New technologies for the actuation and control of large aperture lightweight optical quality mirrors

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ABSTRACT

There is a need for ever-larger apertures for use in space based imaging systems. The design of such large, lightweight optical quality mirrors involves a balance between (a) using thinner face sheet and lighter support structure, which reduces weight but increases the mirror surface deformations due to disturbances, and (b) using more dynamic actuated correction of the increased deformations, which increases weight due to the added actuators, metrology and control. Recent developments, such as the ultra lightweight nanolaminate-based optical quality mirror face sheets (~0.2 kg/m^2 areal density) developed at Lawrence Livermore National Laboratories, are dramatically changing this balance in favor of more actuation and control. To realize the full potential of the new ultra lightweight optical quality face sheets, we need to develop new lightweight large stroke precision actuators.

One of the major design drivers in any optical mirror design is the coefficient of thermal expansion (CTE) mismatch between the face sheet and the substrate. This mismatch forces tight thermal control, which in turn increases weight and constrains operations. Recently, a novel concept of flexure-hinged actuated substrate has been proposed[1] that substantially mitigates this CTE mismatch problem.

This paper discusses new large stroke lightweight discrete and distributed actuator technologies that enable the flexure-hinged substrate concept, for futuristic lightweight large aperture mirrors. The impact of this on the optimum mass balance between the face sheet and substrate is also discussed.

1. Sarma N. Gullapalli, Joseph Duffy, Carl Crane, Neil White, Harvey Lipkin, "Hinged Substrate for Large Aperture Lightweight Deformable Mirrors – A Novel Concept", SPIE Conference, August 2002, Hawaii.

Outline:

1. Introduction
2. The need for novel lightweight discrete and patch actuators for futuristic lightweight mirrors (Sarma)
3. A new lightweight discrete actuator (E.H.)
4. Distributed patch actuation (Mike)
5. Conclusions