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DEVELOPMENT AND INVESTIGATION OF NEW DESIGN PIEZOELECTRIC LASER BEAM SHUTTER

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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.
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Keywords: laser beam, shutter, piezoactuator, deformation.

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 Δu, 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 α_{min}. If piezoactuator 2 is affected by supply voltage, elastic carbon fiber element 3 is pushed and bended by angle α_{max}. Displacement of special blade 4 Δd depends on elastic carbon fiber element 3 bending angle α_{max}. The carbon fiber element 3 is bended with primary deflection n.

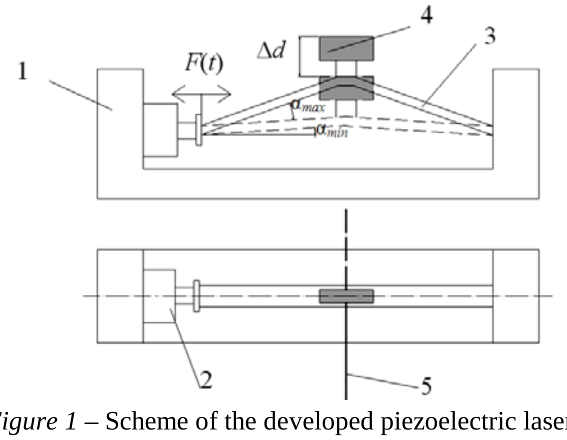

Figure 1 – Scheme of the developed piezoelectric laser shutting system: 1 – housing; 2 – multilayer piezoelectric actuator; 3 – carbon fiber element; 4 – laser beam covering plate; 5 – laser beam

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 Δd of elastic carbon fiber plate on piezoelectric actuator static displacements *Δu* for the plate lengths 44mm and 52mm is presented in figure 5.

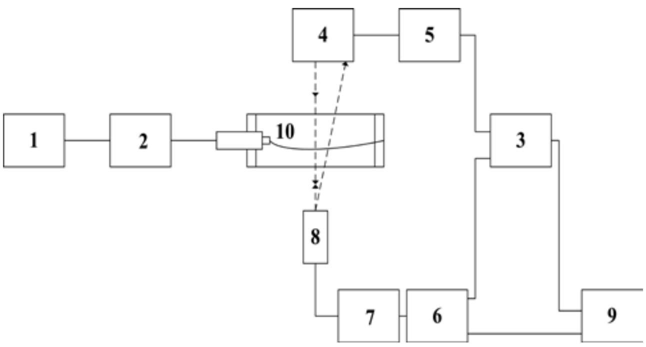

Figure 2 – Experimental set up: 1 – signal generator Agilent 33220A; 2 – power amplifier EPA-104; 3 – analog digital converter (ADC) «PicoScope-3424»; 4 – laser displacement sensor LK-G82; 5 – laser sensor controller LK-G3001PV; 6 – Polytec OFV-5000 vibrometer controller; 7 – Polytec OFV-512 fiber interferometer;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

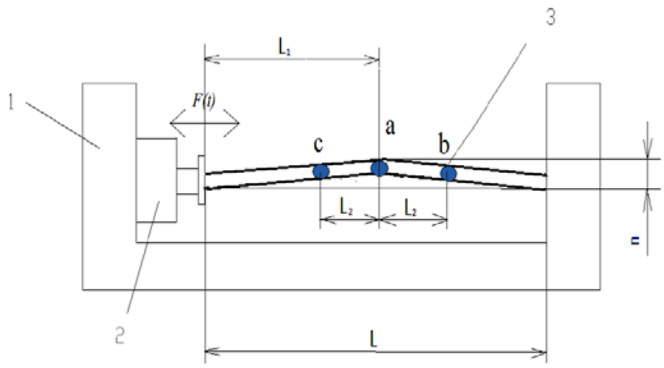

Figure 3 – The scheme of experimental measurements: *a*, *b*, *c* – the points where measurements of displacements of carbon fiber plate were made; *n* – primary deflection of the carbon fiber element

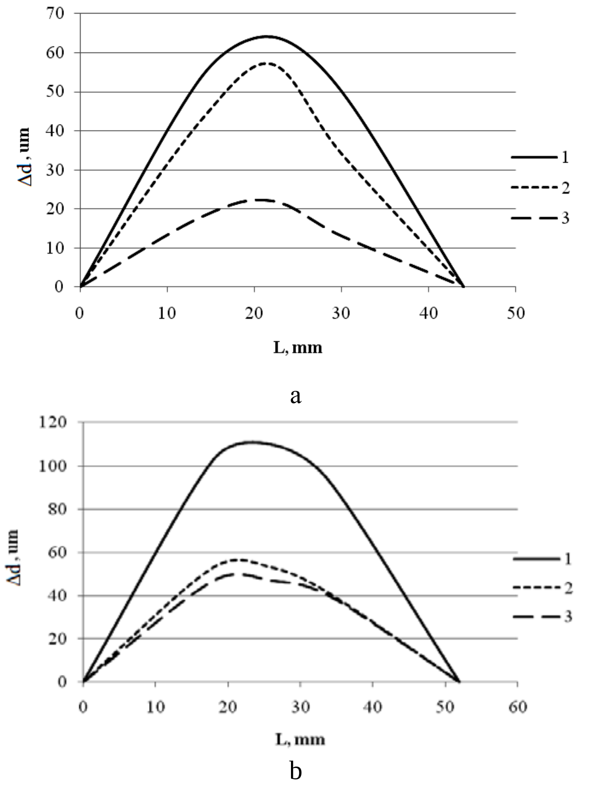

Figure 4 – Displacements of elastic carbon fiber plates with different voltages (1 – 10 V; 2 – 30 V; 3 – 50 V): a – plate length L = 44 mm; b – plate length L = 52 mm

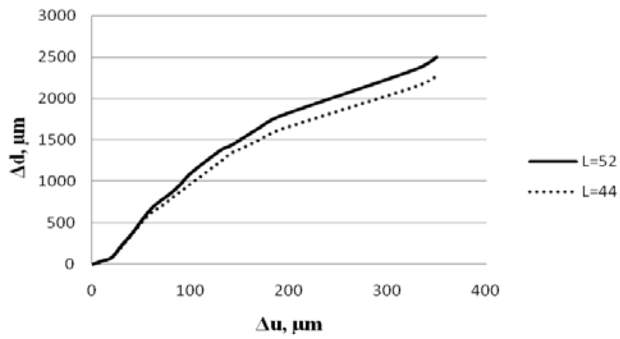

Figure 5 – Dependence of displacements Δ*d* of point a of the elastic carbon fiber plate on piezoelectric actuator displacements Δ*u* for the plate lengths 44 mm and 52 mm

Conclusion

The article presents the experimental investigation of laser beam shutter with buckling type displacement amplification member actuated by the piezolectric 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 amplifycation factor (value of 10-15) can be obtained by the primary buckling deformations of the carbon fiber plate.

Acknowledgments

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References

1. *Tang, B.* Fiber Reinforced Polymer Composites Applications in USA / B. Tang // Structural Engineer, HIBT-10, Bridge Specialist Group 1200 New Jersey Avenue SE, Washington, DC 20590, January 6, 1997, Published in the First Korea/U.S.A. Road Workshop Proceedings. – January 28–29, 1997.
2. *Bensoe, M.P.* On the design of structure and controls for optimal performance of actively controlled flexible structures / M.P. Bensoe, N. Olhoff, J.E. Tatlor // Mech. Struct. & Mach. –Vol. 15. – N. 3 (1987). P. 265–295.
3. *Dibbern, U.* Piezoelectric actuators in multilayer technique / U. Dibbern // Actuator 94. – Bremen, Germany, 1994. – P. 114–118.
4. Fast Laser Shutters With Low Vibratory Disturbances / NASA‘s Jet Propulsion Laboratory. – USA, February 2005.
5. *Freyhold, T.* Miniaturized piezo electric chopper for fiber optical multimode applications realized using LIGA-technology / T. Freyhold [et al.] // Optical MEMS'98, IEEE/LEOS Summer Topical Meetings. – Monterey, Ca, 1998. – P. 75–79.

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Разработка и исследование новой конструкции пьезоэлектрической задвижки лазерного луча

Представлены результаты экспериментальных исследований динамики заслонки лазерного луча с пьезоприводом. Приведены методика измерения деформаций выходного звена заслонки и блок-схема измерительной установки, позволяющей бесконтактным способом с высокой точностью определить амплитудно-частотные характеристики выходного звена пьезопривода. Представлены зависимости деформаций упругого звена заслонки от амплитудных характеристик пьезопривода. (E-mail: algimantas.bubulis@ktu.lt)

Ключевые слова: лазерный луч, заслонка, пьезопривод, деформация.

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