

925. Design and dynamic modeling of piezoelectric laser beam shutters

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Abstract. The paper presents the results of numerical modelling and experiments of piezoelectric bimorph-type bending actuator for laser beam shutting system. Theoretical calculations are realized by using finite element method. The purpose of these calculations is to optimize geometric parameters of a piezoelectric bimorph, ensuring maximum resonant frequency of the first bending form and stability of oscillation amplitude. Experimental performance of piezoelectric actuators is compared with results of finite element simulations.

Keywords: laser beam shutter, piezoelectric bimorph, amplitude-frequency response.

1. Introduction

In this article we investigate a piezo-driven mechanical laser beam shutter, which can be used for modulation or the switching of the light intensity in various laser applications. Presently piezoelectric actuators are widely used in various mechatronic devices and systems, including high accuracy positioning systems, optical and laser scanning/deflecting devices, piezoelectric robots. Particular interest in using piezoelectric actuators was determined by their superior characteristics – high-energy efficiency and short response time. Piezoelectric actuators now belong to the most effective driving force or motion generation mechanisms; they operate both in quasi-static and resonance mode and in order to achieve the desired modal shape, it is necessary to optimize geometric parameters and obtain specific location of excitation zones. This fact is especially important for the ultrasonic transducers with several degrees of freedom [1-3].

The performance of piezoelectric devices strongly depends on the characteristics of the piezoelectric transducers, which are the main components of the piezomechanical system. The synthesis of specific oscillation areas of the piezoelectric actuator can be obtained by optimizing the geometrical parameters, the poling vector and the topology of excitation zones of the piezoelectric transducer. The piezoelectric effect plays an important role in the dynamical behaviour of these actuators [4]. So it is very important to know what modal shape will be excited when applying piezoelectric actuators for high resolution motion control [6].

Such piezoelectric bimorphs have very wide area of applications, such as sensor systems, printing technologies, scanners, ultrasonic atomizers, ultrasonic transducers, positioning transducers, viscosity measurement systems, flow measurement systems, energy harvesting, laser beam controlling systems, pneumatic valves for industrial and automotive applications, valves in medical applications, insulin pumps, braille keys for the blind, textile machinery, optical switches, oil exploration, machine and equipment monitoring, automotive engines, feedback sensors, high temperature accelerometers, rate & gyroscope sensors, intrusion alarms and many other devices. So development and investigations of such type piezoelectric actuators are very important.

2. The beam laser shutter design

The important problem in designing laser devices is controlling the intensity of laser beam power up to zero, effected by various laser beam shutters for safety and beam control