DEVELOPMENT AND INVESTIGATION OF NEW DESIGN PIEZOELECTRIC LASER BEAM SHUTTER

Bubulis A., Jurenas V., Maciukiene V., Navickaite S.

Kaunas University of Technology, Kaunas, Lithuania

In this paper authors investigate laser beam shutting system of a new design. The scheme of the investigated laser beam shutter and working principle are explained. According the experimental research results of the developed laser beam shutting system was performed.

(E-mail: algimantas_bubulis@ltu.lt)

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Introduction

Laser technologies are broadly used in modern equipment. Seeking to control laser beam there are used laser shutting or chopping systems [2]. Laser beam goes without disturbing through laser shutter system, if the shutter is opened, but in that case if the shutter is all or partially closed laser beam is all or partially blocked.

In this paper authors investigate a new design laser beam shutting system.

Most laser beam choppers or shutters developed up to date are single resonance frequency based, and while recent efforts have been made to broaden the frequency range of laser beam choppers, what is lacking is a robust tunable frequency technique of the chopper [4]. Shutters differ from choppers in that they are not limited to a simple periodic on-off cycle but will follow an arbitrary, varying pattern of openings and closings [5]. Optical shutters are useful for low frequency chopping, particularly when slow or non-periodic behavior is desired [6, 7].

The scheme and working principle of the investigated laser beam shutter

The investigated new design piezoelectric laser beam shutter consists of piezoactuator 2 that is housed together in the housing device 1. Special blade 4 for laser beam 5 shutting is attached to elastic carbon fiber element 3. Its design is illustrated in figure 1. Bending deformations of elastic carbon fiber element 3 can be excited by the piezoelectric effect of piezoactuator 2.

After getting supply voltage piezoactuator 2 works in $d_{33}$. It pushes elastic carbon fiber element 3 by the force $F(t)$ and displacement $\Delta u$, special blade 4 shuts (blocks) laser beam 5. Seeking to get the necessary direction of motion of blade 4, elastic carbon fiber element 3 is bended with primary angle $\alpha_{\text{min}}$. If piezoactuator 2 is affected by supply voltage, elastic carbon fiber element 3 is pushed and bended by angle $\alpha_{\text{max}}$. Displacement of special blade 4 $\Delta d$ depends on elastic carbon fiber element 3 bending angle $\alpha_{\text{max}}$. The carbon fiber element 3 is bended with primary deflection $n$.

Experimental investigation

Displacements of piezoelectric laser beam shutter were measured by experimental set up shown in figure 2.
It was investigated two different lengths of carbon fiber plate: $L = 44$ mm and $L = 52$ mm. The measurements of displacements for vibrations frequency of 120 Hz for the piezoelectric laser beam shutter were made in three points as is shown in figure 3. Experimental results for displacements of elastic carbon fiber plate are presented in figure 4. Deformations of the elastic plate due to different fixation conditions of the plate ends can be clearly seen.

Dependence of middle point displacements $\Delta d$ of elastic carbon fiber plate on piezoelectric actuator static displacements $\Delta u$ for the plate lengths 44mm and 52mm is presented in figure 5.

**Figure 2** – Experimental set up: 1 – signal generator Agilent 33220A; 2 – power amplifier EPA-104; 3 – analog digital converter (ADC) «PicoScope-3424»; 4 – laser displacement sensor LK-G82; 5 – laser sensor controller LK-G3001PV; 6 – Polytec OFV-5000 vibrometer controller; 7 – Polytec OFV-512 fiber interferometer; 8 – Polytec OFV-130-3 micro-spot sensor head; 9 – computer; 10 – piezoelectric laser beam shutter

**Figure 3** – The scheme of experimental measurements: $a$, $b$, $c$ – the points where measurements of displacements of carbon fiber plate were made; $n$ – primary deflection of the carbon fiber element

**Figure 4** – Displacements of elastic carbon fiber plates with different voltages (1 – 10 V; 2 – 30 V; 3 – 50 V): $a$ – plate length $L = 44$ mm; $b$ – plate length $L = 52$ mm

**Figure 5** – Dependence of displacements $\Delta d$ of point $a$ of the elastic carbon fiber plate on piezoelectric actuator displacements $\Delta u$ for the plate lengths 44 mm and 52 mm

**Conclusion**

The article presents the experimental investigation of laser beam shutter with buckling type displacement amplification member actuated by the piezoelectric actuator. As it can be seen from experimental results, the buckling deformations of carbon fiber element get maximum value with 64 µm (when the length of element is 44mm) and 111 µm (when the length of element is 52mm). The results
of experimental investigation show possibilities to optimize the geometrical parameters of carbon fiber element seeking to obtain maximum displacements of the laser shutter. The maximum amplification factor (value of 10-15) can be obtained by the primary buckling deformations of the carbon fiber plate.

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References


