Special Section Guest Editorial

Active Optical Components

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Technically, the sensing of phase errors and the use of this feedback signal by a closed loop servo control system that nullifies those errors is the distinguishing factor between adaptive and active optic systems. For the purposes of this special section, the term "active optics" has more to do with the phase conjugate of Gaskill's Law, which is a Fourier integral that describes the ratio of abstracts received to manuscripts accepted for publication. Simply put, the response to the adaptive optics special section required expanding to two issues. I have tried to group the papers within the accepted technical definitions of active and adaptive optical components but have taken the liberty to evenly split the papers into the two issues. This special section is dedicated to active optical components, specifically the active control of structures, the fast steering mirror, the large active primary mirror, the precision solid state actuators, the maturing liquid crystal, and emerging diffractive optics technologies.

The first three papers address the use of active control in space based structures to implement submicrometer control. The first paper, by James Fanson, Eric Anderson, and Donald Rapp, considers the application of active structures technology to the control of precision structures for future NASA space based astrophysics observatories. A review of active structures and associated development programs is presented in terms of applications of the technology to the large optical system. Parameters and trades are identified that are necessary to make such structural control feasible. The second paper is by Mark Janosky and describes the development of a lightweight 17 in. hexagonal mirror that uses a combination of moment and force actuators to control optical figure. NASTRAN finite element modeling was used to determine actuator locations to minimize residual wavefront error. Classic methods of servo system design are used to predict system dynamics. Experimental testing was conducted by using manual closed loop control. The third paper, by Eric Anderson, Donald Moore, James Fanson, and Mark Ealey, describes the development and testing of an active structural element for use as an active member in a truss-like structure. The active member incorporates an eddy current displacement sensor and either a piezoelectric (PZT) or electrostrictive (PMN) actuator. Performance of PZT and PMN actuators is compared for several properties relevant to submicrometer control.

The next three papers provide an overview of steering mirror components for use in a variety of precision pointing applications. The fourth paper is by Steven Forman, John Sultana, and Raymond LeClair. It describes the development and testing of flat steering mirrors for spaceborne laser radar applications. Design configurations and fabrication materials are assessed by computer modeling, prototype fabrication, and evaluation. Low expansion glasses, beryllium, and graphite epoxy materials were evaluated in terms of dimensional stability. In the fifth paper, Larry Germann and Janet Braccio describe the various design configurations considered for fine-steering mirror applications and provide a description of mirror piece parts and relevant equations. Fabrication processes and reactionless designs required for high bandwidth performance are described. Performance of several steering mirrors is overviewed in terms of bandwidth and acceleration criteria. The sixth paper, by Greg Loney, describes the development of a high bandwidth, two axis steering mirror for precision pointing and tracking applications. Mirror dynamics are discussed in terms of fundamental eigenvector equations and corresponding NASTRAN finite element models. Results show a 10 kHz closed loop bandwidth with a 26 mrad peak-to-peak stroke.

The next paper addresses the large active primary mirror, specifically the Keck 10 m telescope segments. Here, John Pepi describes the novel fabrication process used for the manufacture of the Keck telescope segments. NASTRAN and flat plate theory analyses are used to predict the focus and moments necessary to produce the aspheric surfaces. The stress polishing technique involves placing a known stress on the optic being polished with spherical figure. Once the load is removed, the mirror springs into the prescribed aspheric shape. Theoretical finite element models are used to assess distortions and are correlated with interferometric test results.

The next three papers concern the actuator component required for precision control of most active and adaptive optical components. The eighth paper is by Mark Ealey and Paul Davis and describes the evolution of PMN actuators and relevant performance data. Finite element models, fabrication processes, and electrostrictive principles of operation are covered. A summary of SELECT actuator configurations is given with supporting experimental data that show the low hysteresis, low thermal expansion, and exceptional optical stability characteristics of PMN. In the ninth paper, Garry O'Neill and Conal O'Neill examine the requirements of control actuators and propose ferroelectric devices that meet those requirements. Performance of the devices is evaluated in terms of linearity, repeatability, and reliability. The binary stack using both soft and hard ferroelectric material compensates for hysteresis limitations. The tenth paper is by John Galvagni. He describes the advantages of electrostrictive actuators over conventional piezoelectric devices. The paper also provides a brief survey of optical devices that incorporate PMN actuators as the active element and includes a summary of relevant actuator properties.

The final two papers are "novel technologies" that effect active control without mechanical means by employing either a crystal device or a diffractive microlens array. William Goltsos and Michael Holz describe a steering mechanism other than mechanical. Agile steering of a laser beam using a complementary pair of diffractive microlens arrays is discussed. Wavefront quality and beam steering efficiency test results are discussed as a function of steering angle and are compared with theoretical predictions. In the twelfth paper, Ronald Driggers, Carl Halford, and Glenn Boreman describe the use of a spatial light modulator rather than a spinning reticle in a frequency modulated tracking system. A barrel transform is applied to the reticle algorithm to reduce the required system data rate by direct rectangular mapping.

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Mark A. Ealey: Biography and photography appear with the paper "Standard SELECT electrostrictive lead magnesium niobate actuators for active and adaptive optical components" in this issue.