Synthesis and Analysis of Parallel Kinematic XY Flexure Mechanisms

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This thesis presents a family of XY flexure mechanisms with large ranges of motion, first-order decoupled degrees of freedom, and small parasitic error motions. Synthesis is based on an systematic and symmetric layout of constraints that are realized by means of common flexure building blocks. An analytical formulation incorporating geometric non-linearities is used in deriving the characteristics of these flexure building blocks. Of concern are issues related to qualification and quantification of undesirable motions, mobility, stiffness variation within the range of motion, determination of center of stiffness, and sensitivity to manufacturing and assembly tolerances. Based on the properties of the building blocks, the performances characteristics of the resulting XY flexure mechanisms are discussed and the influence of symmetry in reducing error motions is analytically illustrated.

To verify the design theory, a 300mm x 300mm prototype stage was fabricated, assembled and tested at the National Institute of Standards and Technology (NIST). Measurements using laser interferometry, autocollimation and capacitance gauges indicate levels of performance much better than the capabilities of the current state of the art of precision flexure stages. The prototype flexure stage has a 5mm x 5mm range of motion, with cross-axis errors of the order of one part in one thousand, and motion stage yaw errors of the order of a few arc seconds.

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