Miniature wavefront correctors based on monolithic piezostack block

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Abstract — Stacked-actuator deformable mirrors (SADM) allow to compensate for wide range of wavefront distortions. They are distinguished for their large stroke of control elements, high operational speed, the possibility of correction for small-scale aberrations. The SADM with 6x6 actuators placed on the aperture 30x30 mm was developed. The thickness of mirror substrate was 1 mm. The maximal deformation stroke of the SADM was about 5 microns.

Keywords — adaptive optics, wavefront corrector, stacked-actuator deformable mirror.

I. Introduction

The key element of any adaptive optical system is wavefront corrector, that defines its performance. There are a lot of various types of deformable mirrors: MEMS-mirrors [1], bimorph deformable mirrors [2], SADMs [3]. Despite advantages of all wavefront correctors some of them has unquestionable limits: low power threshold (MEMS), non-perfect correction of high-order aberration (bimorph). The most suitable kind of mirrors for correction of high-order aberrations changing with high speed are SADM correctors. However, such mirrors have big-size construction. The most of contemporary scientific tasks (material laser processing, microscopy, ophthalmology, etc.) demand wavefront correctors with comparatively small size (about 10-25 mm) [4,5].

II. Traditional stacked-actuator deformable mirror

SADM is a single optical unit in a metal case, consisting of a thick and rigid base, a two-dimensional matrix of discrete actuators, and a flexible thin optical substrate with a reflective coating. Actuators are either simply multilayer piezoceramic stacks, or these stacks in a metal housing, to which springs are mounted for preliminary mechanical loading. Local deformation of the substrate surface occurs due to an increase (or decrease) of the actuator length due to the inverse piezoelectric effect when applying voltage A high reliability, large stroke, excellent accuracy, high resonant frequencies and flexibility in actuators geometry make SADM the most attractive for use in astronomical telescopes, optical communications, radiation propagation in a turbulent atmosphere, etc. But SADMs have some shortcomings: high cost, labor-intensive process of manufacturing and large dimensions of the mirror.

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III. Miniature stacked-actuator deformable mirror

To minimize technological steps, components and time frames, increase the actuator density, make the corrector size smaller, we propose to manufacture SADMs from monolithic piezoceramic block (Fig.1). The upper part of this block was made of many piezoceramic plate layers with conducting electrodes in-between and the lower part is a thick solid piezoceramic material serving as a base to support the matrix of multilayer piezoceramic stacks. This block was sawn into individual piezoactuators with a gap of 2 mm. Then electrical switching and wiring of the actuators was performed, on the next step the thin mirror substrate was glued on the tops of the actuators. The aperture of mirror was 30x30 mm and it included the matrix of 6x6 actuators. The thickness of the mirror substrate was 1 mm. The maximal deformation stroke of such wavefront corrector was about 5 microns.

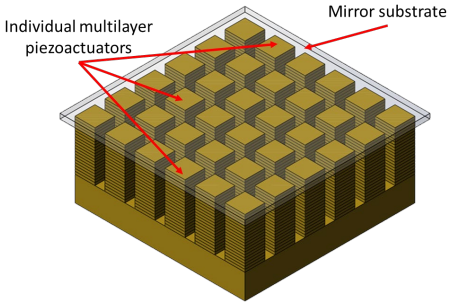

Fig. 1. The concept of miniature stacked-actuator deformable mirror.

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