Journal of The Gujarat Research Society
ISSN: 0374-8588
Volume 21 Issue 13, December 2019

A REVIEW OF OPTICAL MEMS DEVICES

Panduranga Rao M V
Faculty of Engineering and Technology,
Jain (Deemed-to-be University), Ramnagar District, Karnataka – 562112
Email Id: r.panduranga@jainuniversity.ac.in.

Abstract

Optical networks are composed of optical elements in the technology of optical transmission. And optical components are where much of the demand for production and cost savings from the industry comes to bear. Traditionally, optical components have been classified into (i) active components such as lasers, detectors, modulators, transceivers, etc., and (ii) passive components such as filters, couplers, splitters, isolators, etc. A revision to this categorization has recently been introduced that would add a new type of optical components known as Dynamic Components. Dynamic Components are essentially passive but have the added capability of modifying a physical parameter of the light or reconfiguring its optical direction in real-time. This class of components includes the Variable Optical Attenuator (VOA), Tunable filter, 1 x N Switch, Wavelength Selective Switch (WSS), MEMS Scanning Mirror, Dynamic Dispersion Compensation, etc. Optical MEMS (Micro Electro Mechanical Systems) devices are the chosen technology for activating Complex Components. MEMS technology's central idea is to create micro-mechanical devices using the technology of Semiconductor Wafer Manufacturing, which has long been used to construct Integrated Circuits. In this paper, summary of the Micro-Opto-Electro-Mechanical Systems (MoEMS) market products and their success stories are discussed.

Keywords: *Micro Electro Mechanical Systems (MEMS), Micro-Opto-Electro Mechanical Systems (MOEMS), Projection Display, Variable Optical Attenuator (VOA), Wavelength Selective Switch (WSS)..*

I. INTRODUCTION

The field of Optical Engineering has changed the present world. Developing innovation in the region of optical coordinated circuits, optical sign preparing, optical systems administration and optical mems gives more refinement and smallness in the mechanical yields. The "Optical" scope of frequencies is from 0.2 micrometers in the bright to 12 micrometers in the far-infrared area. Use of MEMS in the optical frameworks, which is known as optical MEMS, has started the new class of Micro-Opto-Electro Mechanical Systems (MOEMS) which has empowered us to join the mechanical, optical and electrical segments in limited scope [1]. The key achievement components of numerous optical MEMS items have been the new optical functionalities empowered by the utilization of MEMS innovation. Optical MEMS offer execution points of interest including frequency and polarization lack of care, and versatility to huge port checks dependent on the utilization of smaller than normal free-space optics [2]. Among numerous advantages of MEMS innovation "exhibit capacity", for example the capacity to make enormously resemble optical gadgets in a little structure factor, "reconfigurability," the capacity to change optical properties spatially and transiently and "Nanopositioning," the capacity to situate small size gadgets with nanometer exactness were evaluated by Kim et al.

As indicated by specialists in the business, MOEMS innovation will be driven by the advancement in optical interchanges. Contained minuscule electromechanical gadgets coordinated with light sources, optical components, and finders, they have discovered utilizations in numerous applications [3]. Optics and MEMS have a characteristic synergism. Photonic switches, scanners, shows, and miniature mirrors will be the principle gadgets that will empower MOEMS to infiltrate enormous instrumentation and media transmission markets. Since the mid-1990s, there has been a blast of interest in Micro Electro Mechanical Systems for optical fiber interchanges. Optical MEMS gadgets are smaller than normal optical components, (for example, miniature mirrors) equipped for moving and overseeing light. These gadgets steer the light pillars and not electrons, so they are bit rate, frequency (channel) and convention free. The principle focal point of the survey is the aggregation of much commonsense data on various optical MEMS and frameworks created for show innovation.

The Case Studies of Optical MEMS Products:

Optical MEMS devices have seen applications in flexible applications such as adaptive optics, projection display, scanning applications and optical communication switches etc. due to their intrinsic capacity to incorporate various mechanical properties such as array-ability, re-configurability and Nano-positioning.

I. Adaptive Optics:

Adaptive optics alludes to an optical framework that adjusts to make up for the undesirable and unfortunate optical impacts presented by inhomogeneous medium and different segments. Adaptive optics incorporates wavefront rectification, distortion revision, sharpness remedy and differentiation change and so forth MEMS deformable mirrors created by Texas Instruments have been utilized widely for such applications [4]. These structures comprise of electrostatically incited films upheld by focal post. The essential exhibition boundaries of these deformable mirrors are the quantity of actuators, data transmission control, most extreme actuator stroke and goal. For galactic applications, the basic exhibition measures are Strehl proportion (a proportion of imaging execution), frequency of interest, attributes of optical unsettling influence and the framework opening [5]. The layer in mix with wavefront sensor and a constant regulator is utilized to balance the spatial period of an optical wavefront and

ISSN: 0374-8588
Volume 21 Issue 13, December 2019

remunerate optical abnormalities by disfiguring the mirrors so that undesirable variations are estimated and afterward dropped by stage formation.

II. DMD based Projection Display:

The Texas Instrument's Digital Micro-mirror Device (DMD) has altered the craft of projection innovation by outflanking customary LCD based projectors by drastically lessening the expense and expanded execution. Right now, 95% of the absolute world's reduced projection show hardware is being served by Texas Instrument's DLP motor which has a DMD at its center. The DLP chip comprises of a variety of MEMS mirrors orchestrated in 2D exhibit mounted over SRAM cell. Every one of the small mirrors is equipped for producing 3 precise tilt positions (+10 degree, 0 degrees and - 10 degree) contingent on electrostatic possible applied between activation anodes. By controlling the obligation pattern of mirror incitation, a 10 cycle (1024) grayscale picture can be created for every essential tone [6]. A mix of three DMD chips or a shading wheel in formation with one DMD chip is utilized for creating the shading picture. A digital encoded arrangement of picture data is utilized to activate the small mirrors which thus direct light through a projection focal point to make an enormous screen shading picture. Each micro-mirror is created solidly by CMOS viable manufacture with every aluminum micro-mirror is 16um*16um.

Splendor and differentiation are the two significant boundaries which have an immediate connection with projected picture quality. DMD has a difference proportion of 1000:1 to 2000:1. Other than projection applications, DMD likewise has some non-show applications like a volumetric showcase where 3D pictures can be made to skim in space. Because of rapid beat width balance, torsional radiates require high dependability over its working life cycle.

III. Grating Light Valve Display:

Simple partner of Texas instrument's DMD chip is a Grating light valve created by Stanford bunch in year 1994. GLV is a one of a kind item that comprises of a progression of metallic miniature strips wherein a mix of 6 double upheld equal shafts establishes a solitary pixel suspended over the air hole over the substrate. GLV utilizes the rule of diffraction to constrict and adjust light. The other miniature strips can be pulled vertically downwards to a distance of ¼ of episode light frequency electrostatically to make diffraction designs.

The development of miniature strip results in one or the other reflection or diffraction of occurrence light [7]. At the point when all strips are pulled downwards, GLV goes about as an intelligent mirror and when substitute strips are pulled downwards, it diffracts episode light to a point which is a solid capacity of spatial recurrence of miniature strips. Since GLV is needed to be pulled somewhere near quarter frequencies just, there is no actual contact between miniature strips and substrate coming about is little wear and tear and stiction issues.

As projected light is acquired by diffraction arranges as opposed to reflection, loss of episode power is noticed. GLV professes to have a diffraction productivity of 81% which is close to the greatest hypothetical effectiveness of diffraction, fill factor of 95% and top layer reflectivity of 91% [8]. The GLV framework has a joined optical productivity of 70%. GLV can be stretched out in 2D cluster for projection show, computerized imaging framework, and media transmission.

IV. Optical Communication switches:

The utilization of MEMS switch in media transmission application for interconnects and signal directing has particular favorable circumstances over customary exchanging. By the utilization of optical crossbars, the prerequisite of the optical-electrical-optical change cycle at optical cross-interfaces is diminished. By the utilization of optical switches, light sign can straightforwardly be directed to the necessary channel.

2D MEMS optical switches are optical crossbar switches fit for exchanging the optical bar in two-dimensional planes. These 2D switches are able to do specifically reflecting optical bars to yield ports. Fixed cathodes are manufactured on base wafer and suspended mirror is created on top wafer. The incitation distance of miniature mirror is chosen by the exact arrangement of two wafers and is important for uniform point [9]. In certain plans, reflect is put at the tip of a long actuator plate and kept up at point of 900 and it is made to go here and there by utilization of electrostatic field between lower part of plate and terminal put underneath the mirror plate.

With increment in number of port checks, optical cross interface for enormous port tally is required. Double hub miniature mirror or 3D MEMS switch is the ideal structure which is fit for reflecting episode optical shaft into any of the yield port and hence light can go in three dimensional spaces. Quantities of mirrors needed to address NxN ports utilizing 3D MEMS reflect is exceptionally less (2N) contrasted with number of mirrors to address same no. of ports (N2).

V. Multi-object Spectroscopy:

The utilization of DMD for galactic examination was first spearheaded for NIRSPEC spectrograph locally available JWST. For Near infrared Spectroscopy, huge assets have been made accessible by NASA for the improvement of Micro screen Array and DMD. Miniature shade exhibits are trans-note cuts which are utilized for target choice by diffraction. In traditional multi-object spectroscopy, a metal plate with miniature cuts is set at the central plane of the telescope to choose the objective of interest from the field of view [10]. Light from chosen targets is taken to a spectrograph where a range is produced and broke down. Spectroscopy utilizing cuts is disadvantageous as pre-imaging of 'field of view' is needed before cut punching. Once punched, plate renders futile for next imaging as totally new arrangement of target investigation might be required.

To conquer the issues of static 'trans letter cuts', Micro mirror exhibit has been utilized as 'dynamic intelligent cuts' to specifically mirror light coming from focus of interest toward the spectrograph understudy. These miniature mirrors are put at central plane of noticing telescope and avoid light towards the spectrograph, where range is produced and dissected. A Micro-reflect cluster (MMA) is a lattice of individual mirrors with incorporated hardware to coordinate light coming from space towards spectrograph.

II. CONCLUSION

In terms of large rotation angles and lower actuation voltages, the optical micro-mirror technology has distinct advantages over its analogue equivalent. DMD's analogue equivalent is the grating light valve, which can be worked faster (10 MHz) than the bulkier torsional micro-mirrors (typically KHz). In addition, there are hundreds of MEMS devices available, from oscillators, switches, microphones and capacitive touch sensors to optical and magnetic sensors for flow, location, motion, and strain. Technology for MEMS will continue to expand.

III. REFERENCES

[1] A. C. R. Grayson et al., "A BioMEMS review: MEMS technology for physiologically integrated devices," in Proceedings of the IEEE, 2004, doi: 10.1109/JPROC.2003.820534.

[2] W. C. Chuang, H. L. Lee, P. Z. Chang, and Y. C. Hu, "Review on the modeling of electrostatic MEMS," Sensors. 2010, doi: 10.3390/s100606149.

[3] M. C. Wu, O. Solgaard, and J. E. Ford, "Optical MEMS for lightwave communication," Journal of Lightwave Technology. 2006, doi: 10.1109/JLT.2006.886405.

[4] F. Sarvar, D. A. Hutt, and D. C. Whalley, "Application of adhesives in MEMS and MOEMS assembly: A review," in 2nd International IEEE Conference on Polymers and Adhesives in Microelectronics and Photonics, POLYTRONIC 2002 - Conference Proceedings, 2002, doi: 10.1109/POLYTR.2002.1020178.

[5] S. M. Spearing, "Materials issues in microelectromechanical systems (MEMS)," Acta Mater., 2000, doi: 10.1016/S1359-6454(99)00294-3.

[6] N. T. Nguyen, X. Huang, and T. K. Chuan, "MEMS-micropumps: A review," Journal of Fluids Engineering, Transactions of the ASME. 2002, doi: 10.1115/1.1459075.

[7] O. Solgaard, A. A. Godil, R. T. Howe, L. P. Lee, Y. A. Peter, and H. Zappe, "Optical MEMS: From micromirrors to complex systems," J. Microelectromechanical Syst., 2014, doi: 10.1109/JMEMS.2014.2319266.

[8] MOEMS: Micro-Opto-Electro-Mechanical Systems. 2017.

[9] M. Tanaka, "An industrial and applied review of new MEMS devices features," Microelectron. Eng., 2007, doi: 10.1016/j.mee.2007.01.232.

[10] H. J. Lee, N. Choi, E. S. Yoon, and I. J. Cho, "MEMS devices for drug delivery," Advanced Drug Delivery Reviews. 2018, doi: 10.1016/j.addr.2017.11.003.