells **206** with other electrical components of the electric vehicle **116** to provide electrical power to various systems or components of the electric vehicle **116**. The battery pack **202** can provide power to the any components described in system **100**. For example, the battery cells **206** or the battery modules **218** can connect with other electrical components of the electric vehicle **116** to provide electrical power to various systems or components of the electric vehicle **116**.

[0028] Referring to FIG. **1** and FIGS. **2**B-**2**C, FIGS. **2**B-**2**C depict examples of the DMD high resolution lamp such as headlamp **118**. The headlamp **118** can include four optical modules **120** as shown in FIG. **2**B. For example, a headlamp **118** of an electric vehicle **116** can include four optical modules **120** disposed within the headlamp **118**. The headlamp **118** can include three optical modules **120** as shown in FIG. **2**C, as well as other numbers of optical modules **120**. For example, a headlamp **118** of an electric vehicle **116** can include three optical modules **120** disposed within the headlamp **118**. The three optical module headlamp **118** can create a more powerful beam of light in comparison to the four optical module headlamp. Each optical module **120** in the four optical module headlamp **118** can include a greater number of micromirrors in comparison to the three optical module headlamp. The headlamp **118** can be placed at the rear of the electric vehicle **116**. For example, a rear headlamp **118** with three optical modules **120** can be placed at the rear of an electric vehicle **116**. The digital micromirror device described herein can integrate into or be disposed within the headlamp **118**. For example, an array of micromirrors **122** can be located within the optical module **120** or within one or more cavities of the headlamp **118** in a symmetrical, asymmetrical, two dimensional, or three-dimensional arrangement to allow for directional or intensity control of emitted light out from the headlamp **118**.

[0029] The headlamp **118** can include a stadium shape as shown in FIGS. **2**B-**2**C. The stadium shape can include two parallel lines and two semicircles as shown in FIGS. **2**B-**2**C. The stadium shape can be a curved or elliptical like design. The stadium shape of the headlamp **118** can include a depth resembling a bowl. The stadium shape can include angular contours and sharp edges to form the bowl. One or more optical modules **120** can be disposed along a vertical axis within the headlamp **118**. The processor **130** can direct electrical energy to illuminate the headlamp **118** to provide the light beam **220**. The processor **130** can use the optical module **120** to provide the light beam **220**. For example, the processor **130** can control the optical module **120** to adjust the array of micromirrors **122** to provide the light beam **220**.

[0030] The system **100** can include at least one array of micromirrors **122** located within the optical module **120**. The array of micromirrors **122** can be a plurality of micromirrors **122** arranged in a structured pattern and each micromirror **122** in the plurality of micromirrors **122** may have a dimensionality in micrometers. For example, a plurality of micromirrors **122** may include 1.2 million to 1.6 million micromirrors **122**. The array of micromirrors **122** can be disposed along the optical module **120**. For example, an array of micromirrors **122** can be arranged within the optical module **120**. The optical module **120** can include at least one lens **124**, light source **126**, and light absorber **128**.

[0031] Referring now to FIG. **1**A and FIG. **1**B, FIG. **1**B depicts an example **140** of the array of micromirrors **122** for the DMD high resolution lamp. In the optical module **120** of the headlamp **118**, the array of micromirrors **122** can include the plurality of micromirrors (e.g., micromirrors **122**A-M, micromirrors **122**A-N). Electronic circuits, one or more processors (e.g., processor **130**, pixel controller **106**) can control each micromirror **122** in the array of micromirrors **122**. Each micromirror can include an orientation and a tilt. The orientation defines a degree of rotation for each micromirror **122**. The tilt defines a level of elevation (i.e., raise or lower) for each micromirror **122**. Each micromirror **122** can rotate between 0 and 90 degrees. In example **140**, each micromirror **122** is at 0 degrees. Referring now to FIG. **1**C, FIG. **1**C depicts another example **180** of the array of micromirrors **122** for the DMD high resolution lamp. Example **180** shows each micromirror **122** with various tilts and orientations. For example, a first set of micromirrors **122** can elevate to a first angle of elevation and a second set of micromirrors can elevate to a second angle of elevation. In another example a first set of micromirrors **122** can rotate to a first degree of rotation and a second set of micromirrors can rotate to a second degree of rotation.

[0032] Referring again to FIG. **1**, the system **100** can include at least one processor **130** within the data processing system **102**. The data processing system **102** can include a physical computer system operatively coupled or that can be coupled with one or more components of the system **100**, either directly or through an intermediate computing device or system. The data processing system **102** can include a virtual computing system, an operating system, and a communication bus to effect communication and processing. The data processing system **102** can include at least one processor **130**, state selector **104**, pixel controller **106**, projector **108**, and memory **110**.

[0033] The processor **130** can execute one or more instructions associated with the system **100**. The processor **130** can include an electronic processor, an integrated circuit, or the like including one or more of digital logic, analog logic, digital sensors, analog sensors, communication buses, volatile memory, nonvolatile memory, and the like. The processor **130** can include, but is not limited to, at least one microcontroller unit (MCU), microprocessor unit (MPU), central processing unit (CPU), graphics processing unit (GPU), physics processing unit (PPU), embedded controller (EC), or the like. The processor **130** can include a memory operable to store or storing one or more instructions for operating components of the processor **130** and operating components operably coupled to the processor **130**. For example, the one or more instructions can include one or more of firmware, software, hardware, operating systems, embedded operating systems. The processor **130** or the system **100** generally can include one or more communication bus controller to effect communication between the processor **130** and the other elements of the system **100**.

[0034] The system **100** can include at least one memory **110** within the data processing system **102**. The memory **110** can be coupled to the processor **130**. The memory **110** can store data associated with the system **100**. The memory **110** can include one or more hardware memory devices to store binary data, digital data, or the like. The memory **110** can include one or more electrical components, electronic components, programmable electronic components, reprogrammable electronic components, integrated circuits, semiconductor devices, flip flops, arithmetic units, or the like. The memory **110** can include at least one of a non-volatile memory device, a solid-state memory device, a flash memory device, and a NAND memory device. The memory **110** can include one or more addressable memory regions disposed on one or more physical memory arrays. A physical memory array can include a NAND gate array disposed on, for example, at least one of a particular semiconductor device, integrated circuit device, or printed circuit board device. The memory **110** can include images **112** and states **114**.

[0035] The processor **130** and the memory **110** can provide at least one beam of light. To provide the beam of light (referred to as light beam **220** herein), the processor **130** can communicate, via the network **101**, with the optical module **120**. For example, a processor **130** can transmit an instruction to an optical module **120** to provide a light beam **220**. The optical module **120** can include a light source **126**. The light source **126** can be a component of the optical module **120** responsible for generating light. For example, an optical module **120** may trigger a light source **126** to produce a plurality of light rays to generate light. The light source **126** can be at least one of but is not limited to a light emitting diode (LED), a laser diode, an incandescent lamp, a halogen lamp, a white light source, or a phosphor converted LED, among others. For example, a light source **126** can be a LED. In another example, a light source **126** can be a laser diode.

[0036] The optical module **120** can include at least one lens **124** to control propagation of the light source **126**. The lens **124** may control the propagation of the light source **126** through the concept of refraction. The concepts of refraction can include focusing (e.g., convergence and divergence of the light source **126**), collimating (e.g., control the divergence of light, ensure light rays are parallel), and beam shaping (e.g., altering intensity distribution, divergence, or convergence). For example, a lens **124** may be in the shape of a concave (e.g., divergence) to cause parallel light rays from a light source **126** to diverge from a focal point. The optimal module **120** can include a plurality of lenses **124** to achieve a desired performance.

[0037] The light beam **220** can include at least one origin **224** within the headlamp **118**. The origin **224** of the light beam **220** can be a point, apex, or a focal point at which the light beam **220** begins propagation from the light source **126**. For example, an origin **224** of a light beam **220** can be the starting point of the light beam **220**. The origin **224** can be located after the optical module **120** to allow the light beam **220** to propagate from the light source **126** located within the optical module **120**. The origin **224** can be placed based on the characteristics of the light source **126**. For example, for brighter light source **126** may have an origin **224** closer to the front of a vehicle to illuminate a larger area.

[0038] The light beam **220** can converge at the origin **224** after emitting from the light source **126**. The design of the lens **124** can dictate the position of the origin **224** to maximize illumination efficiency and visibility for the driver, occupant, or operator of the electric vehicle **116**. The origin **224** can cause the headlamp **118** to provide an evenly distributed light beam **220** to enhance visibility without cause a glare or blind oncoming drivers. By controlling the placement of the origin **224**, the electric vehicle **116** can control light intensity and beam shape of the light beam **220**.

[0039] The system **100** can include at least one pixel controller **106** within the data processing system **102**. The pixel controller **106** can have the same structure and hardware components as the processor **130**. The pixel controller **106** can use the array of micromirrors **122** to control a zone (referred to as high-definition area **222** herein) within the light beam **220**. To use the array of micromirrors **122**, the pixel controller **116** may be configured to control at least one micromirror **122** of the array of micromirrors **122**. The pixel controller **106** controlling at least one micromirror **122** in unison can define a pixel. For example, a pixel controller **106** can adjust the pattern of two micromirrors **122** in the array of micromirrors **122**. In another example, a pixel controller **106** can adjust the pattern of fifty micromirrors **122** in the array of micromirrors **122**.

[0040] The pixel can be an element that corresponds to at least one micromirror **122** in the array of micromirrors **122** used in unison. For example, two micromirrors **122** controlled by a pixel controller **106**, can define a pixel. In another example, 50,000 micromirrors **122** controlled by a pixel controller **106**, can define a plurality of pixels. The pixel controller **106** can be configured to control a plurality of pixels. For example, a pixel controller **106** can control 900,000 pixels. In another example, a pixel controller **106** can control 975,000 pixels. In yet another example, a pixel controller **106** can control 990,980 pixels. In yet another example, a pixel controller **106** can control 1 million pixels.

[0041] Controlling the pixels can require the pixel controller **106** to adjust or tilt at least one micromirror **122** in the array of micromirrors **122**. The pixel controller **106** can determine an angle at which to tilt each micromirror **122** in the array of micromirrors **122**. For example, a pixel controller **106** can tilt at least one micromirror **122** to have an angle 2 degrees. In another example, a pixel controller **106** can tilt a first set of at least one micromirror **122** to 13 degrees and tilt a second set of micromirrors **122** to 15 degrees. To determine the angle, the processor **130** may transmit a signal to the pixel controller **106** in response to the processor **130** detecting an oncoming vehicle **116**. The signal may include a distance of the oncoming vehicle, a size of the coming vehicle, and a speed of the oncoming vehicle. Using the distance, the speed, and the size, the pixel controller **116** may calculate the angle to tilt or adjust the micromirrors **122**. The pixels can define a resolution for the array of micromirrors **122**. For example, a resolution for an array of micromirrors **122** can be 9:5, where there are 9 micromirrors **112** in a horizontal (or first) direction for every 5 micromirrors **112** in a vertical (or second) direction.

[0042] The system **100** can include at least one state selector **104** within the data processing system **102**. The state selector **104** can have the same structure and hardware components as the processor **130**. The state selector **104** can receive instructions or signals from the pixel controller **106** to change a state **114** of one or more micromirrors **122** in the array of micromirrors **122**. For example, to control a pixel, a pixel controller **106** can send a first signal to a state sector **104** to tilt one or more micromirrors **122** in an array of micromirrors **122** to change to a first state **114**. During a future time period, the pixel controller **106** can send a second signal to the state sector **104** to tilt the one or more micromirrors **122** in the array of micromirrors **122** to change to a second state **114**.

Tilting the array of micromirrors **122** can be interchangeable with change the state of the array of micromirrors **122**.

[0043] In response to the state selector **104** receiving an instruction or signal from the pixel controller **106**, the state selector **104** can communicate with the memory **110** to select one state **114** from the states **114**. Each state **114** within the states **114** in memory **110** can correspond to an angle tilt one or more micromirrors **122** in the array of micromirrors **122**. For example, one state **114** can correspond to a two-degree tilt of one or more micromirrors **122**. In another example, one state **114** can correspond to a 15-degree tilt of one or more micromirrors **122**. In yet another example, one state **114** can correspond to a 30-degree tilt of one or more micromirrors **122**. The signal sent by the pixel controller **106** can indicate a number of degrees to tilt one or more micromirrors **122**. For example, the signal can indicate that the one or more micromirrors **122** should be tilted to 11 degrees.

[0044] The pixel controller **106** or the processor **130** can control the high-definition area **222** within the light beam **220**. To control the high-definition area **222**, the pixel controller **106** or the processor **130** can use the array of micromirrors **122**. The high-definition area **222** can be an have a dimensionality within the light beam **220** where objects, structures, and/or landscapes are emphasized. The dimensionality can include clearer images of the objects, structures, and/or landscapes. For example, an oncoming vehicle **116** within the high-definition area **222** may be clearer to an operator of an incoming vehicle **116**.

[0045] Referring to FIG. **2** and FIG. **3**, FIG. **3** depicts an example **300** of a high-definition area **222** of the electric vehicle **116**. The high-definition area **222** can include a contrast ratio of at least 400:1 within the light beam **220** as seen in example **300**. For example, a high definition area **222** can include a contrast ratio of 400:1. In another example, a high definition area **222** can include a contrast ratio of 500:1. In yet another example, a high definition area **222** can include a contrast ratio of 600:1. The contrast ratio can be within at least a 20 degree by 10 degree field of view from the origin **224** of the light source **126**. For example, a contrast ratio can be within a 20 degree by 10-degree field of view from the origin **224**. In another example, a contrast ratio can be within a 30 degree by 20-degree field of view from an origin **224** from the light source **126**. In yet another example, a contrast ratio can be within a 40 degree by 20-degree field of view from an origin **224** from the light source **126**.

[0046] The high-definition area **222** can include at least 1000 lumens. For example, a high-definition area **222** can include 1000 lumens. In another example, a high-definition area **222** can include 2000 lumens. In yet another example, a high-definition area **222** can include 5000 lumens. A lumen can be a unit of measurement to establish a total amount of visible light emitted by the light source **126**. The lumen can measure the brightness of the light source **126** perceived by a human eye. For example, a light source **126** with 5000 lumens may be brighter than a light source **126** with 1000 lumens. In another example, a light source **126** with 5000 lumens may be similar than a light source **126** with 5000 lumens.

[0047] The system **100** can include at least one light absorber **128** with the optical module **120**. The light absorber **128** can absorb or attenuate the light beam **200** within a wavelength range. The light absorber **128** can reduce stray light that can interfere with an image **112**. For example, a light absorber **128** can include one or more sensors to minimize stray light to improve an image **112**. The light absorber **128** can reduce flare that may reflect of objects, vehicles **116**, landscapes, and surfaces. For example, a light absorber **128** may absorb reflected light to reduce flare. The light absorber **128** can employ thermal control for the optical module **120**. For example, a light absorber **128** can dissipate absorbed light as heat to manage temperature with an optical module **120**.

[0048] The optical module **120** can include one or more sensors to detect objects in front of the vehicle **116**. For example, a sensor within an optical module **120** can detect an oncoming vehicle **116** in front of the vehicle **116**. In another example, a sensor can detect a pedestrian walking in front of the vehicle **116**. In yet another example, a sensor can detect a street sign on the side of the road, in front of the vehicle **116**. The one or more sensors can be configured to detect object up to a certain distance away from the vehicle. For example, a sensor can detect objects up to 10 meters away. In another example, a sensor can detect objects up to 15 meters away.

[0049] In response to detecting objects in front of the vehicle **116**, the light absorber **128** can employ one or more light traps to create an excluded zone **302** with the high-definition area **222**. The excluded zone **302** can be an area where the one or more light traps have removed all light at specific angles from the origin **224**. For example, a sensor of an optical module **102** can detect an oncoming vehicle **116** at an angle of 35 degrees from the origin **224** of a vehicle **116**. Therefore, the optical module **120** can trigger a light absorber **128** to employ one or more light traps to absorb all light that would normally travel at an angle of 35 degrees and prevent a light beam **220** from reaching the oncoming vehicle **116**.

[0050] The optical module **120** can use sensors to calculate a shape for the excluded zone **302**. The shape can be at least one of a square, a rectangle, a circle, or an ellipse, among others. For example, if a pedestrian is further away from a vehicle **116**, a sensor may calculate a square for an excluded zone **302**, whereas a sensor may calculate a rectangle for the excluded zone **302** when the pedestrian is closer to the vehicle **116**. The sensor can constantly update the excluded zone **302** if the object is in motion. For example, a sensor of the optical module **120** calculate a square for an excluded zone **302** for an oncoming vehicle **116**, as the oncoming vehicle approaches an electric vehicle **116**, the excluded zone **302** can get bigger.

[0051] The system **100** can include the projector **108** within the data processing system **102**. The projector **108** can have the same structure and hardware components as the processor **130**. The projector **108** can receive instructions or signals from the pixel controller **106** to project a graphic **304** within the light beam **220**. For example, a pixel controller **106** can send a signal to a projector **108** to generate a graphic **304** based on the array of micromirrors **122**. The graphic **304** can be a visual element to represent information or to improve communication. The graphic **304** can include images **112**, signals, or markers, among others to represent an action of the vehicle **116**. For example, a graphic **304** can be an arrow. In another example, a graphic **304** can be a number. In yet another example, a graphic **304** can be a phrase saying, "Turning Right." The graphic **304** can be a hazard indicator (as shown in FIG. **3**) for a pothole, object, or dangerous occurrence on the road. For example, the light beam **220** can project a graphic **304** (e.g., hazard indicator) in response to the detection of a pothole.

[0052] The projector **108** can send a signal to the pixel controller **106** to generate the graphic **304**. For example, a projector **108** can send a signal to the pixel controller **106** including a graphic **304**. The pixel controller **106** can trigger one or more micromirrors **122** to change the state **114**. An optical module **120** can project the graphic **304** from the light source **126**. The projector **108** can communicate with other systems of the electric vehicle **116** to trigger the graphic **304** in response to actions taken by a driver of the electric vehicle **116**. For example, a driver of an electric vehicle **116** can use a right turn signal to turn right. A projector **108** may receive the signal and send a right arrow as a graphic **304** to a pixel controller **106** to project the right arrow to pedestrians and other vehicles **116**.

[0053] FIG. **4** depicts a flow diagram illustrating an example method of executing the DMD high resolution lamp. The method **400** can be performed by system **100**, a battery back **206**, one or more processors (e.g., processor **130**, pixel controller **106**, state selector **104**, projector **108**) or an electric vehicle **116**. At ACT **402**, the method **400** can include providing a beam of light. At ACT **404**, the method **400** can include controlling a zone within the beam of light.

[0054] At ACT **402**, the method **400** can include providing a beam of light where the beam of light includes an origin **224**. The method can include disposing an optical module (e.g., optical module **120**) within a headlamp (e.g., headlamp **116**). The method can include powering on the headlamp to provide the beam of light. The method can include generating the beam of light using a light source (e.g., light source **126**) of the optical module. The method can include adjusting a lens (e.g., lens **124**) within the optical module to arrange the beam of light. The method can include using a light absorber (e.g., **128**) to sharpen the beam of light.

[0055] At ACT **404**, the method **400** can include controlling a zone within the beam of light to provide a graphic within the beam of light. The zone can include a contrast ratio of at least 400:1 within at least a 20 degree by 10-degree field of view from the origin. The zone can have the contrast ratio within 400:1 and 600:1. The zone can have one 1000 lumens. The graphic can be an image (e.g., images **112**) indicative of an action a vehicle. The method can include using an array of micromirrors (e.g., micromirrors **122**). The array of micromirrors includes 1.2 million to 1.5 million micromirrors. The method can include controlling at least one micromirrors of the array of micromirrors in unison to define a pixel. The pixel can include micromirrors at a resolution of 9:5. The method can include controlling the array of micromirrors by changing one or more micromirrors of the array of micromirrors from a first state (e.g., states **114**) to a second state (e.g., states **114**).

[0056] FIG. **5** depicts an example of a computer system **500** within the electric vehicle **116**. The computer system **500** can have the same functionality of the data processing system **102** described herein. The computer system **500** can include a bus **502**, main memory **504**, ROM **506**, a storage device **508** and a processor **130**. The computing system **500** can communicate with a display **512** and an input device **510**. The main memory **504**, ROM **506**, and the storage device **508** can be the memory **110** or be located within the memory **110**. The bus **502** can be any communication bus described herein to effect communication and processing. The display **512** can be any user interface including the one or more UI elements to a user of the electric vehicle **116** in accordance with a configuration the display **512**. The UI elements may correspond to visual components of the user interface, such as a command button, a text box, a check box, a radio button, a menu item, and a slider, among others.

[0057] Example and non-limiting module implementation elements include sensors providing any value determined herein, sensors providing any value that is a precursor to a value determined herein, datalink or network hardware including communication chips, oscillating crystals, communication links, cables, twisted pair wiring, coaxial wiring, shielded wiring, transmitters, receivers, or transceivers, logic circuits, hard-wired logic circuits, reconfigurable logic circuits in a particular non-transient state configured according to the module specification, any actuator including at least an electrical, hydraulic, or pneumatic actuator, a solenoid, an op-amp, analog control elements (springs, filters, integrators, adders, dividers, gain elements), or digital control elements.

[0058] While operations are depicted in the drawings in a particular order, such operations are not required to be performed in the particular order shown or in sequential order, and all illustrated operations are not required to be performed. Actions described herein can be performed in a different order.

[0059] Having now described some illustrative implementations, it is apparent that the foregoing is illustrative and not limiting, having been presented by way of example. In particular, although many of the examples presented herein involve specific combinations of method acts or system elements, those acts and those elements may be combined in other ways to accomplish the same objectives. Acts, elements and features discussed in connection with one implementation are not intended to be excluded from a similar role in other implementations or implementations.

[0060] The phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including” “comprising” “having” “containing” “involving” “characterized by” “characterized in that” and variations thereof herein, is meant to encompass the items listed thereafter, equivalents thereof, and additional items, as well as alternate implementations consisting of the items listed thereafter exclusively. In one implementation, the systems and methods described herein consist of one, each combination of more than one, or all of the described elements, acts, or components.

[0061] Any references to implementations or elements or acts of the systems and methods herein referred to in the singular may also embrace implementations including a plurality of these elements, and any references in plural to any implementation or element or act herein may also embrace implementations including only a single element. References in the singular or plural form are not intended to limit the presently disclosed systems or methods, their components, acts, or elements to single or plural configurations. References to any act or element being based on any information, act or element may include implementations where the act or element is based at least in part on any information, act, or element.
[0062] Any implementation disclosed herein may be combined with any other implementation or embodiment, and references to “an implementation,” “some implementations,” “one implementation” or the like are not necessarily mutually exclusive and are intended to indicate that a particular feature, structure, or characteristic described in connection with the implementation may be included in at least one implementation or embodiment. Such terms as used herein are not necessarily all referring to the same implementation. Any implementation may be combined with any other implementation, inclusively or exclusively, in any manner consistent with the aspects and implementations disclosed herein.
[0063] References to “or” may be construed as inclusive so that any terms described using “or” may indicate any of a single, more than one, and all of the described terms. References to at least one of a conjunctive list of terms may be construed as an inclusive OR to indicate any of a single, more than one, and all of the described terms. For example, a reference to “at least one of ‘A’ and ‘B’” can include only ‘A’, only ‘B’, as well as both ‘A’ and ‘B’. Such references used in conjunction with “comprising” or other open terminology can include additional items.
[0064] Where technical features in the drawings, detailed description or any claim are followed by reference signs, the reference signs have been included to increase the intelligibility of the drawings, detailed description, and claims. Accordingly, neither the reference signs nor their absence have any limiting effect on the scope of any claim elements.
[0065] Modifications of described elements and acts such as variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations can occur without materially departing from the teachings and advantages of the subject matter disclosed herein. For example, elements shown as integrally formed can be constructed of multiple parts or elements, the position of elements can be reversed or otherwise varied, and the nature or number of discrete elements or positions can be altered or varied. Other substitutions, modifications, changes and omissions can also be made in the design, operating conditions and arrangement of the disclosed elements and operations without departing from the scope of the present disclosure.
[0066] For example, descriptions of positive and negative electrical characteristics may be reversed. For example, negative busbar and a positive busbar can be reversed, as well as negative current collector and the positive current collector. Elements described as negative elements can instead be configured as positive elements and elements described as positive elements can instead by configured as negative elements. For example, elements described as having first polarity can instead have a second polarity, and elements described as having a second polarity can instead have a first polarity. Further relative parallel, perpendicular, vertical or other positioning or orientation descriptions include variations within +/−10% or +/−10 degrees of pure vertical, parallel or perpendicular positioning. References to “approximately,” “substantially” or other terms of degree include variations of +/−10% from the given measurement, unit, or range unless explicitly indicated otherwise. Coupled elements can be electrically, mechanically, or physically coupled with one another directly or with intervening elements. Scope of the systems and methods described herein is thus indicated by the appended claims, rather than the foregoing description, and changes that come within the meaning and range of equivalency of the claims are embraced therein.

## Claims

**1**. A system, comprising: an optical module configured to dispose in a headlamp, the optical module comprising an array of micromirrors; and one or more processors coupled with memory, configured to: provide a beam of light comprising an origin; control, using the array of micromirrors, a zone within the beam of light configured to project a graphic within the beam of light; detect an object within the zone; and control a subset of the array of micromirrors to create an excluded zone that includes the object by preventing light from reflecting from the subset of the array of micromirrors into the excluded zone, the subset of the array of micromirrors configured to prevent at least a portion of the beam of light from reaching the object within the zone.
**2**. The system of claim 1, wherein the zone has at least a 400:1 contrast ratio within at least a 20 degrees by 10 degrees field of view from the origin.
**3**. The system of claim 1, comprising: the one or more processors configured to control between 900,000 to 1 million pixels and wherein each pixel comprises at least one micromirror of the array of micromirrors.
**4**. The system of claim 1, comprising: the one or more processors configured to control the array of micromirrors by changing one or more micromirrors of the array of micromirrors from a first state to a second state.
**5**. The system of claim 1, wherein the array of micromirrors comprises between 1.2 million to 1.5 million micromirrors.
**6**. The system of claim 1, wherein the zone has a contrast ratio between 400:1 and 600:1.
**7**. The system of claim 1, wherein the pixel comprises micromirrors at a resolution of 9:5.
**8**. The system of claim 1, wherein the one or more processors are configured to illuminate the beam of light from the headlamp including the optical module, wherein the shape of the headlamp is a stadium shape.
**9**. The system of claim 1, wherein the one or more processors are configured to adjust an angle of at least one micromirror of the array of micromirrors in unison to define a pixel.
**10**. The system of claim 1, wherein the optical module is disposed within the headlamp.
**11**. A method, comprising: providing, by one or more processors coupled with memory, a beam of light comprising an origin; controlling, by the one or more processors using an array of micromirrors disposed within an optical module, a zone within the beam of light to project a graphic within the beam of light; detecting, by the one or more processors an object within the zone; controlling, by the one or more processors, a subset of the array of micromirrors to create an excluded zone that includes the object by preventing light from reflecting from the subset of the array of micromirrors into the excluded zone; and preventing, by the one or more processors using the subset of the array of micromirrors, at least a portion of the beam of light from reaching the object within the zone.
**12**. The method of claim 11, wherein the zone has at least a 400:1 contrast ratio within at least a 20 degrees by 10 degrees field of view from the origin.
**13**. The method of claim 11, comprising: controlling, by the one or more processors, between 900,000 to 1 million pixels and wherein each pixel comprises at least one micromirror of the array of micromirrors.
**14**. The method of claim 11, wherein the one or more processors are configured to control the array of micromirrors by changing one or more micromirrors of the array of micromirrors from a first state to a second state.
**15**. The method of claim 11, wherein the array of micromirrors comprises between 1.2 million to 1.5 million micromirrors.
**16**. The method of claim 11, wherein the zone has a contrast ratio between 400:1 and 600:1.
**17**. The method of claim 11, wherein the one or more processors are configured to control at least

one light source to illuminate the beam of light from a headlamp including the optical module, the headlamp having a shape, wherein the shape of the headlamp is a stadium shape.

**18**. The method of claim 11, wherein the one or more processors are configured adjust an angle of at least one micromirror of the array of micromirrors in unison to define a pixel.

**19**. An electric vehicle, comprising: an optical module configured to dispose in a headlamp of the electric vehicle, the optical module comprising an array of micromirrors; and one or more processors coupled with memory, configured to: provide a beam of light comprising an origin; control, using the array of micromirrors, a zone within the beam of light configured to project a graphic within the beam of light; detect an object within the zone; and control a subset of the array of micromirrors to create an excluded zone that includes the object by preventing light from reflecting from the subset of the array of micromirrors into the excluded zone, the subset of the array of micromirrors configured to prevent at least a portion of the beam of light from reaching the object within the zone.

**20**. The electric vehicle of claim 19, wherein the zone has at least a 400:1 contrast ratio within at least a 20 degrees by 10 degrees field of view from the origin.