



Optical MEMS Technology at AGM

Asif Godil
AG Microsystems Inc.
Fremont, CA

January 24, 2022



Introducing AGM

- AGM: a leader in Optical MEMS Technology
 - Founded in 2005 and engaged with Customers and Suppliers globally
 - HQ in Fremont, CA with Customer support office in Chengdu, China
 - Leading supplier of Optical MEMS products to customers in Asia and US
 - AGM has majority share of the ESVOA market with 20+ customers
 - Developed 1xN switch chip based on 2-axis mirror technology. Also, applications in Tunable filter/OCM, 3D imaging and LIDAR
 - Introduced Mini VOA/Tunable filter chip in 2018
 - MEMS Foundry partners in US and Canada
 - AGM has an Excellent Technical and Customer Support team.
- Founded by Asif A. Godil
 - President & CEO, AGM
 - Proven Technical and Business leader
 - Founded LIGHTCONNECT in the Optical MEMS space. Successful acquisition by Neophotonics.
 - Developed Grating Light Valve (GLV MEMS) display technology at Silicon Light Machines. Later acquired by Sony Corporation, Japan
 - Visiting Scientist, Sony Research Center, Tokyo, Japan
 - Stanford University Ph.D.



Organizational Structure

- Sales and Business Development
 - Direct engagement with customers and their CMs globally
 - AGM Asia established in Hong Kong in 2010 and closed in 2018
 - Customer support office established in Chengdu, China in 2012 for supporting customers in China and Asia Pacific and is led by Lei Zhong, Customer Support Manager.
 - Product Development
 - Understanding Advanced Optical component design and Customer use
 - MEMS Design Expertise including advanced FEA tools.
 - Process Development Expertise
 - Foundry Collaboration with Top tier foundries in USA and Canada
 - Advanced Optical Test and Measurement with software automation
 - Good Qualification and Reliability System
 - Excellent Customer Support
 - Manufacturing
 - Quality control systems and documentation in place
 - Automated Wafer Test at AGM
 - Top Tier Foundry Suppliers in USA and Canada
-



R&D Capability at AGM

- **Diverse Experience in Optical MEMS Development**
 - GLV (Grating Light Valve) development at Silicon Light Machines for Display application
 - Diffractive MEMS for VOA and DGE (Dynamic gain equalizer for EDFA) at Lightconnect (now Neophotonics)
 - VOA chip and 2D chip for 1xN switch development at AGM. Both are in volume production. Mini VOA/TF chip moved to production in 2019
 - All MEMS development were successful and led to commercialization
- **MEMS Development Tools and Experience**
 - Advanced Finite Element Analysis using Comsol, Ansys and Abaqus
 - Optical Design using Zemax
 - Software Development using Python and Labview
 - Strong fundamental understanding of Solid Mechanics, Electrostatics, Optics, and Semiconductor processing
 - Advanced Optical Test and Measurement with Software automation
- **MEMS Foundries**
 - Close relationship with MEMS Foundries in Canada, US, Europe and Asia



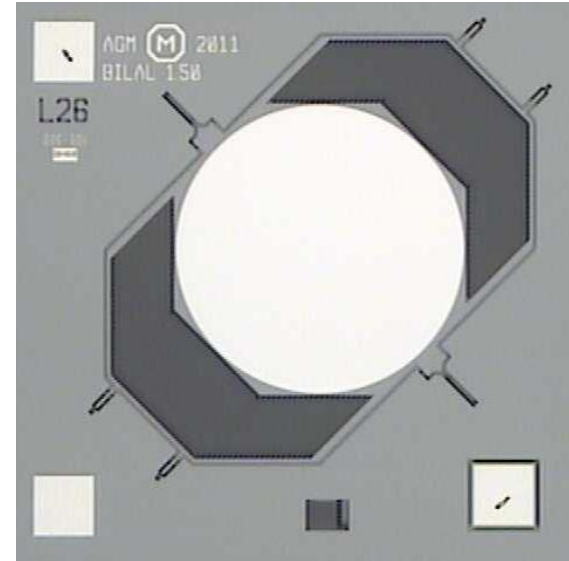
AGM's Customers in Optical Communication



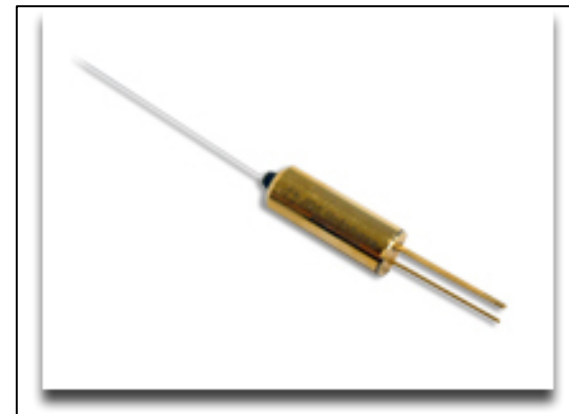


ESVOA Chip Product Line

- ESVOA MEMS chip available in volume production from two foundries
- Shipping to customers in Asia and North America
- Shipping > 700k/year
- Excellent optical, electrical and mechanical performance
- Available in low voltage and high voltage
- Qualified at several top-tier customers



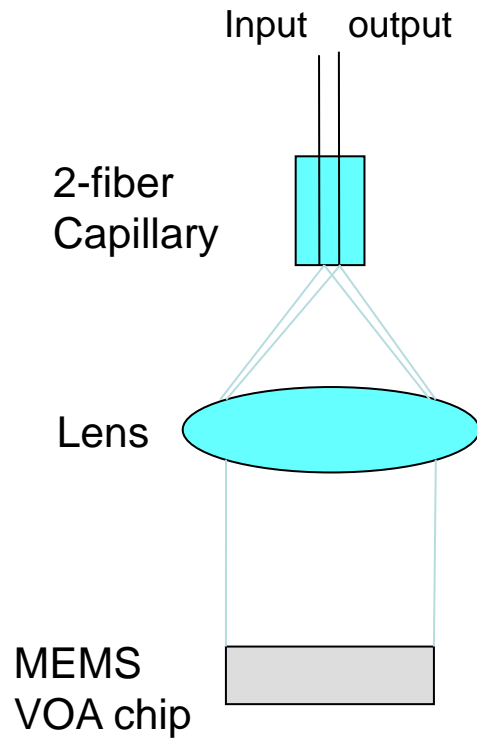
1.7 x 1.7 mm
Chip



Packaged
VOA
(Customer)



MEMS VOA principle



As the mirror rotates, it moves the light away from the core of the output fiber thus causing attenuation, and eventually completely blocking the light (> 45 dB)



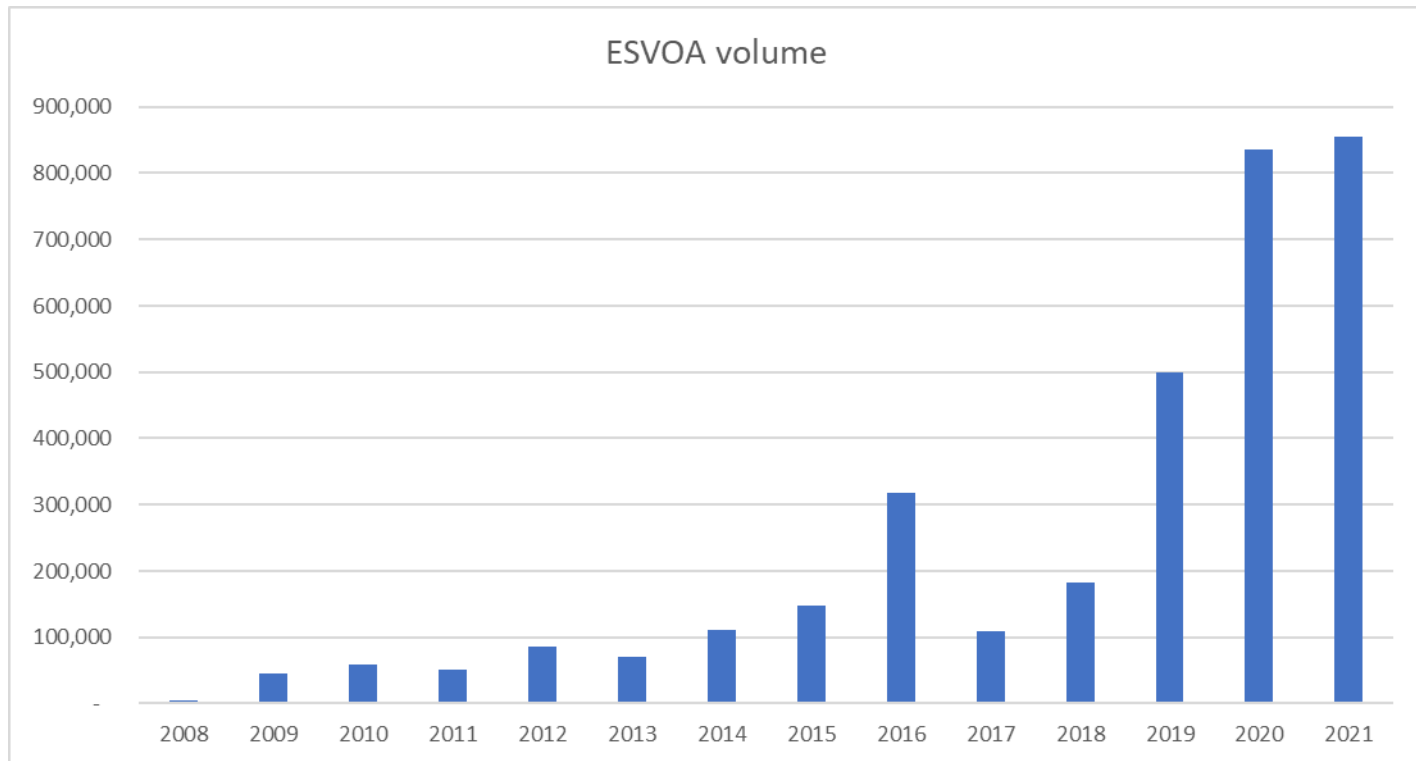
Functional Testing at AGM

- Electroglas automated wafer prober
- Computer controlled instruments with customized hardware
- Custom Test software
- 100% automated functional testing of ESVOA wafers and 1xN (2D) wafers





ESVOA business volume



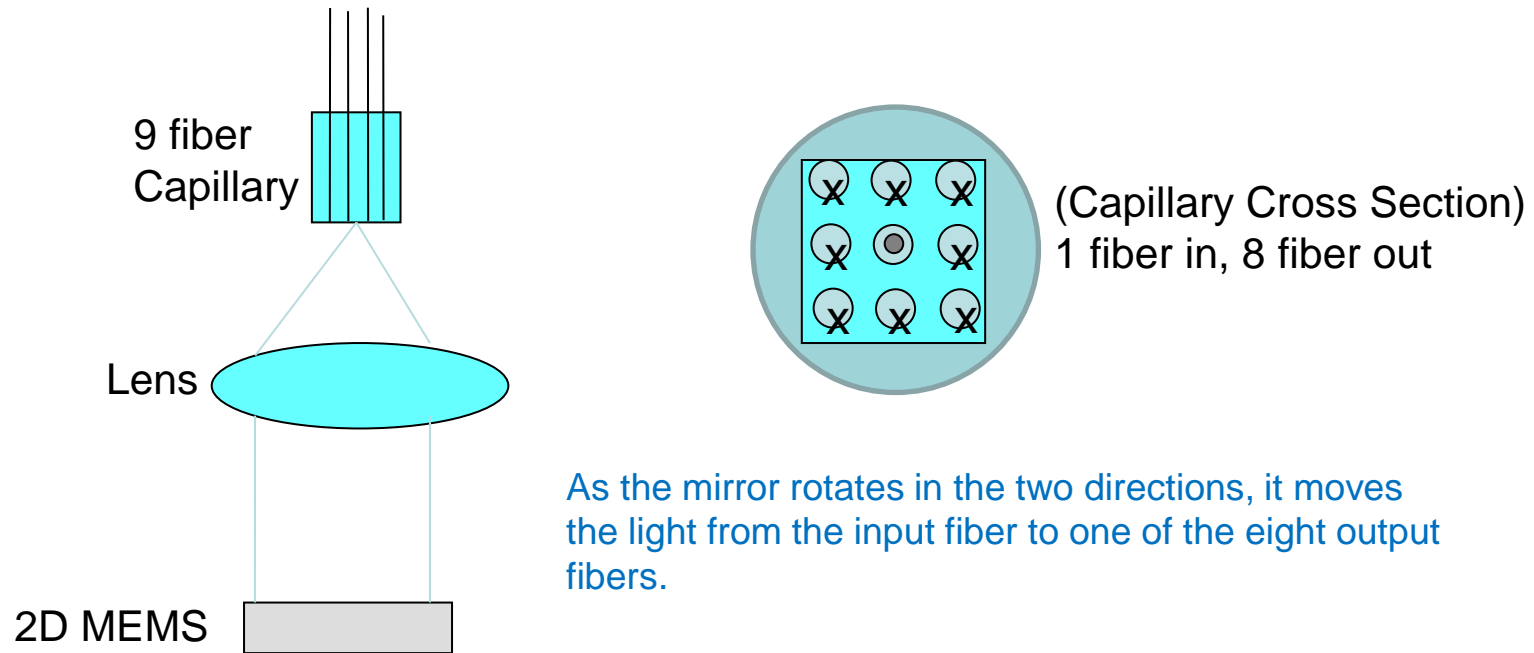


2-axis Mirror Technology

- AGM has developed a 2-axis Mirror Technology with comb drive actuation for robust design and high performance
- Initial product is targeted for a 1x17 switch in a TO46 can.
- AGM can offer bare die or header with glass window or lens
- Technology platform can be extended to other applications
 - Tunable Filter/OCM
 - NxN cross connects with mirror arrays
 - Larger 1xN switches with larger mirror and angle
 - 3D imaging using structured light projector
 - LIDAR
 - Free space optical communication
 - Virtual Reality/Augmented Reality



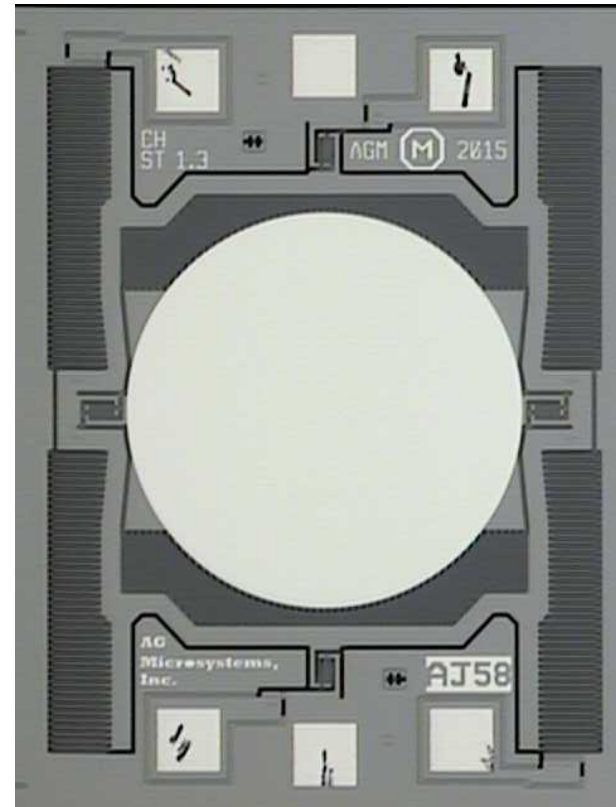
1x8 MEMS Switch





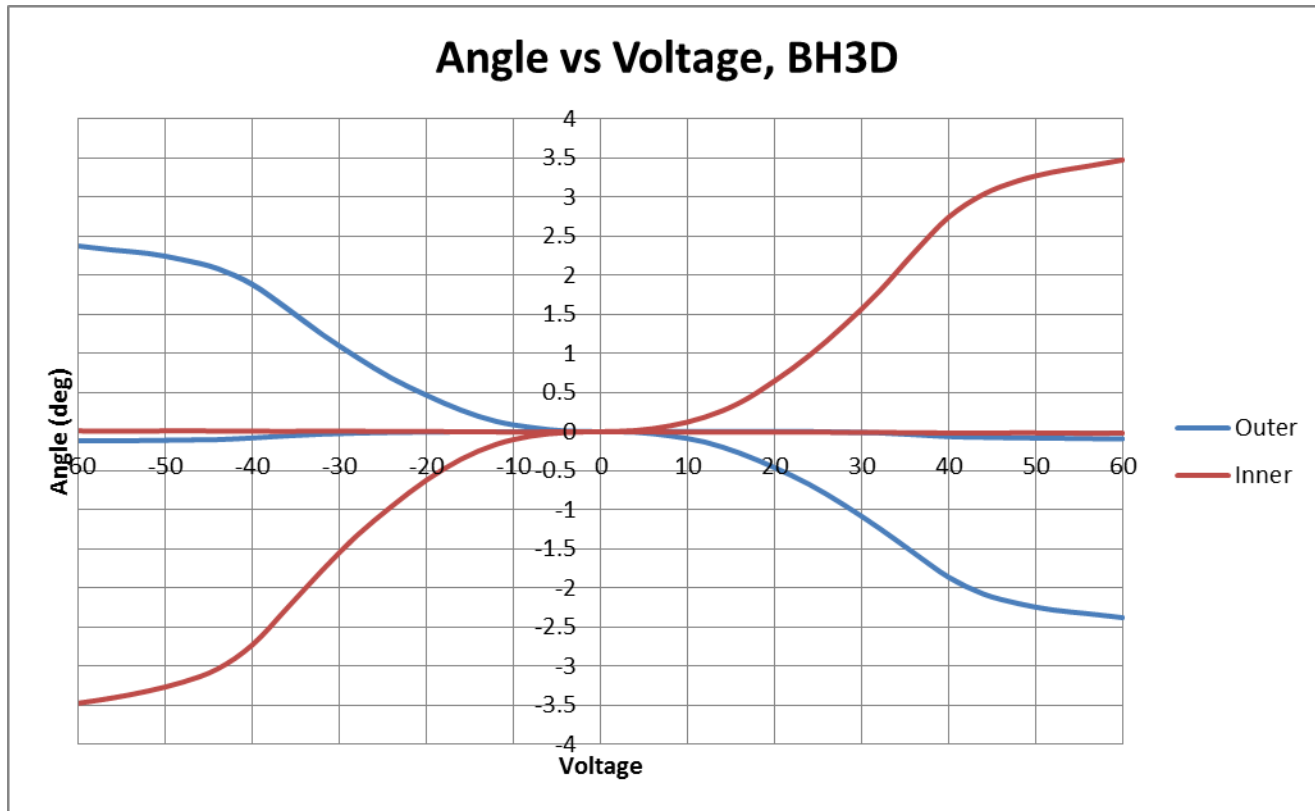
Spec for 1xN Mirror

- 2-axis Mirror
- Chip size: 1.8 x 2.1 mm
- 4 drive bondpads + ground
- Mirror size: 1000um round, ROC > 1 m
- Angle in x-axis: +/- 2.5 deg (mech.)
- Angle in y-axis: +/- 3.2 deg (mech.)
- Drive Voltage: ~ 50-60 V
- Snap Voltage > 70V
- Resonant freq. 900-1100 Hz
- Repeatability < 0.5 mdeg
- Long term drift < 5 mdeg
- Angular cross talk < 3%
- Operating temperature -5 to 75 C
- This allows the customer to make 1x8, 1x12, and 1x17 switches in TO46 or TO39 headers with standard 125u fiber



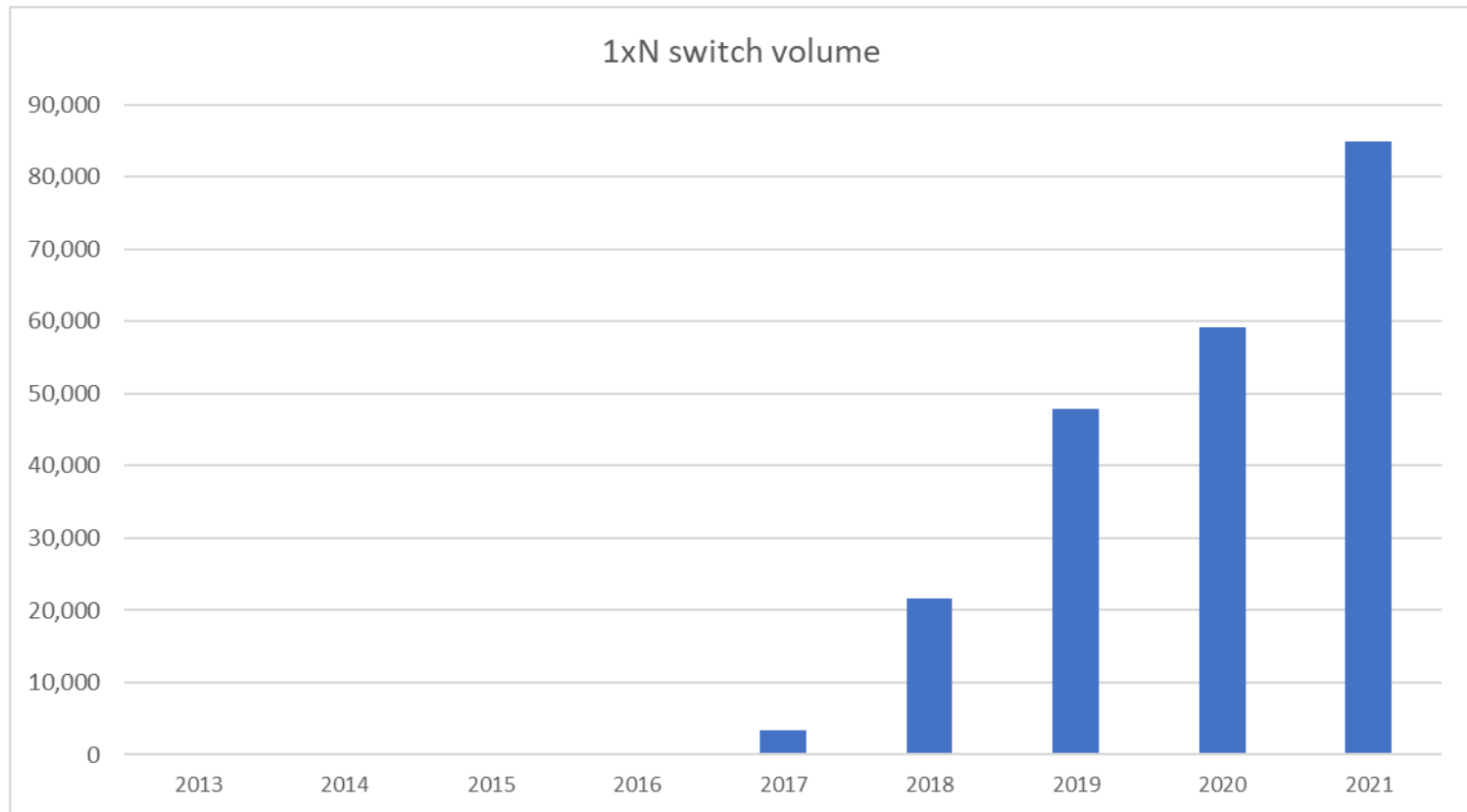


Angle vs. Voltage



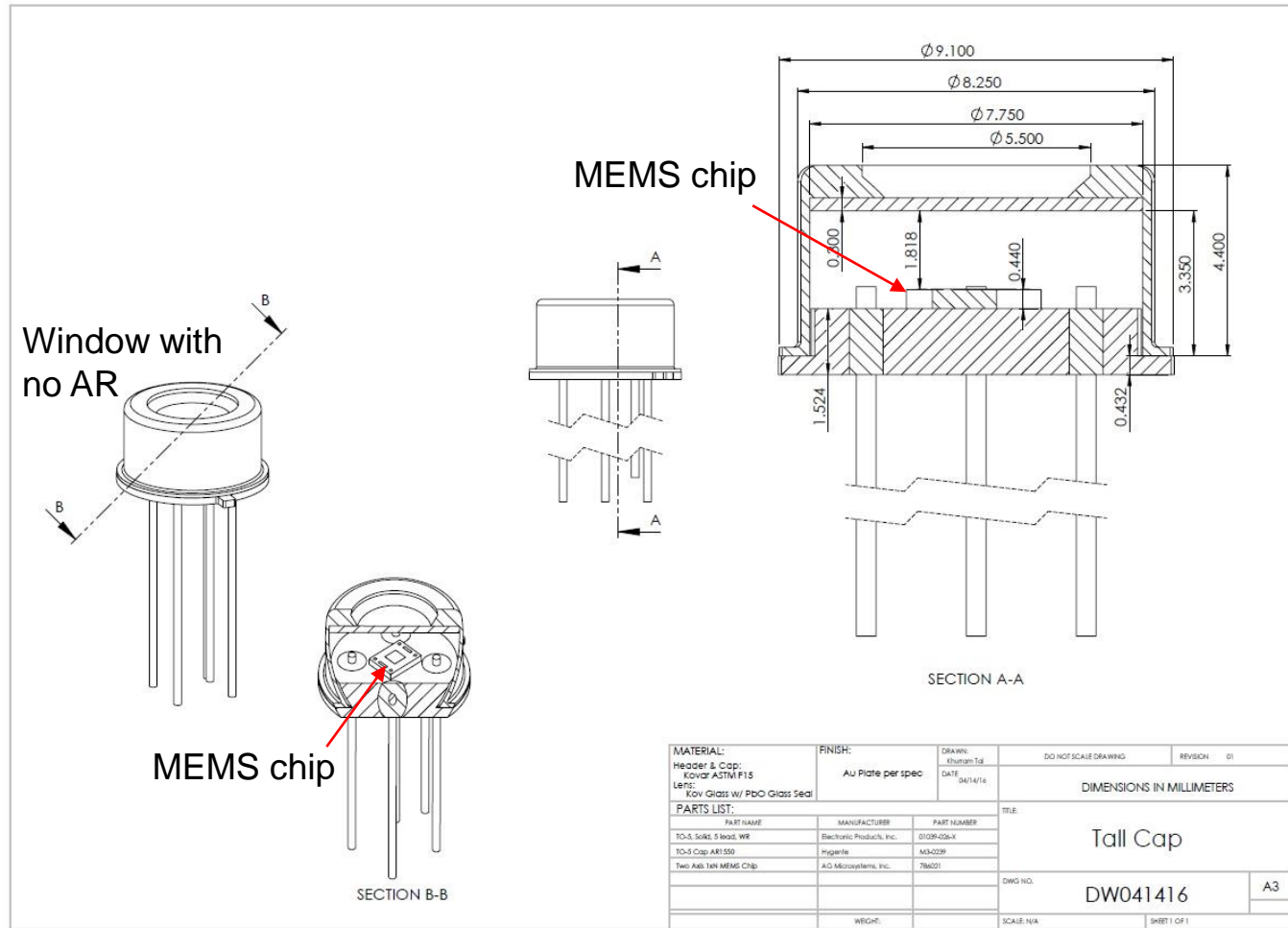


1xN switch business volume



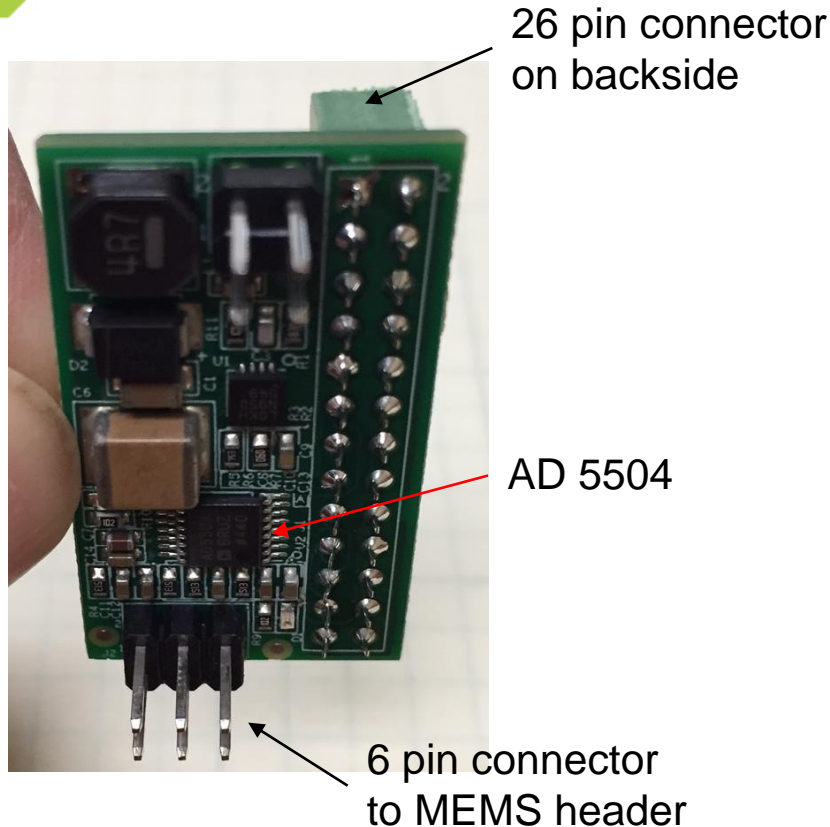


TO39 header with MEMS chip and cap





2D MEMS Driver PCB



PCB size: 20 x 35 mm

Interface: SPI

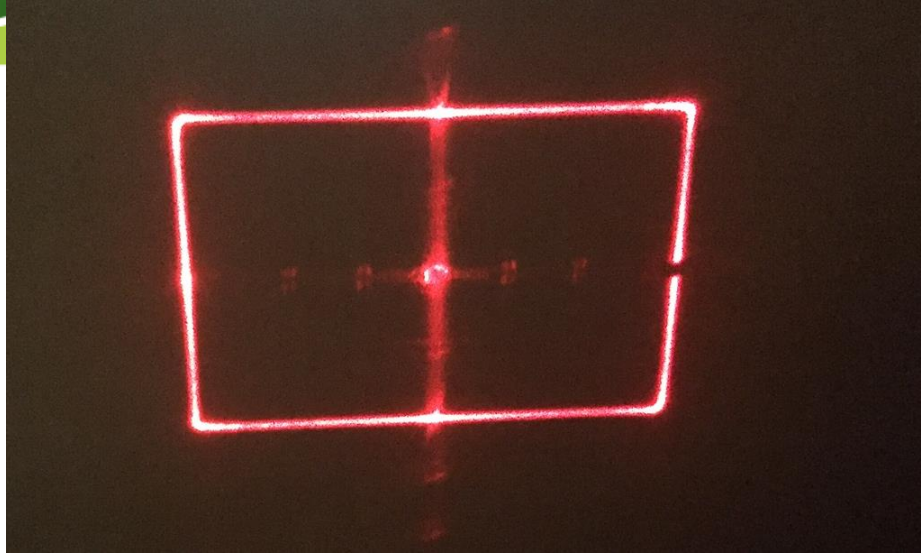
Designed to plug into a Raspberry Pi but will work with any hardware with SPI interface

Provide 3.3V and 5V power. Internal HV boost provides needed 60V

AD 5504 is a four channel HV 12 bit DAC where each channel goes from 0 to 60V. These drive the four pins of the MEMS chip

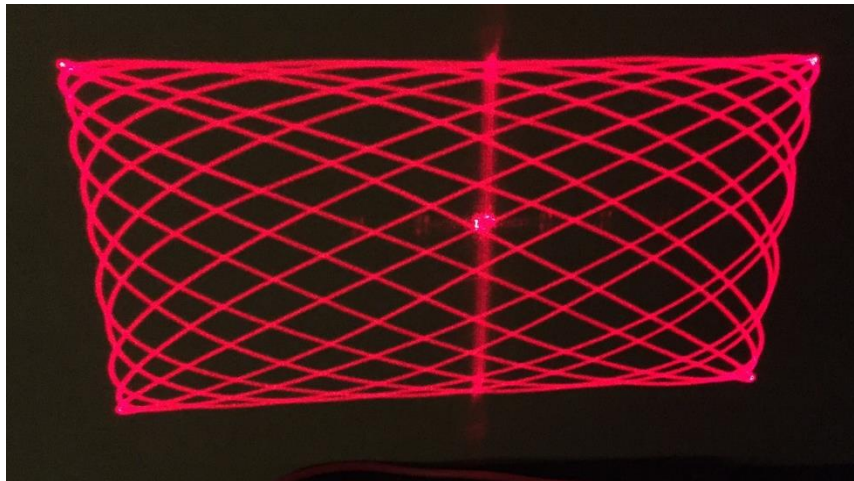


Scan Pictures



Scan with 60V
driver PCB

FOV: 14 x 9 deg



Lissajous scan

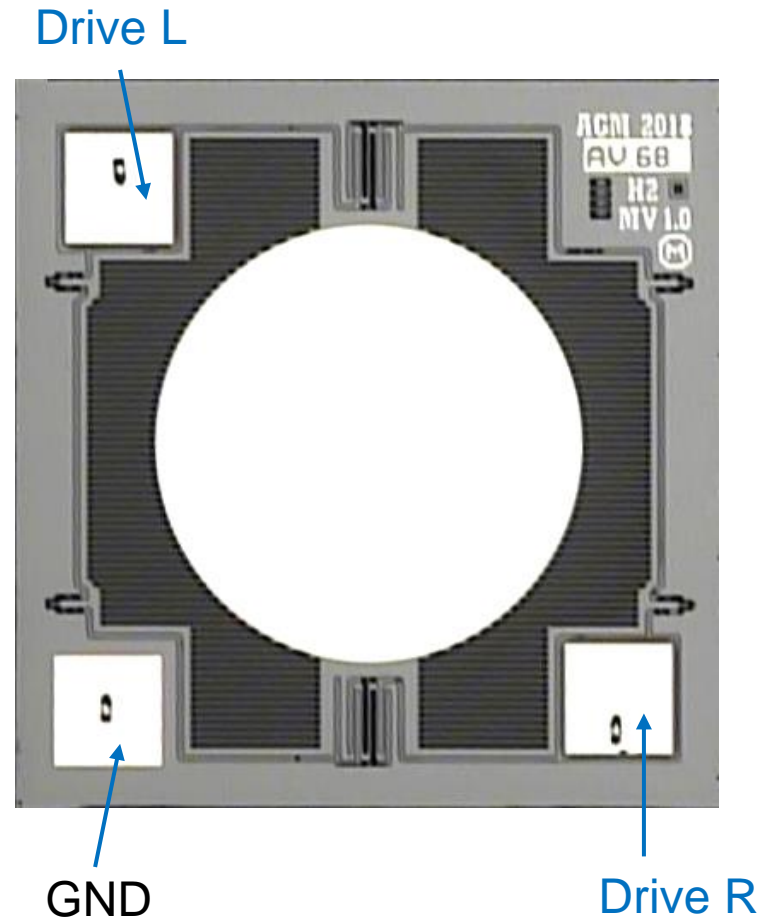
FOV: 30 x 18 deg

Link to vimeo videos
available upon request



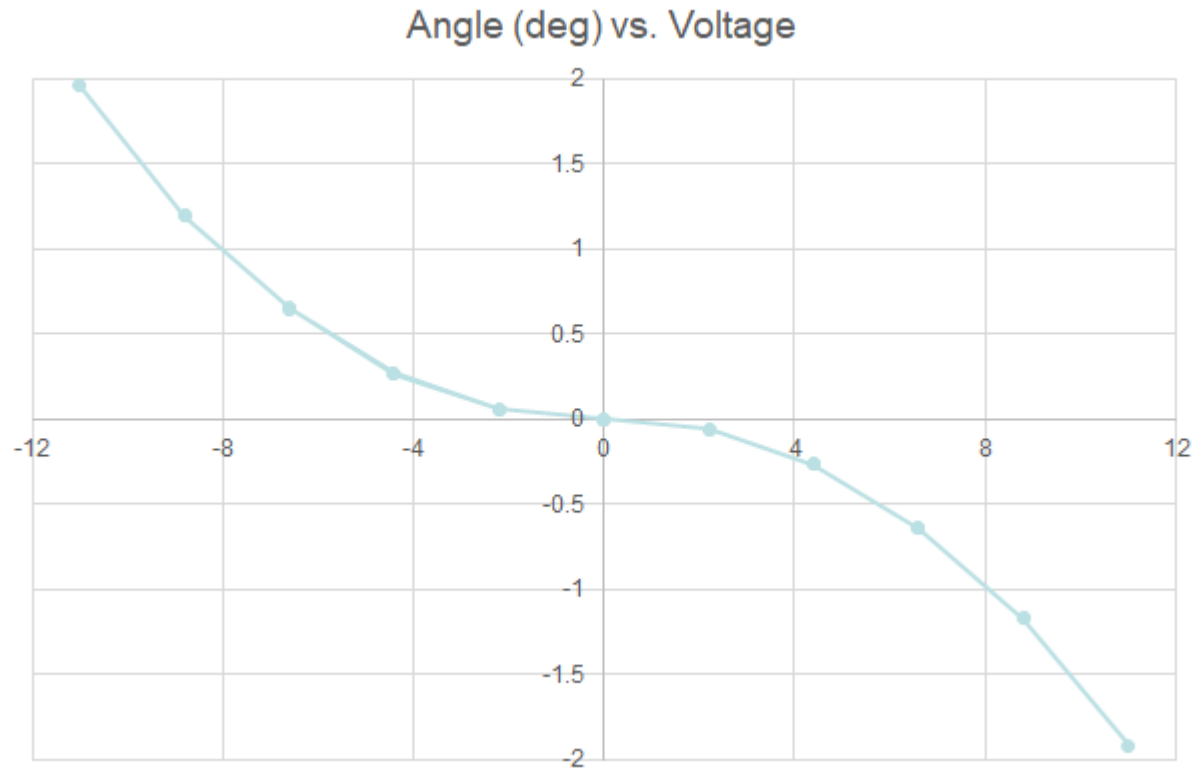
Spec for Mini VOA/TF chip

- 1D Mirror with Left and Right Drive voltages
- Chip size: 1.0 x 1.0 x 0.44 mm
- Mirror size: 600 μm
- Bondpads 150u square
- Drive Voltage for VOA. Angle of 0.3 deg at $V < 5\text{V}$
- Drive Voltage for TF. Max angle $> \pm 1.5$ deg at $V < 12\text{V}$
- Snap Margin $\sim 10\%$
- Resonant freq ~ 1200 Hz
- Insertion Loss < 0.2 dB
- Good shock and vibration performance
- Max Optical Power ~ 0.5 W





Transfer function of Mini VOA





Mini VOA business volume

