Simulation of a Scaled-up Deformable Mirror System Driven by MEMS-Based Lorentz Actuator Arrays

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1. Introduction

Deformable Mirror (DM): An adaptive optics (AO) element that compensates for distorted wavefronts in optical systems (Earth-based telescopes and optical communication systems) by atmospheric turbulence and defective optical systems [1,2].
Micro-electromechanical system (MEMS): Technology that miniaturizes devices to decrease power consumption and space occupancy, resulting in integration of large numbers of elements together, ensuring higher reliability than classical manufacturing processes [3].

2. Design

- A new scaled-up version of the low-current Lorentz force deformable mirror system is comprised of an underlying 400 horseshoe shaped actuators attached to an overlying mirror (supported on SU-8 or silicon nitride).
- Design specifications for the DM were ± 5 µm deformation and 10 % - 40 % inter-actuator coupling for adjacent mirror locations above each actuator.

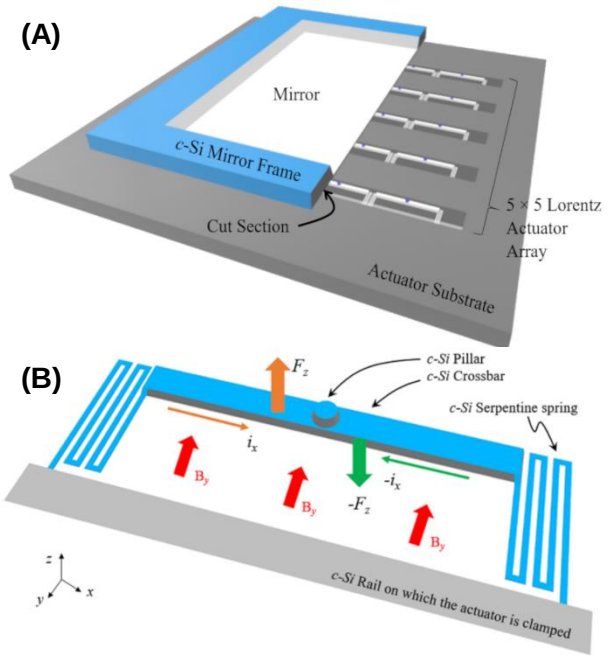
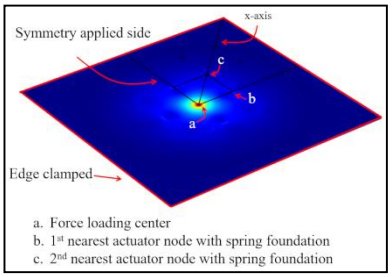


Figure 1. Illustration of a 5 × 5 array of Lorentz actuators with mirror attached (A), and a Lorentz force actuator showing the working principle (B).

3. Computation Method



$$\vec{F} = \vec{\imath}\vec{L} \times \vec{B}$$

1. Computing the inter-actuator coupling
2. A total of 10 µm stroke, 10 – 40% inter-actuator coupling.
3. Less than 1 K Joule heating.

4. Results

- ✓ A newly designed MEMS-based Lorentz actuator is presented that is scaled-up from 5 × 5 to 20 × 20 actuator array.
- ✓ The mechanical inter-actuator coupling of both SU-8 and silicon nitride DM was successfully simulated and satisfies a 10 – 40% coupling
- ✓ A large stroke of 10 µm with 2 mm actuator pitch, was successfully designed.
- ✓ This design suppresses the heat caused by Joule heating to less than 1 K.

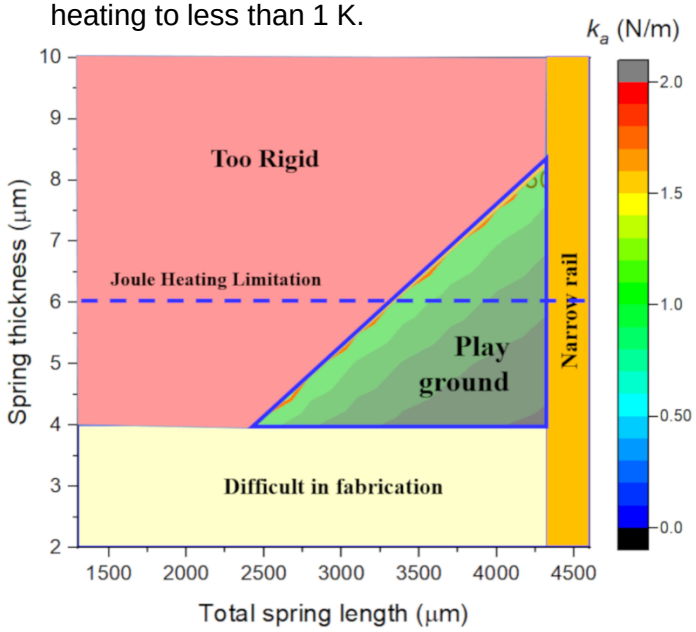


Figure 2. Design map to determine the optimized spring dimension of the actuator.

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