

## 高性能波导集成型锗 pin 光电探测器的制备

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摘要: 采用 CMOS 兼容工艺, 在绝缘体上硅(SOI)晶圆片上制备了高性能波导集成型锗 pin 光电探测器。该光电探测器锗区长度为 15  $\mu\text{m}$ , 宽度分别为 1,2,3,4 和 5  $\mu\text{m}$ 。光波导与探测器间的光耦合为倏逝波耦合。为了进一步提高探测器的性能, 在结构设计上采用了聚焦耦合光栅及楔形耦合增强结构, 在材料生长方面采用了选择性外延生长法, 以提高锗的质量。通过暗电流、响应度、带宽及眼图测试对光电探测器性能进行了表征。测试结果表明在-2 V 的反向偏压下, 尺寸为 15  $\mu\text{m}\times 4 \mu\text{m}$  的光电探测器暗电流低至 169 nA, 其在波长 1 530 nm 处的最高响应度为 0.43 A/W, 3 dB 带宽高达 48 GHz 并获得 40 Gbit/s 的清晰眼图。

关键词: 光电探测器; 波导集成; 选择性外延; 锗 (Ge); pin; 绝缘体上硅 (SOI)

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Fabrication of a High Performance Waveguide Integrated Germanium pin Photodetector

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Abstract: A high performance waveguide integrated germanium (Ge) pin photodetector was fabricated on the patterned silicon on insulator (SOI) wafer by the process compatible with the CMOS technique. The length of the Ge region in the photodetector is 15  $\mu\text{m}$ , while the width increases from 1  $\mu\text{m}$  to 5  $\mu\text{m}$  with an increment of 1  $\mu\text{m}$ . The light is evanescently coupled from the silicon waveguide to the photodetector. In order to further improve the performance of the detector, a focusing coupling grating and a wedge coupling enhancement structure were adopted in the structure design, and the selective epitaxial growth method was used to improve the quality of the Ge. The performances of the device were characterized by a series of the tests, including the dark current, responsivity, frequency bandwidth and eye diagram. The test results show that for the photodetector with a size of 15  $\mu\text{m}\times 4 \mu\text{m}$  at -2 V reverse bias voltage, the dark current is as low as 169 nA, the maximum responsivity and 3 dB bandwidth are 0.43 A/W and 48 GHz at 1 530 nm wavelength, respectively, and the obtained 40 Gbit/s eye diagram is clear.

Key words: photodetector; waveguide integration; selective epitaxy; germanium (Ge); pin; silicon on insulator(SOI)

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单根 Ni/NiO 核壳纳米线器件的光电特性

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摘要: 利用化学还原法制备了 Ni 纳米线后经过高温氧化得到了 Ni/NiO 核壳纳米线, 最后利用半导体工艺制备出单根 Ni/NiO 核壳纳米线器件, 并对其光电特性进行了测试分析。I-V 曲线测试结果表明器件具有很好的整流特性。在-1 V 外加偏压下, 暗电流为  $1.6 \mu\text{A}$ , 光电流为  $15 \mu\text{A}$ , 光电流约是暗电流的 10 倍。在波长为 248 nm、功率密度为  $40 \text{ mW/cm}^2$  的脉冲光照射下, 器件的最大光生电压约为 23 mV, 响应时间约为  $1 \mu\text{s}$ 。通过曲线拟合发现器件的恢复时间由两部分组成, 分别为 3.3 和  $25 \mu\text{s}$ 。器件的恢复时间远长于响应时间, 这可能是由于 Ni/NiO 核壳纳米线中大量的缺陷阻碍了光生电子和空穴之间的复合所致。

关键词: Ni/NiO 核壳纳米线; 光电特性; 整流特性; 响应时间; 恢复时间

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Photoelectric Properties of a Single Ni/NiO

Core Shell Nanowire Device

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Abstract:The Ni nanowires were prepared by the chemical reduction method, and then the Ni/NiO core shell nanowires were obtained by high temperature oxidation. Finally, the single Ni/NiO core shell nanowire device was fabricated by the semiconductor process, and the photoelectric characteristics of the single Ni/NiO core shell nanowire device were measured and analyzed. The I-V curves test results show that the device has good rectification properties. At -1 V bias voltage, the dark current and photocurrent are  $1.6$  and  $15 \mu\text{A}$ , respectively. The photocurrent is about 10 times of the dark current. Under the laser pulse irradiation with a wavelength of 248 nm and a power density of  $40 \text{ mW/cm}^2$ , the maximum photovoltage of the device is about 23 mV with the responding time is about  $1 \mu\text{s}$ . The fitting curve shows that the first recovery time and the second recovery time of the device are 3.3 and  $25 \mu\text{s}$ , respectively. It is obviously found that the recovery time is much longer than the responding time, which is possibly induced by lots of defects in the Ni/NiO core shell nanowire hindering the recombination between the photo induced electrons and holes

Key words:Ni/NiO core shell nanowire; photoelectrical property; rectification property; responding time; recovery time

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高热导率纳米银胶在大功率器件上的应用

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摘要: 对高热导率纳米银胶进行了性能分析, 并与 Au80Sn20 焊料进行了对比; 将其应用于一大功率器件, 通过对粘结芯片进行剪切力测试, 验证了纳米银胶具有可靠的连接强度; 调整粘结样品的键合参数, 并对键合丝进行拉力测试, 结果在正常范围内; 对器件进行热阻测试, 与 Au80Sn20 焊料烧结对比, 温度分布基本一致; 进一步进行各项电性能测试, 器件各参数正常。各项结果表明, 此纳米银胶可替代 Au80Sn20 焊料烧结, 应用于大功率器件上。

关键词: 纳米银胶; 功率器件; 导电胶; 热阻; 焊料

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Application of the High Thermal Conductivity Nano Silver  
Adhesive in High Power Devices

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Abstract: The performances of the high thermal conductivity nano silver adhesive were analyzed and compared with those of the Au80Sn20 solder. The nano silver adhesive was used in a high power device, and the shearing strength of the bonded chip was tested to validate the reliable connection strength of the nano silver adhesive. Then the bonding parameters of the sample bonded by the nano silver adhesive were adjusted, and the pulling force of the bonded wire was tested. The results show that the pulling force is in the normal range. Besides, the thermal resistance of the device was tested and the result was compared with that of the sample soldered by Au80Sn20. The temperature distributions were almost identical. Furthermore, various electrical properties were tested, and all the parameters were in the normal range. All the results indicate that the nano silver adhesive can replace Au80Sn20 solder to be applied for a high power device.

Key words: nano silver adhesive; power device; conductive adhesive; thermal resistance; solder  
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基于微流体通道的柱状预浓缩器的设计与仿真

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摘要: 实现痕量气体分子检测的前提是实现气体的高效富集, 针对这个问题给出了微流控芯片上柱状预浓缩器的结构设计与仿真数据。在气相微流体研究的基础上, 基于微电子机械系统(MEMS)加工技术, 设计了圆形、菱形、长方形和三角形四种形状和不同排列方式的六种硅基微柱, 采用有限元分析(FEA)方法对柱状预浓缩器模型进行仿真与分析。基于微柱形状、流道侧壁、微柱间距和进出口模式四个影响因素对其进行了结构优化。研究表明, 采用微柱间距为 50  $\mu\text{m}$  的凸槽壁同向错位三角微柱和分流式进出口的预浓缩器具有较低的气体流速和浓度方差, 可以实现气体样品在微柱阵列中的有效富集和捕获, 有利于后续气体分子检测。

关键词: 微柱; 气相微流体; 预浓缩器; 有限元分析(FEA); 微电子机械系统(MEMS)

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Design and Simulation of the Columnar Preconcentrator

Based on the Microfluidic Channel

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Abstract: The premise of detecting trace level gas molecules is to realize high efficiency gas enrichment. To solve the problem, the structure design and simulation data of the columnar preconcentrator on the microfluidic chip were presented. Based on the study of microfluidics in gas phase fluids, six kinds of silicon based micro columns with four geometries i.e. circle, diamond, rectangle and triangle and different arrangement patterns were designed using the micro electro mechanical system (MEMS) technology. The finite element analysis (FEA) method was used to simulate and analyze the models of the columnar preconcentrator. Four factors including the micro column shape, flow channel sidewall, micro column spacing and inlet outlet mode were optimized for the structure. The results show that the preconcentrator with the hierarchical mode of the inlet and outlet and the 50  $\mu\text{m}$  spacing triangular micro column of the convex groove wall and dislocation in the same direction has a low gas flow rate and concentration variance, thus the gas sample can be effectively enriched and captured in the micro column array, which is conducive to the subsequent detection of gas molecules.

Key words: micro column; gas phase microfluidics; preconcentrator; finite element analysis (FEA); micro electromechanical system (MEMS)

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## W 波段含非谐振节点的 MEMS 波导带通滤波器

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摘要: 设计了一款含有一个非谐振节点的 W 波段矩形波导带通滤波器, 实现了其传输函数中传输零点可任意放置的功能。滤波器包括一个 T 型结波导结构、两个 TE<sub>101</sub> 模谐振腔和四对电感膜片。其中 T 型结波导结构中连接了一个 TE<sub>101</sub> 模谐振腔, 能够产生一个传输零点, 通过调整该谐振腔的结构参数尺寸, 能够独立地控制传输零点的位置。使用 Ansoft HFSS 软件对滤波器整体结构参数进行仿真和分析, 将传输零点放置在通带的任意一侧, 提高了滤波器的带外抑制。使用微电子机械系统 (MEMS) 工艺对传输零点在通带低频端的滤波器原型进行加工并测试, 测试结果与仿真结果总体上吻合良好。

关键词: 带通滤波器; 非谐振节点; 传输零点; 矩形波导; 微电子机械系统 (MEMS)

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W Band MEMS Waveguide Passband Filter

with a Non Resonating Node

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Abstract: A W band rectangular waveguide passband filter with a non resonating node was designed to realize the transfer function with arbitrarily placed transmission zero. The filter consists of a T type junction waveguide, two TE<sub>101</sub> mode resonant cavities and four pairs of inductive irises. A TE<sub>101</sub> mode resonant cavity was connected to the T type junction waveguide. And the resonant cavity can generate a transmission zero that can be controlled independently by adjusting the structure parameter dimensions of the resonant cavity. The whole structure parameters of the filter were simulated and analyzed by Ansoft HFSS software, and the transmission zero was placed on any side of the passband to improve the out of band suppression of the filter. The filter prototype with a transmission zero below the passband was fabricated by the micro electromechanical system (MEMS) process and measured. The measured results as a whole are in good agreement with the simulation results.

Key words: passband filter; non resonating node; transmission zero; rectangular waveguide; micro electromechanical system (MEMS)

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基于 HTCC 的新型薄膜高温压力传感器

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摘要: 无源压力传感器在一些极端环境下有着广阔的应用前景。提出了一种新型无源 LC 薄膜高温压力传感器, 在传统的平面螺旋电感基础上加入了多组叉指电容。传感器的基底材料采用的是高温共烧陶瓷 (HTCC), 通过厚膜后烧工艺将平面螺旋电感和叉指电容集成在 HTCC 基板上完成传感器的制备。本传感器较传统的 LC 传感器实现了单层布线, 制作工艺简单, 节约了制作成本。在实验室的条件下, 完成了高温压力复合测试平台的搭建, 在高温环境下, 测试了传感器的压力性能。测试结果表明, 该传感器能够在 800 °C 环境中稳定工作, 并且完成了 1~4 bar (1 bar=105 Pa) 内压力的原位测试, 传感器的谐振频率随外界压力的增大而减小, 在相同环境温度条件下谐振频率随压力的变化近似于线性变化。

关键词: 高温压力传感器; 叉指电容; 高温共烧陶瓷 (HTCC); 原位测试; 谐振频率

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New Thin Film High Temperature Pressure Sensor

Based on the HTCC

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Abstract: Passive pressure sensors have broad application prospects in some extreme environments. A new type of passive LC film high temperature pressure sensor was proposed, and several groups of the interdigital capacitance were added on the basis of the traditional planar spiral inductor. The substrate of the sensor was made of high temperature co-fired ceramic (HTCC). And the planar spiral inductor and interdigital capacitance were integrated on the HTCC substrate through the post-burn thick film process to complete the preparation of the sensor. Compared with the traditional LC sensor, the sensor realizes the single layer wiring and has the advantages of simple process and low cost. Under the laboratory conditions, the test platform was built by the combination of high temperature and pressure, and the pressure performance of the sensor was tested at high temperature. The test results show that the sensor can work stably in the environment of 800 °C. Besides, the pressure in situ test was completed in the scope of 1 to 4 bar (1 bar=105 Pa). The result indicates that the resonant frequency of the sensor decreases with the increase of the external pressure, and the resonant frequency almost changes linearly with the pressure under the same ambient temperature.

Key words: high temperature pressure sensor; interdigital capacitance; high temperature co-fired ceramic (HTCC); in situ test; resonant frequency

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## 微惯性测量单元橡胶减振器结构设计

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**摘要:** 为减小外部环境的振动和冲击对微惯性测量单元 (MIMU) 的输出影响, 基于减振器六种隔振模式理论和单自由度系统无阻尼自由振动原理, 选择合适的隔振模式并分析了 MIMU 橡胶减振器谐振频率的影响因素。通过构建有效的有限元模型分析 MIMU 减振结构的频率响应, 并调整减振器内环、外环结构及减振橡胶的材料硬度等因素, 设计得到了一种 MIMU 橡胶减振器结构。最终, 通过对含减振结构的 MIMU 样机进行扫频振动实验, 实验结果与预期设计结果一致。实验结果表明, 该结构不仅减少了 MIMU 受内部和外部振动源的干扰, 还实现了减振系统的三向等刚度。研究作为 MIMU 橡胶减振器设计提供了有效可行的方法。

**关键词:** 微惯性测量单元 (MIMU); 有限元仿真; 橡胶减振器; 隔振; 三向等刚度

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### Structure Design of a MIMU Rubber Isolator

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**Abstract:** Based on the theory of six kinds of vibration isolation patterns of the isolator and the principle of damped free vibration theory of the single degree of freedom (DOF), the suitable mode of the vibration isolation was selected and the influencing factors of the resonance frequency of micro inertial measurement unit (MIMU) rubber isolators were analyzed in order to reduce the influences of the vibration and impact of the external environment on the output of the MIMU. A structure of the MIMU rubber isolator was designed through establishing an effective finite element model to analyze the frequency response of the MIMU rubber isolator and changing the factors, such as the structures of the inner ring and outer ring, the material hardness of the vibration attenuation rubber and so on. Finally, the swept frequency vibration test of the MIMU prototype with the rubber isolator was completed. The experimental results are consistent with the expected design results. The experiment results show that the structure can reduce the influence of external and internal vibration interference, and make the stiffness of the damping system equal in three directions. The research provides an effective method for the structure design of MIMU rubber isolators.

**Key words:** micro inertial measurement unit (MIMU); finite element simulation; rubber isolator; vibration attenuation; tri directive equal rigid

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一种基于 SOI 技术的 MEMS 电容式压力传感器

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摘要: 利用绝缘体上硅 (SOI) 技术研制了一种可以用于飞行高度测量、气象环境监测和医疗等领域的高精度微电子机械系统 (MEMS) 电容式压力传感器。利用有限元分析软件对传感器敏感结构进行了结构建模、静力和模态仿真分析。敏感结构为敏感电容和参考电容差动输出形式, 可以有效减小温度漂移和重力误差对压力测量准确度的影响。比较了无岛和有岛两种敏感膜的性能差异。为了提高传感器性能, 利用成熟的 MEMS 加工工艺制作了 SOI 敏感电容极板, 并利用硅-硅键合工艺实现了真空腔体。传感器采用标准塑封封装后, 采用高低温压力测量系统进行了性能测试。测试结果表明, 传感器量程达到 30~120 kPa, 非线性 0.04%~0.09%, 分辨率 1 Pa。

关键词: 微电子机械系统 (MEMS); 电容式压力传感器; 高精度; 绝缘体上硅 (SOI); 硅-硅键合

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MEMS Capacitive Pressure Sensor Based on  
the SOI Technique

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Abstract: A high accuracy micro electromechanical system (MEMS) capacitive pressure sensor was developed utilizing the silicon on insulator (SOI) technology for the flight altitude measurement, meteorological environment monitoring and medical industry. The structural modeling, static force and modal simulation and analysis were carried out by the finite element analysis software. The sensing structure consists of a sensing capacitor and a reference capacitor with the differential output form, thus the effects of the temperature drift and gravity error on the accuracy of the pressure measure can be reduced effectively. The performances of two sensing films with island and without island were compared. The SOI sensing capacitive plate was fabricated based on the mature MEMS technology to improve the sensor performance, and a vacuum chamber was made by the silicon silicon bonding technique. The performances of the sensor chip packaged by plastic packaging were tested with the high and low temperature pressure measure system. The test results show that the sensor is of 30-120 kPa full measure range, 0.04%-0.09% nonlinearity and 1 Pa resolution.

Key words: micro electromechanical system (MEMS); capacitive pressure sensor; high accuracy; silicon on insulator (SOI); silicon silicon bonding

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Force Sensitivity of MEMS Based Ring, Rectangle  
and I2 Shaped AFM Probes

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**Abstract:** The micro electromechanical system (MEMS) based ring, rectangle and I2 shaped resonators have shown great potential to be used as the atomic force microscope (AFM) probes for the physical surface high speed imaging experiment due to their advantages of high resonance frequency and high quality factor. The key indexes affecting the performances of the three MEMS probes i.e. resonance frequency, effective stiffness and quality factor were analyzed and compared synthetically with the similar structure dimensions. Based on the above results, the force sensitivity for these MEMS probes was evaluated. And the results show that the ring shaped MEMS probe is fit for high precision imaging of the flexible object, while the I2 shaped MEMS probe is fit for high speed real time imaging in a wide range. Through the optimization of the mechanical structure and detection circuit, the force sensitivity of the MEMS probe is expected to reach and surpass that of the current cantilever probe.

**Key words:** micro electromechanical system (MEMS); resonator; force sensitivity; atomic force microscope (AFM) probe; quality factor; resonance frequency

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环形、矩形及 I2 形 MEMS 原子力显微镜探针的力灵敏度

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**摘要:**基于微电子机械系统(MEMS)技术的环形、矩形以及 I2 形谐振器由于具有较高的谐振频率与品质因数等优点, 可作为原子力显微镜(AFM)探针用于物理表面高速成像实验。在结构尺寸近似的情况下, 对影响上述三种 MEMS 探针性能的谐振频率、有效刚度以及品质因数等关键指标进行综合分析比较。在此基础上, 对上述 MEMS 探针的力灵敏度进行了评估。结果表明, 环形 MEMS 探针适用于对柔性物体的高精度成像, 而 I2 形 MEMS 探针则更适用于对大范围区域的高速实时成像。通过对机械结构与检测电路的进一步优化, MEMS 探针的力灵敏度有望达到并超越现有悬臂式探针的水平。

**关键词:**微电子机械系统(MEMS); 谐振器; 力灵敏度; 原子力显微镜(AFM)探针; 品质因数; 谐振频率

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高灵敏低噪声光束偏转检测系统设计

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摘要: 为了进一步提高自制超高真空室温非接触式原子力显微镜(NC AFM)的检测灵敏度和获得材料表面更高分辨率的原子图像, 在比较了原子力显微镜探针振动位移检测的三种方法的基础上, 重点研究了光束偏转检测方法, 理论上分析了这种方法的偏转检测灵敏度与噪声。设计了一个高灵敏度、低噪声的光束偏转检测系统, 该系统的激光光斑能够高精度地聚焦在悬臂上, 能容易、直观地对准激光光路, 并高效地检测到悬臂的振动和探针的共振频率。通过实验, 验证了准直激光的质量及光路的对准, 并利用该系统在超高真空非接触式原子力显微系统中进行探针振动实验, 得到了探针的共振频率为  $161\ 736\ 8\ \text{kHz}$ , 通过计算得到探针共振的品质因数为  $12\ 939$ , 说明系统具有高灵敏度和低噪声的性能。有望在进一步提高原子力显微镜分辨率方面得到应用。

关键词: 光学测量; 非接触式原子力显微镜(NC-AFM); 光束偏转检测; 高灵敏度; 低噪声; 共振频率

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Design of a Low Noise Optical Beam Deflection

Detection System with High Sensitivity

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Abstract: To improve the detection sensitivity of the home made non contact atomic force microscopy (NC AFM) under the ultra high vacuum (UHV) at room temperature and to obtain the high resolution atomic image of the material surface, the method of the optical beam deflection detection was researched emphatically based on the comparison of three methods of the probe oscillation displacement detection with the AFM. And the detection sensitivity and noise of the method were analyzed theoretically. And then a low noise optical beam deflection detection system with high sensitivity was designed, ensuring that the laser spot of the system can be focused on the cantilever accurately, the laser path can be aligned easily and intuitively, and the oscillation of the cantilever and the resonant frequency of the probe can be detected efficiently. The quality of the collimation laser and the alignment of the laser path were demonstrated through the experiment, and then the probe oscillation experiment was carried out using the system in the UHV NC AFM. The results show that the resonant frequency of the probe is  $161\ 736\ 8\ \text{kHz}$ , and through calculation, the probe resonant quality factor is  $12\ 939$ , verifying high sensitivity and low noise performance of the system. Further, it is expected to be applied to improve the resolution of the AFM.

Key words: optical measurement; non contact atomic force microscope(NC AFM); optical beam deflection detection; high sensitivity; low noise; resonant frequency

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光 MEMS 芯片驱动结构自对准技术

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摘要: 针对垂直梳齿静电驱动微光机电系统 (MOEMS) 芯片制备工艺中, 用于静电驱动的固定梳齿和可动梳齿难以精确对准的问题, 通过开发一种自对准工艺技术, 利用一次光刻和预掩蔽层梳齿定位以及连续两次深反应离子刻蚀 (DRIE) 工艺, 可成功实现固定梳齿和可动梳齿的精确定位。基于该技术制备出的静电梳齿驱动光可调衰减器 (VOA) 芯片和光开关 (OSW) 芯片具有良好的光学性能, 两款芯片的微镜可分别实现静电驱动电压 6 和 55 V 下  $0 \sim 5^\circ$  及  $3 \sim 0^\circ$  的角度偏转。结果表明, 应用该自对准工艺, 使易于加工、低成本且可批量化的芯片制备成为可能。

关键词: 光通信; 微光机电系统 (MOEMS); 垂直梳齿驱动; 微镜; 自对准技术

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Self Aligned Technique for the Driving Structure of  
Optical MEMS Chips

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Abstract: The precise aligning between the electrostatic driven fixed comb and movable comb is considered to be the main issue during the fabricating process of the vertical comb electrostatic driven micro opto electro mechanical system (MOEMS) chip. A self aligned technique was developed with once photolithography, pre mask for the comb fixing structure, and then two sequential deep reactive ion etching (DRIE) process, by which the fixed comb and movable comb were precisely aligned successfully. The electrostatic comb driven optical variable attenuator (VOA) and optical switch(OSW) chips of good optical characteristics were fabricated by the technique. The deflection angle of the micro mirror of the VOA chip was  $0 \sim 5^\circ$  at 6 V static driving voltage, the deflection angle of the micro mirror of the OSW chip was  $3 \sim 0^\circ$  at 55 V static driving voltage. The result shows that the self aligned technique can be a very promising approach to easily fabricate low cost mass chips.

Key words: optical communication; micro opto electro mechanical system (MOEMS); vertical comb drive; micro mirror; self aligned technique

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微流控液滴光学检测系统的仿真与实验

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摘要: 利用 TracePro 软件设计微流控液滴检测光学系统, 构建系统组件模型, 对不同尺寸和形状的液滴与气泡通过检测窗口所引起的光强信号变化进行仿真, 分析光强信号与液滴尺寸和形状之间的关系。同时, 搭建光学检测实验平台, 对微流控芯片中生成的液滴和气泡进行实验测试, 实验结果与仿真结果吻合。结果表明, 液滴直径越大, 光强越大, 液滴纵向长度越长, 波峰间距就越宽, 同时能够区分气泡和液滴。通过 TracePro 软件仿真可以优化光学系统设计, 为搭建光学实验平台提供参考。该光学检测系统可以用于监控液滴尺寸的均一性、计算液滴的生成频率和精准统计液滴的数量。

关键词: 微流控; 液滴检测; 光学仿真; 光学检测; TracePro

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Simulation and Experiment of an Optical Detection System

for Microfluidic Droplets

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Abstract: The optical detection system of the microfluidic droplet was designed by the TracePro software, and the component models of the system were built. The change of the optical intensity signal was simulated, which was caused by the droplets with different sizes and bubbles with different shapes flowing through the detection window. Then, the relationships between the optical intensity signal and the sizes, shapes of the droplets were analyzed. Meanwhile, an optical detection experiment apparatus was built to detect the droplets and bubbles formed in the microfluidic chips. The experimental results are accordant with the simulation results. The results show that the greater the diameter of the droplet is, the greater the optical intensity is; the longer the longitudinal length of the droplet is, the wider the peak separation is; meanwhile the droplet and bubble can be distinguished. The design of the optical system was optimized by the simulation of TracePro software to provide a reference for building the optical experiment platform. The optical detection system can be used to monitor the size uniformity of droplets, calculate the formation frequency of droplets and count the number of droplets accurately.

Key words: microfluidics; droplet detection; optical simulation; optical detection; TracePro

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