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信息科学

两点封装的光纤布拉格加速度传感器设计

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摘要： 提出了一种双半孔梁光纤布拉格光栅(FBG)加速度传感器实现加速度信号测量的方法。首先,建立了两点封装FBG的加速度传感模型,理论分析了加速度与位移敏感点的线性响应。其次,从理论上分析了两点封装方案中FBG的自振特性,讨论了封装光纤的长度和预应力对光纤自振频率的影响。最后,依据FBG的自振特性设计了FBG加速度传感器,并通过实验研究了FBG加速度传感器的线性响应和幅频响应特性。实验结果表明:提出的传感器在10~250 Hz具有较好的平坦区,加速度响应灵敏度为41.2 pm/G;加速度与波长具有较好的线性关系,线性度为99.8%。同时,该加速度传感器具有较强的方向抗干扰性,轴向交叉灵敏度小于4.8%。

关键词： 光纤光学 光纤布拉格光栅 两点封装 自振特性 加速度传感

Design of FBG acceleration sensor based on two-dot coating

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Abstract: A Double-semicircle Cantilever Beam(DSCB) accelerometer based on a fiber Bragg grating (FBG) was proposed to measure the acceleration signals. Firstly, the model of FBG accelerometer based on the two-dot coating was established,and the linear response between acceleration and displacements of sensitive elements was analyzed theoretically. Then, the natural vibration of the FBG based two-dot coating was described, and the effects of the length and prestress of the coated fiber on natural vibration frequency were discussed. Finally, according to the natural vibration of FBG, the FBG accelerometer was designed, and the linear response, amplitude-frequency characteristics, and direction anti-interference of the FBG accelerometer were researched experimentally. Experimental results indicate that the sensor has good flat response from 10-250 Hz, and the sensitivity of the accelerometer is 41.2 pm/G. Furthermore, the sensor can offer a good linear response in a linear fitting of 99.8% and a good cross-axis anti-interference ability in the cross-axis sensitivity less than 4.8%.

Keywords: fiber optics fiber Bragg grating two-dot coating natural vibration acceleration sensing

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参考文献：

[1] MITA A, YOKOI I. Fiber Bragg grating accelerometer for structural health monitoring. *Fifth International Conference on Motion and Vibration Control (MOVIC 2000), Sydney*, 2000. [2] TODD M D, JOHNSON G A, ALTHOUSE B A, *et al*.. Flexural beam-Based fiber Bragg grating accelerometer[J]. *IEEE Photo. Technol. Lett,* 1998, 10(11):1605-1607. [3] ZHANG J H, QIAO X G, HU M L, *et al*.. Flextensional fiber Bragg grating-based accelerometer for low frequency vibration measurement [J]. *Chinese Optics Letters*, 2011,9(9): 090607. [4] BERKOFF T A, KERSEY A D. Experimental demonstration of a Fiber Bragg grating accelerometer [J]. *IEE Photo. Technol. Lett,* 1996, 8(12):1677-1679. [5] 李学成, 刘肃, 张文涛, 等. 双膜片结构光纤光栅地震检波器低频特性的研究[J]. 光电子·激光,2010,21(4):529-532. LI X CH, LIU S, ZHANG W T, *et al*.. Study on low frequency characteristic of double diaphragm fiber Bragg grating geophone [J]. *Journal of Optoelectronics Laser*, 2010, 21(4):529-532. (in Chinese) [6] 沈洋,孙利民. 高灵敏度温度自补偿型光纤光栅加速度传感器设计[J]. 结构工程师,2009,25(2):141-146. SHEN Y, SUN L M. Design of FBG-based accelerometer with high sensitivity and temperature self-compensation [J].*Structural Engineers*, 2009, 25(2):141-146. (in Chinese) [7] 刘波,牛文成,杨亦飞,等. 新型光纤光栅加速度传感器的设计与实现[J]. 仪器仪表学报,2006,27(1):42-44. LIU B, NIU W CH,YANG Y F, *et al*.. A Novel fiber Bragg grating accelerometer [J]. *Chinese Journal of scientific Instrument,* 2006, 27(1):42-44. (in Chinese) [8] 李国利,赵彦涛,李志全. 基于双光纤光栅的加速度传感探头结构的设计[J] 压电与声光, 2006,28(4):387-389. LI G L, ZHAO Y T, LI ZH Q. Design of acceleration sensing probe structure based on dual fiber Bragg grating [J]. *Piezolectectrics & Acoustooptics*, 2006, 27(6): 299-301. (in Chinese) [9] 赵彦涛,李志全. 基于Bragg光纤光栅的三维加速度传感器的研究[J]. 仪器仪表学报,2006,27(6):299-301. ZHAO Y T, LI ZH

Q. Study on triaxial accelerometer based on FBG [J]. *Chinese Journal of Scientific Instrument,* 2006, 27(6): 299-301. (in Chinese) [10] WENG Y Y, QIAO X G, FENG ZH Y, *et al*.. Compact FBG diaphragm accelerometer based on L-shaped rigid cantilever beam [J]. 2011,9(10): 100604. [11] MULLER M S, BUCK T C, KOCH A W. Fiber bragg grating-based acceleration sensor. *Optomechatronic Technologies, International Symposium*,2009:127-123. [12] OUSAMA M A, MUSTAFA A A, KARTHIK N. Novel three-axes fiber Bragg grating accelerometer[J]. *SPIE*, 2009: 58770Z. [13] 王焕定,章梓茂,景瑞. 结构力学 [M],北京:高等教育出版社,2009. WANG H D, ZHANG X M, JING R. *Structural mechanics*[M], Beijing: Higher Education Press, 2009. (in Chinese)

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4．饶春芳, 张华, 冯艳, 肖丽丽, 叶志清.镍金属保护光纤布拉格光栅的热处理及高温传感[J]. 光学精密工程, 2011,19(9): 2006-2013

5．CHENG Chin-hsing, CHANG Min-chih, LIU Wen-fung.基于光纤布拉格光栅和压电转换器的电功率传感器[J]. 光学精密工程, 2011,19(9): 2255-2262

6．王宏亮, 宋娟, 冯德全, 邬华春.应用于特殊环境的光纤光栅温度压力传感器[J]. 光学精密工程, 2011,19(3): 545-551

7．任恩恩, 鲁 彦, 鲁怀伟, 罗冠炜.全光纤MZI型三信道波长交错滤波器的改进[J]. 光学精密工程, 2010,18(7): 1483-1490

8．杨银川,;李东玲,;尚正国,,.力平衡式真空微电子加速度传感器的机电耦合特性[J]. 光学精密工程, 2009,17(6): 1361-1366

9．王玮;李德胜;高宗余;周卫;张鹏飞.空中手写笔笔迹检测系统[J]. 光学精密工程, 2009,17(6): 1286-1292

10．陈伟民,张娅玲,章鹏,张亮.FBG旁瓣对复用解调的影响及旁瓣抑制方法[J]. 光学精密工程, 2009,17(11): 2672-2677

11．尹霄丽,张琦,余重秀,刘小磊,刘会师,王宇.相移超结构光纤布拉格光栅OCDMA编/解码器及其相关特性研究[J]. 光学精密工程, 2008,16(9): 1608-1613

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13．郭明金;姜德生;袁宏才.两种封装的光纤光栅温度传感器的低温特性[J]. 光学精密工程, 2007,15(3): 326-330

14．车录锋[1];卢 云[1,2];徐志农[2].铰链式高冲击微加速度传感器封装的有限元模拟[J]. 光学精密工程, 2007,15(2): 199-205

15．于志辉;余重秀;王葵如;王 旭;颜玢玢;陈 卓;李安俭.直流切趾对光纤光栅特性的影响[J]. 光学精密工程, 2006,14(6): 935-938