光学 精密工程
OPTICS AND PRECISION ENGINEERING
核心期刊
主管：中国科学院
主办：中国科学院长春光学精密机械与物理研究所
中国仪器仪表学会
主编：曹健林



光学精密工程 2012, 20(9) 2051-2059 ISSN: 1004-924X CN: 22-1198/TH



信息科学

# 悬臂梁陀螺仪机械性能优化及系统实现

刘宇[1], 段耀宇[1], 刘利[1], 潘英俊[2]

1. 重庆邮电大学 光电工程学院,重庆 400065;
2. 重庆大学 光电工程学院, 重庆 400044

摘要： 为了提高悬臂梁振动陀螺仪在惯性测量系统中的测量精度,改进了悬臂梁振动陀螺仪的敏感结构,开发了基于该陀螺仪的测量系统,研究了改进悬臂梁陀螺仪的结构特性、温度特性、零位漂移和线性度。首先,根据悬臂梁振动陀螺仪的工作原理分析了影响其测量精度的原因。针对原有悬臂梁振动陀螺仪压电片耦合结构的不足提出了一种新的压电片耦合结构。接着,结合50、60、100 mm悬臂梁和ANSYS软件对改进结构进行了建模仿真,证明了新结构的工程可行性。最后,基于改进结构制作了陀螺仪样机,并进行了相关的测试实验。仿真实验和样机实验表明,改进后的陀螺仪灵敏度平均提高了8.73%,25℃时的零位漂移平均下降了30.5%,温度漂移平均降低了10%,证明了新结构陀螺仪在工程应用中的可行性。

关键词： 悬臂梁陀螺仪 机械性能 镶嵌式耦合 惯性测量

# Mechanical performance optimization and system implementation of cantilever beam gyroscope

LIU Yu[1], DUAN Yao-yu[1], LIU Li[1], PAN Ying-jun[2]

1. Department of Optoelectronics Engineering, Chongqing University of Posts and Telecommunications, Chongqing 400065, China;
2. Department of Optoelectronic Engineering, Chongqing University , Chongqing 400044, China

Abstract: To improve the measurement accuracy of a cantilever vibration gyroscope in an inertial measurement system, the sensitive structure of the cantilever vibration gyroscope was modified and a measurement system was developed based on the gyroscope. The structural and temperature characteristics of the improved gyroscope were analyzed and the zero drift and linearity were researched in detail. Firstly, the reasons that affect the gyroscope measurement accuracy were analyzed base on the working principle of the cantilever vibration gyroscope. According to the insignificance of the piezoelectric film coupling structure of the original cantilever vibration gyroscope, a new piezoelectric film coupling structure was proposed. Then, the new structure was simulated by ANSYS software combined with 50, 60, 100 mmcantilevers to prove its engineering feasibility. Finally, a prototype of the gyroscope based on the new structure and test performance was produced in a laboratory. Simulation and prototype experiments show that the average sensitivity of the new structure gyroscope increases by 8.73%, and the average zero drift and temperatare drift decrease by 30.5% and 10%, respectively when the temperature is 25℃. These results prove that the improved cantilever vibration gyroscope can be used in engnieering practices.

Keywords: cantilever vibration gyroscope mechanical performance mosaic coupling inertial measurement

收稿日期 2012-04-17 修回日期 2012-06-05 网络版发布日期

基金项目:

国家自然科学基金资助项目(No.51175535);国家科技创新基金资助项目(No.10C26215113044);重庆市教委科技项目基金资助项目(No.KJ110507);重庆市自然科学基金重点项目(No.CSTC-2012jjB40003)

通讯作者: 刘宇

作者简介: 刘 宇 (1972-),男,重庆人,博士,教授, 2000年于重庆大学获得硕士学位,2006年于重庆大学获得博士学位,主要从事空间行人定位,井下寻北,光纤传感技术,惯性导航及传感器器件和信号处理方面的研究。E-mail: liuyu.cqupt@yahoo.com.cn
作者Email: liuyu.cqupt@yahoo.com.cn

参考文献：

[1] VIKRANT B, NADER J, NIMA M. A novel piezoelectrically actuated flexural /torsional vibrating beam gyroscope [J]. *Journal of Sound and Vibration*,2008,311: 1305-1324. [2] LIU Y, LIU J. Design and evaluation of a vibration sensor for measurement-while-drilling [J]. *Int. J. Computer Applications in Technology*, 2011, 40(1): 79-84. [3] 张永祥,孙辉,马天伟,等.抑制压电陀螺仪噪声方法的研究[J]. 光学 精密工程,2004,12(3):230-234. ZHANG Y X, SUN H, MA T W, *et al*.. Method for suppression of piezoelectricity gyroscope noise[J], *Opt. Precision Eng*., 2004, 12(3): 230-234. (in Chinese) [4] 刘宇,路永乐,曾燎燎,等.固态振梁角速率传感器的动力学特性与误差分析[J]. 机械工程学报,2011,47(4):7-11. LIU Y, LU Y L, ZENG L L, *et al*.. Analysis on dynamic characteristic and error of solid vibration beam rate sensor[J]. *Journal of Mechanical Engineering*, 2011, 47(4): 7-11.(in Chinese) [5] LIU Y, LU Y L, ZENG L L, *et al*.. Dynamic characteristic analysis and machining error study based on solid vibration beam rate sensor[J]. *IEEE Advanced Materials Research*, 2011, 148-149:529-534. [6] BUMKYOO C, SEUNG-YOP L, TAEKHYUN K, *et al*.. Dynamic characteristics of vertically coupled structures and the design of a decoupled micro gyroscope[J]. *Sensors*, 2008, 8:3706-3718. [7] 施芹,裘安萍,苏岩,等.微硅陀螺仪的机械耦合误差分析[J]. 光学 精密工程,2008,16(5):894-898. SHI Q,QIU A P,SU Y.*et al*.. Mechanical coupling error of silicon microgyroscope[J].*Opt. Precision Eng*., 2008,16(5):894-898. (in Chinese) [8] 李杰,刘俊,张文栋,等.MEMS陀螺仪随机误差补偿方法研究[J], 中北大学学报,2009,30(4):381-385. LI J, LIU J, ZHANG W D, *et al*.. Research on random error compensating methods for MEMS gyroscope[J].*Journal of North University of China*, 2009, 30(4):381-385. (in Chinese) [9] 刘宇,路永乐,曾燎燎,等.光纤陀螺漂移误差的T-S模糊建模补偿[J]. 重庆大学学报,2010,33(2):60-65. LIU Y, LU Y L, ZENG L L, *et al*.. Drift error compensation algorithm

for fiber optic gyro base on T-S fuzzy modeling[J]. *Journal of Chongqing University*, 2010, 33(2):60-65. [10] 谢立强,吴学忠,李圣怡.石英微角速率传感器的机械耦合问题研究[J]. 国防科技大学学报,2007,29(1):131-134. XIE L Q, WU X Z, LI S Y. The study of mechanical coupling in quartz micromachined gyroscope system[J].*Journal of National University of Defense Technology*,2007,29(1):131-134. (in Chinese) [11] 刘宇. 固态振动陀螺与导航技术 [M]. 北京:中国宇航出版社,2010:47-77. LIU Y. *Solid-state Vibration Gyroscope and Navigation Technology*[M]. Beijing: China Aerospace Press,2010. ( in Chinese)

本刊中的类似文章

1．代刚, 李枚, 苏伟, 邵贝贝.微惯性测量单元的误差整机标定和补偿[J]. 光学精密工程, 2011,19(7): 1620-1626

2．阎永达,胡振江,费维栋,程相杰,孙涛,董申.基于单片机的AFM纳米机械性能测试系统[J]. 光学精密工程, 2008,16(7): 1223-1229

3．解旭辉, 刘危, 张明亮, 李圣怡.微惯性测量组合关键技术与应用[J]. 光学精密工程, 2002,10(2): 154-159

4．刘宇 段耀宇 刘利 潘英俊.悬臂梁陀螺仪机械性能优化及系统实现[J]. 光学精密工程, ,(): 0-0