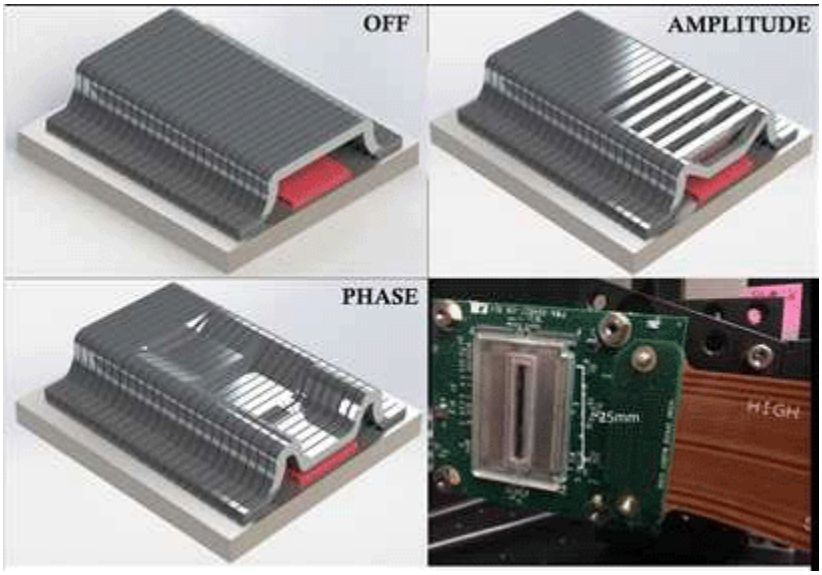
Docket #: S18-327

MEMS phased array for high-speed, random access variable focusing and control for LIDAR and 3D imaging

Engineers in the Solgaard lab have developed a high-speed, random access grating light valve (GLV) for phase modulation to steer and focus light in LIDAR and 3D imaging applications. This MEMS-based phased array technology uses small voltages to control independently addressable silicon ribbons that act as a diffraction grating for a pulsed laser light. This enables beams to be steered to any of the possible positions from any other position and in any order with refresh rates up to 350 kHz.

Beam scanners using GLV have a large field of view (FOV) and are smaller, lower cost and more robust than conventional modulators. This optical remote sensing technology could enable LIDARs with unique capabilities for tracking objects at high speed for applications in autonomous control and machine learning and vision.



Phased Array for Random Access Scanning: *Model of phased array with silicon ribbons in passive state (off) and active operation (amplitude and phase). By controlling the ribbon with small voltages, the device acts as a diffraction grating for pulsed laser light.*

Stage of Development

The inventors have demonstrated proof of concept for random access of variable-depth focusing and steering of a non-patterned line with a high-speed linear MEMS phase modulator with 1088 electronically addressable elements (silicon nitride ribbons). This device was capable of random access scanning at 350 kHz in a Fourier regime and achieved 725 scan lines with a .9 degree field of view (FOV), with an expected far field response of 660 lines with an 18 degree FOV after magnification. Inventors have built a proof of concept 3D varifocal display. Further research extending device resolution and field of view will improve 3D imaging and demonstrate LIDAR imaging. The scanning and display principles are also being incorporated into a prototype microscope.

Applications

- **LIDAR or 3D imaging** - MEMS phased array device can be incorporated into a more complete sensing and control system for scanning a single pixel or complex patterned line at high speeds with end-user applications such as:
    - autonomous vehicles and drones – particularly in combination with slower and less precise radar to pinpoint and track areas of interest with higher speed and accuracy
    - machine vision and learning
    - microscopy - variable focus systems
    - direct view displays

Advantages

- **Random access control:**
    - beam can be steered to any of the possible positions from any other position in any order at full speed
    - random access scanning is not possible with conventional mechanical scanners

    - can be combined with slower or less precise modalities to improve overall performance features
- **High speed scanning and focusing** - refresh rates up to 350 kHz, faster than liquid crystal or tunable lenses
- **Compatible with free space optics** which is not possible with waveguide phased arrays
- **Advantages of MEMS phase array:**
    - robustness - immune to vibrations
    - reliable - hermetically packaged for reliable, long-term operation
    - large field of view (FOV) - scan lines with a .9 degree FOV and expected 18 degree FOV after magnification
    - compact - only small motion needed to create large scan angles
    - relatively low cost with simplified packaging

Publications

- Hamann, S., Ceballos, A., Landry, J., & Solgaard, O. (2018). "High-speed random access optical scanning using a linear MEMS phased array." *Optics letters*, 43(21), 5455-5458.
- Hamann, S., & Solgaard, O. (2018, July). "Variable Focusing and Steering Using High Speed MEMS Phased Array." In 2018 International Conference on Optical MEMS and Nanophotonics (OMN) (pp. 1-2). IEEE.
- Hamann, S. S., Itoh, R., Eng, L., Hunter, J., Payne, A., & Solgaard, O. (2017, May). "Random access optical scanning using a MEMS phased array." In Lasers and Electro-Optics (CLEO), 2017 Conference on (pp. 1-2). IEEE.

Patents

- Published Application: 20200041865
- Issued: 11,131,845 (USA)

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