Vibration Test Report

eMEMS™ Mini Reflection Fiber Optic Switch (Non-Latching)

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1 Overview

We are specialized in producing thermally actuated *et*MEMS^{TM} at the in-house 150mm wafer fabrication facility located at Woburn headquarter. This capability allows us to reduce the fabrication cost through tight control of manufacturing yield and quality and continuously improve the performance of our MEMS-based products through the combination of design and process improvements. Moreover, we have developed vision-based automatic wafer testing tools that ensure each individual MEMS chip's dynamic performance and quality.
Conventional MEMS are based on electrostatic actuation that is prone to electrical charge build-up induced drift and moisture-induced electrical shorting requiring expensive hermetic sealing. Photonwares' MEMS is based on the electro-thermal driven actuation principle. Our unique etMEMSTM design provides advantages for fiber optic components, including:

- Large actuation force over mm
- Low direct driving voltage <5V
- A few fabrication steps, high yield
- No need for a hermetic package
- Intrinsic tolerance to EDS

Our MEMS switches and VOAs are based on single crystalline silicon, exceptional material that does not deform, fatigue, or wear out over time, and its dimensions and mechanical properties are immune to stress unless a critical fracture stress level or a permanent deformation high temperature is reached. Data results from testing show that Photonwares MEMS switches and VOAs still work within specifications after many billion cycles.

We have performed vibration tests on the *et*MEMS^{TM} 1x2 Mini Reflection fiber optic switch (PN: MURS-125211131). This switch connects optical channels by redirecting an incoming optical signal into a selected output optical fiber. This is achieved using a patented *et*MEMS^{TM} configuration and activated via an electrical control signal.

This report briefs the vibration (1G & 200Hz) results in operation about the *et*MEMS^{TM} family of non-latching switches. All of the *et*MEMS^{TM} non-latching products have switch cores with the same design and process and have similar package design and manufacturing process as well. Thus, it is not necessary to run the vibration tests for each product of this family. The 1550nm 1x2 non-latching *et*MEMS^{TM} Mini Reflection version (PN: MURS-125211131) was selected for the vibration tests in operation. By similarity, the other products of this family will be automatically qualified with this module, including all available configurations (1xN, Nx1, 2x2, etc.), wavelength range options, and input/output fiber and connector options. A schematic and functional diagram of the *et*MEMS^{TM} 1x2 Mini Reflection switch is shown in Figure 1 below.

The first reflection is performed by the MEMS mirror without the voltage, while another reflection is performed by a fixed mirror with 4.5V applied to move the MEMS mirror out of the optical path.

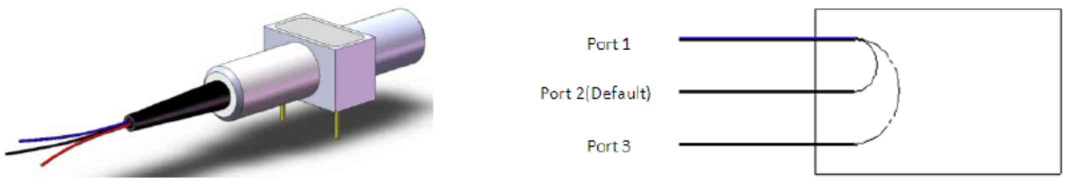

Figure 1: Schematic and functional diagram of etMEMS^{TM} 1x2 Mini Reflection Switch

2 Test Orientation

Experimentally, it was verified 1) Neglectable impaction of vibration on insertion loss along x and y-axis because the vibration is parallel to mirror surface while the mirror is much larger than optical beam reflected; 2) the vibration along Z-axis may change the mirror' angle, which causes the misalignment of the reflected beam to the output collimators.

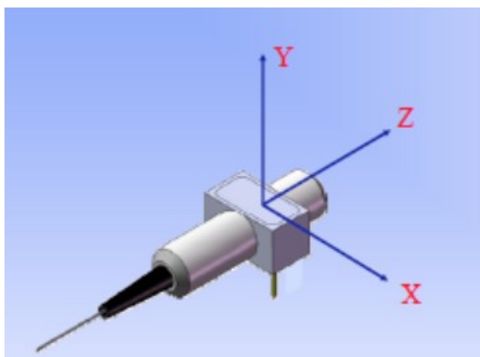

Figure 2: Orientation definition on MEMS switch

So, the vibration test was performed along Z-axis only.

3 IL Frequency Response

In order to assess the vibration impact on insertion loss (IL) in operation, IL was scanned first over the frequency from 100Hz to 1000Hz with the acceleration of 1G on the vibration test station. One typical result of the insertion loss (IL) vs frequency is shown in Figure 3. The scale of IL and frequency scale is in log. The resonant frequency is ~700Hz in Z-axis.

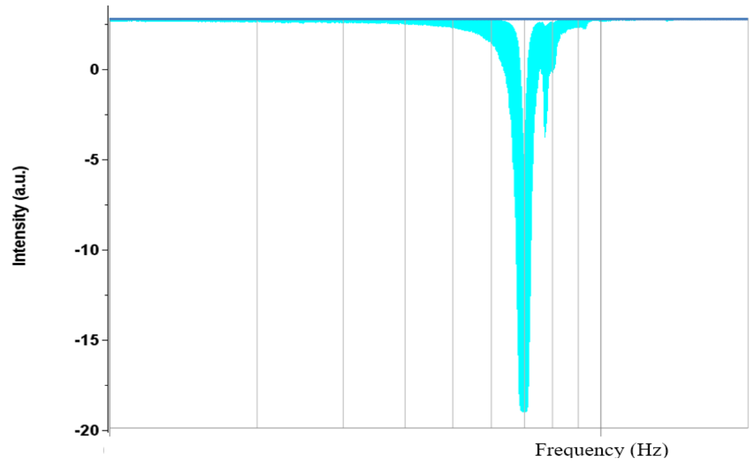

Figure 3: IL vs. Frequency (SN: 611152)5

4 Operational IL In Vibration

The insertion losses (IL) in vibrations were measured on the vibration test station. The vibration condition was set at 1G of acceleration with 200Hz. 13 samples were tested, and the variation of ILs were listed in the table below.

SN:	841200	841199	841196	611152	611151	611146	611145
ΔIL (dB)	0.11	0.08	0.03	0.06	0.06	-0.03	0.02
SN:	611148	611147	611200	190335	190133	190691	
ΔIL (dB)	0.03	0.03	0.10	0.02	0.02	0.03	

5 Summary

The insertion loss (IL) in vibration could be specified <= 0.2dB in the family of MEMS non-latching switches.