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基于铌酸锂制作光弹调制器用压电驱动器

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Fabrication of piezoelectric actuator for photoelastic modulator based on lithium niobate

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摘要 基于石英(SiO_2)制作光弹调制器(PEM)的压电驱动器时,存在机电耦合系数小、需高压驱动且谐振频率随温度漂移严重等缺陷,故本文研究了PEM的优化设计方法.考虑铌酸锂($LiNbO_3$)特殊的晶体结构,从理论上推导了$LiNbO_3$晶片作为压电驱动器的可行性,并确定其切型为*zyw*/35°切.基于有限元分析软件COMSOL4.3a仿真,确定了晶片体积和谐振频率,设计了$LiNbO_3$压电驱动器.对设计出的压电驱动器进行了压电性能测试,并和SiO_2压电驱动器进行了比较.将$LiNbO_3$压电驱动器和硒化锌(ZnSe)光弹晶体组合成PEM,用671 nm激光进行了光弹调制实验.实验结果表明:实现相同位移时,SiO_2压电驱动器需要的驱动电压是$LiNbO_3$压电驱动器的100多倍,且后者横向长度伸缩振动模式单一性和稳定性均优于前者.驱动电压为3.76 V时,671 nm的激光通过基于$LiNbO_3$压电驱动器的PEM的调制光程差为3.7 μm.得到的结果表明:基于$LiNbO_3$压电驱动器的PEM易于驱动控制,调制性能优于基于SiO_2 驱动器的PEM.

关键词 : 压电驱动器, 光弹调制器, 铌酸锂晶体, 谐振

Abstract : When the quartz(SiO_2) is used as the piezoelectric actuator of a photoelastic modulator(PEM), it has shortcomings of smaller electromechanical coupling coefficient, high driving voltage required, and serious frequency drifting with a temperature. Therefore, this paper designs an optimized PEM. In consideration of the special crystal structure of lithium niobate ($LiNbO_3$), the feasibility of $LiNbO_3$ crystal to be a piezoelectric actuator was verified and its cut shape was set as *zyw*/35°cut. Based on the finite element analysis software COMSOL4.3a simulation, the chip size and the resonant frequency were determined. Then, a $LiNbO_3$ piezoelectric actuator was designed. The piezoelectric performance of the piezoelectric actuator was tested and compared with SiO_2 piezoelectric actuator. Finally the $LiNbO_3$ piezoelectric actuator was combined with a ZnSe crystal to construct a PEM, and it was performed a photoelastic experiment by a 671 nm laser. The experiment for achieving the same displacement show that the drive voltage for the SiO_2 based piezoelectric actuator is 100 times that of $LiNbO_3$ based piezoelectric actuator, and the unity and stability of lateral length stretching vibration mode for the latter is better than that for the former. Moreover, when the drive voltage is 3.76 V, the optical path difference of 671 nm laser will be modulated to 3.7 μm through the $LiNbO_3$ piezoelectric actuator based PEM. These results demonstrate that proposed $LiNbO_3$ piezoelectric actuator based PEM is easy to drive and control and the modulation performance is better than that of previous PEMs.

Key words : piezoelectric actuator photoelastic modulator lithium niobate resonance

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