Design and analysis of a novel precision fast steering mirror with wide bandwidth based on piezoelectric actuator

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Abstract

As one of the best solutions for future space communication, inter-satellite laser communication possesses such advantages as high data rate, large capacity, and high secrecy compared with microwave communication. The compact precise fast steering mirror (FSM) determines the performance of inter-satellite laser communication systems.

This work presents a novel structure design of FSM with wide bandwidth based on piezoelectric actuator. The tilt movement of the developed FSM is implemented by the elastic deformation of a flexible ring. The flexible ring achieves high kinematic decoupling. Disc springs are used to promise the wide bandwidth of FSM. The strain gages bonded to the side of the piezoelectric stack are used as sensing units for feedback. The FSM is built-in bridge self-balancing module to ensure high-precision feedback signal. In order to protect the piezoelectric stack from bending moments, steel balls are adopted to realize force transmission between the mirror holder of FSM and the piezoelectric stack. Finite element model is established to check the strength of the FSM and its ability to withstand vibration and overload. The experimental results show that the angle travels for more than 2.5 mrad under 100 V voltage drive, for both axes, with a low coupling ratio of less than 0.5%, and the working bandwidth of the FSM arrives over 2 kHz. The parameters of the FSM can meet the needs of inter-satellite laser communication.

Keywords: Inter-satellite laser communication; Fast steering mirror; Piezoelectric actuator; Flexible ring; Bridge self-balancing module