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Design and Characterization of a two-axis, flexure-based nanopositioning stage with 50 mm travel and reduced higher order modes

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Highlights

- Parametric design and prototype fabrication of two flexure based XY nanopositioning stages (DPF and modified DPF) with travel ranges up to two inches is presented.
- Both experimental and FEA predictions shown to be in good agreement with analytical results for both stage designs.
- Higher order modes of the modified stage (with underconstraint eliminator) have been shown to be shifted from 25 Hz in the DPF stage to over 86 Hz in the modified DPF stage.

1 ABSTRACT

Long range, high precision, XY stages have a multitude of applications in scanning probe microscopy, lithography, micro-AM, wafer inspection and other fields. However, finding cost effective precision motion stages with a range of more than 12 mm with a precision better than one micron is a challenge. This study presents parametric design of the two XY flexure-based stages with a travel ranges of up to 50 mm and sub-micron resolution. First, the fabrication and testing of a two-axis double parallelogram flexure stage is presented and the results obtained from FEA and experimental measurements are shown to be in good agreement with the analytical predictions for this stage. A modified stage design with reduced higher order modes and same range, is also presented. This modified design is shown to be capable of achieving an open loop resolution of 100 nm with a travel range of greater than 50 mm. Higher order modes of the modified stage have been shown to be shifted from 25 Hz in the double parallelogram flexure (DPF) stage to over 86 Hz in the modified DPF stage making it much simpler to design a high speed (> 10Hz) controller for the modified stage.

Keywords: Nanopositioning, Double parallelogram, Flexure stage, Underconstraint eliminator, 50 mm

2 INTRODUCTION

Long range XY stages with high precision have a number of applications in fields such as lithography [1,2], scanning probe microscopy [3], atomic force microscopy [4] to molecular spectroscopy [5], nanometrology [6], biological cell manipulation [7], micro additive manufacturing processes [8], wafer inspection, chip packaging [9], optics [10], and micro-machining. There have been a number of studies pertaining to the design of precision motion stages with range