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, (8) 1740-1746 ISSN: 1004-924X CN: 22-1198/TH

微纳技术与精密机械

全相位谱分析在自混合干涉位移测量中的应用

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摘要： 提出基于全相位谱分析的自混合干涉信号处理方法,用于减小激光自混合干涉位移测量的误差。首先,基于三镜法布里-珀罗腔模型介绍了自混合干涉系统的数学模型,分析了自混合干涉信号的产生机理和特性。然后,研究了弱反馈条件下自混合干涉位移测量方法,采用全相位谱分析算法进行相位测量,重构外部反射体位移曲线;讨论了信号处理算法原理并进行了算法仿真。最后,进行自混合干涉位移测量实验,并给出压电陶瓷位移测量实验结果。结果表明,全相位谱分析算法可将自混合干涉位移测量误差减小到4.4 nm;应用全相位谱分析算法分析自混合干涉信号,可在不增加外部光学元件的前提下将位移测量误差减小到纳米量级。

关键词： 自混合干涉 全相位谱分析 位移测量 压电陶瓷

Application of all-phase spectral analysis to self-mixing interferometry for displacement measurement

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Abstract: A signal processing technique based on all-phase spectral analysis was proposed to reduce the displacement measurement error of a self-mixing interferometer. Self-mixing interference principle and signal processing technique were analyzed. First, the mathematical model and signal characteristics for the self-mixing interferometer were presented based on the model of laser oscillation cavity with three mirrors. Then, the displacement principle based on self-mixing interference was introduced. A all-phase spectral analysis was used to extract the phase of self-mixing interference signal to reconstruct the displacement of a reflective target and the signal processing algorithm was investigated with arithmetic simulation. Finally,an experiment system was established and the calibration result of bimorph PZT was presented. Experimental results indicate that the displacement error can be decreased to 4.4 nm by using all-phase spectral analysis. It concludes that the all-phase spectral analysis can reduce the displacement error of the self-mixing interferometer to nanometer level without increasing the number of optical elements.

Keywords: self-mixing interference all-phase spectral analysis displacement measurement piezo-electric ceramics

收稿日期 2012-04-13 修回日期 2012-05-14 网络版发布日期

基金项目:

高等学校博士学科点专项科研基金资助项目(No.20110032110052);精密测试技术及仪器国家重点实验室开放基金资助项目(No.2006A10401006)

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