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A One-step laser engraved FPCB MEMS Lorentz force actuator for large aperture deformable mirror application

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ABSTRACT

Deformable mirrors (DMs) are widely applied in adaptive optics in the areas of telescope, free-space communication, medical imaging, etc. DMs surface can be deformed in real-time corresponding to the distorted wavefront to control and compensate optical aberration. The critical parameters of DMs are the number of actuators, actuator pitch, stroke, and response time. Microelectromechanical system (MEMS) based actuators are one of the promising concepts of deformable mirror design, which offer fast response time, suppressed hysteresis, and enable a higher actuator count at a more cost-effective price. Various MEMS deformable mirror actuators reported in literature are based on Lorentz or magnetic force, electrostatic force, piezoelectric force, or thermal expansion actuators. Lorentz force actuators require a low driving voltage, and they are capable of providing large displacement with bi-directional motion, which is superior to many other types of MEMS actuators.

Traditional MEMS devices and actuators are based on rigid substrates such as silicon. The fabrication processes usually requires a complex fabrication process in cleanroom environment. Also, the size of the wafer limits can make application to the fields of LiDAR and DM difficult, which require large mirrors. Flexible Printed Circuit Board (FPCB) fabrication technology can be a promising alternative method. It is well-established, low-cost, and the process is similar to microfabrication. These benefits are of interest to both industry and academic researchers to reduce the cost, speed up the design, and promote commercialization. Polyimide is the substrate material most commonly used in flexible PCBs. Its properties allow it to be an excellent structural material for MEMS devices. In recent years, a variety of MEMS devices based on flexible PCBs have been reported.

In this work, we demonstrate Lorentz force actuators based on an FPCB polyimide substrate for deformable mirror application. Actuators consisted of spring supported crossbar with the thickness of the copper and polyimide 18 μm and 25 μm, respectively. After FPCB fabrication, the actuator was released using laser cutting to remove the extra material. A device with crossbar of 0.3 mm wide × 2 mm long and two one-loop 60 μm wide × 2 mm long S-shaped serpentine springs on each side, showed 15 μm out of plane displacement when driven by a 100 mA current in a 0.5 T magnetic field. Using COMSOL software, the spring constant and resonant frequency are simulated to be 1.2 N/m and 2827 Hz, satisfying telescope deformable mirror requirements.

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