



## 2.5 MEMS Specification and Status

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### 1 Introduction

The Boston Micromachines Corporation MEMS deformable mirror (DM) is the perhaps the most important component in the MagAO-X system. We have identified high-yield as the most important characteristic, that is we desire 0 bad actuators within the illuminated portion of the mirror. BMC has not yet delivered a device to this specification, but are confident that their process has matured to the point that they have guaranteed it. Nevertheless, we recognize this as a schedule and performance risk.

As we have now developed the  $f/11+$  woofer option, a further interesting possibility is to obtain a MEMS device with  $3.5 \mu\text{m}$  of stroke (compared to  $1.5 \mu\text{m}$  for the nominal one). This could potentially obviate the need for a woofer to deal with Kolmogorov turbulence. This would significantly simplify the control problem.

Given these points, we have begun procurement of a BMC MEMS 2040 actuator (2K) DM. BMC has agreed to attempt to first produce a  $3.5 \mu\text{m}$  stroke device meeting our yield requirements *at no extra cost* using already fabricated die. If this is not successful, BMC has guaranteed us a  $1.5 \mu\text{m}$  stroke device which meets our yield requirements.

### 2 MEMS Specifications

Here we list the minimum specifications of the MEMS DM which BMC has agreed to deliver:

- Continuous Surface
- 2040 Actuators
- 50 Actuators across circular active aperture
- 100% Yield in specified area
- For bad actuators adjacent to (edge or corner) the specified area or under a spider, no more than 1 bad actuator per  $3 \times 3$  square
- For bad actuators not adjacent to the specified area, waiver required for more than 1 bad actuator per  $3 \times 3$  square.
- Spiders: the center of any bad actuator must fall under a 400 micron wide ( $\pm 200$  micron from spider) mask centered on the spider
- The spider pattern can be rotated.
- A waiver is possible for non-functioning actuators which are not stuck up or down.



**MagAO-X Preliminary Design**  
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- 1.5  $\mu\text{m}$  Max Stroke (minimum)
- 12-18% influence functions
- 0.85  $\mu\text{m}$  inter-actuator Stroke (minimum)
- Temporal response: 5-95% rise/fall < 65 microseconds (single actuator 100 nm step)
- 19.6 mm aperture
- 400  $\mu\text{m}$  pitch
- Gold Coating
- Surface finish after coating < 20 nm rms after applying a high pass filter with a cutoff frequency of 1.25/mm
- For potential 3.5  $\mu\text{m}$  device: 2.5  $\mu\text{m}$  of stroke after device is flattened (all terms). 3  $\mu\text{m}$  of stroke after flattening without correcting for focus
- Protective Window on 6° Wedge w/ AR Coating: 550-2400 nm (both sides) with specifications:
  - MATERIAL: UVFS
  - PARALLELISM:  $\leq 5$  arcsec
  - THICKNESS TOLERANCE: 0.3 mm
  - DIAMETER TOLERANCE: +0.0/-0.2 mm
  - SURFACE QUALITY: 20-10 SCRATCH-DIG
  - SURFACE FLATNESS:  $\lambda/10$  AT 633nm
  - CLEAR APERTURE: > 90% OF DIAMETER
  - COATINGS:  $R_{\text{avg}} < 1\%$  550-2500 (as in infinite optics scans 7-2956R S1 and 7-2957R S2)
  - Scan to be provided after coating.