

一种阵列波导光栅的芯片级封装结构

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摘要: 阵列波导光栅(AWG)在密集波分复用(DWDM)光通信和芯片光谱仪中有广泛的应用。提出了一种可与光纤耦合的 AWG 芯片级封装结构, 其特点是设计了三片式叠片结构, 可实现波导和光纤的三维对准; 通过微加工工艺制作了锥形空腔, 在此锥形空腔中注入和固化与波导和光纤芯层折射率匹配的光学胶后, 可以形成类似拉锥光纤前端的锥形波导, 有效减小了由于光纤和波导尺寸失配造成的耦合损耗; 且片上拉锥结构和芯片相对位置固定, 热可靠性和抗振动能力有所提高; 实验和测试结果表明该方法具有光纤即插即用、可使用普通光纤和高可靠性等优点。

关键词: 阵列波导光栅(AWG); 光纤耦合; 片上拉锥结构; 芯片级封装; 微加工工艺

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A Chip Level Packaging Structure of Arrayed Waveguide Gratings

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Abstract: Arrayed waveguide grating (AWG) is used widely in dense wavelength division multiplexing (DWDM) optical communication and chip spectrometers. A chip level packaging structure of the AWG was presented. And the structure can be coupled with the optical fiber. Triple stacked chips were adopted to achieve the three dimensional alignment between the optical fiber and AWG. Tapered trenches were prepared by the microfabrication process. The tapered waveguide like the tapered fiber front end was prepared after filling and solidifying of the optical adhesive matching with the waveguide and refractive index of the optical fiber core layer in the tapered trenches, then the coupling loss caused by the mismatch between the optical fiber and waveguide size was effectively reduced. The relative position of the on chip tapered structure and the chip was fixed, then the thermal reliability and vibration resistance were improved. The experiment and test results show that the method has the advantages of "plug and work" of the optical fiber, using ordinary fibers and high reliability.

Key words: arrayed waveguide grating (AWG); optical fiber coupling; on chip tapered structure; chip level packaging; microfabrication process

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硅基级联光栅石墨烯吸波器设计与分析

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摘要: 提出硅基级联光栅石墨烯吸波器设计, 该吸波器由波导层光栅和缓冲层光栅上下级联而成, 采用小角度入射, 利用波导模式耦合形成的非简并波导模共振实现石墨烯条光吸收效率的显著增强。计算表明, 2° 入射硅波导光栅中非简并波导模为分裂的波导模式, 其归一化光强的最大值较正入射情形增大了 428 倍; 石墨烯条的峰值光吸收效率最高达 83.3%, 相对单层石墨烯的本征光吸收效率增大了 36 倍。研究发现吸收峰位置几乎不受缓冲层光栅深度变化影响, 而吸收效率和透射率将随缓冲层光栅深度变化分别作趋势相反的类法布里-珀罗(Fabry-Pérot, FP)周期波动。此外, 吸波器具有稳定的高吸收效率和较高的 Q 因子, 改变波导光栅的深度和宽度, 均可在光通信 C 波段实现吸收波长和 Q 因子的准线性调谐。

关键词: 石墨烯; 硅基级联光栅; 吸波器; 非简并波导模; 增强吸收

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Design and Analysis of a Graphene Absorber Using

Silicon Based Cascaded Gratings

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Abstract:A design of a graphene absorber using the silicon based cascaded grating was presented. The graphene absorber is consisted of a waveguide grating at the top and a buffer grating at the bottom. With a small incident angle, the absorption of the graphene strips was significantly enhanced by using the resonance of the nondegenerate waveguide mode resulting from the coupling of the waveguide modes. The theoretical simulation shows that the nondegenerate waveguide mode in the silicon waveguide grating is the split waveguide mode at the incident angle of 2° , and the maximum normalized light intensity is enhanced 428 times comparing with that of the normal incidence. The maximum of the peak light absorption efficiency of the graphene strips is 83.3%, which is 36 times higher than the intrinsic light absorption efficiency of the monolayer graphene. The study shows that the location of the absorption peak is almost unaffected by the grating depth variation of the buffer layer, while the absorptivity and transmissivity fluctuate periodically in the opposite tendency like the Fabry-Pérot (FP) resonance with the variation of the buffer layer grating depth. In addition, the high absorption efficiency and high Q factor of the absorber can be maintained, the quasi-linear tunings of the absorption wavelength and Q factor is realized in the optical communication C band by changing the depth and width of the waveguide grating.

Key words:graphene; silicon based cascaded grating; absorber; nondegenerate waveguide mode; enhanced absorption

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6 500 V 15 A 4H SiC JBS 二极管的研制

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摘要: 基于有限元仿真的方法对 6 500 V 15 A 4H SiC 肖特基二极管开展了材料结构、有源区结型势垒肖特基(JBS)结构和终端保护结构的优化设计。基于 4 英寸(1 英寸=2.54 cm) n 型 4H SiC 导电衬底, 采用厚度为 55 μm 、杂质浓度为 $9 \times 10^{14} \text{ cm}^{-3}$ 的外延材料、48 个宽度为 30 μm 浮空场限环实现了一款反向击穿电压大于 6 500 V 的 4H SiC JBS 二极管。电特性测试结果表明, 室温下正向电流为 15 A 时, 正向电压为 2.9 V, 开启电压为 1.3 V; 150 $^{\circ}\text{C}$ 下正向电流为 15 A 时, 正向电压为 5.2 V, 开启电压为 1.2 V。

关键词: 4H SiC; 结型势垒肖特基(JBS)二极管; 结终端技术; 浮空场限环; 4 英寸外延

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Development of a 6 500 V 15 A 4H SiC JBS diode

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Abstract: Using the finite element simulation method, the material structure, junction barrier Schottky (JBS) structure of active region and termination protection structure for a 6 500 V 15 A 4H SiC JBS diode were optimized and designed. Based on the 4 inch (1 inch=2.54 cm) n type 4H SiC conductive substrate, the 4H SiC JBS diode with the reverse breakdown voltage higher than 6 500 V was fabricated by using the epitaxial material with the thickness of 55 μm , the impurity concentration of $9 \times 10^{14} \text{ cm}^{-3}$ and 48 floating guard rings with the width of 30 μm . The electrical characteristics test results show that when the forward current is 15 A at room temperature, the forward voltage is 2.9 V and the threshold voltage is 1.3 V; when the forward current is 15 A at 150 $^{\circ}\text{C}$, the forward voltage is 5.2 V and the threshold voltage is 1.2 V.

Key words: 4H SiC; junction barrier Schottky (JBS) diode; junction termination technique; floating guard ring; 4 inch epitaxy

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复合纳米聚合物摩擦发电效能的研究

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摘要: 将具有高介电常数的钛酸钡 (BaTiO_3) 纳米颗粒填充于室温硫化硅胶中, 制备出复合纳米聚合物薄膜。采用复合纳米聚合物薄膜作为摩擦负性材料, 聚酯纤维镀银导电布作为摩擦正性材料及电极材料, 设计了接触-分离式摩擦纳米发电机。从理论和实验角度系统分析了 BaTiO_3 纳米颗粒质量分数不同时, 复合纳米聚合物薄膜对摩擦纳米发电机输出性能的影响。实验结果表明, 在测试频率为 3 Hz、测试压力为 100 N 的条件下, 当 BaTiO_3 纳米颗粒的质量分数为 10% 时, 摩擦纳米发电机的输出开路电压达到 466 V, 输出短路电流达到 $14.3 \mu\text{A}$, 分别为纯硅胶薄膜制备的摩擦纳米发电机的 1.37 倍和 1.34 倍。从材料改性的角度提出了一种提高摩擦纳米发电机输出性能的重要途径。

关键词: 摩擦纳米发电机; 介电常数; 纳米颗粒; 复合薄膜; 发电效能

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Research on the Triboelectric Power Generation Efficiency of the Composite Nano Polymer

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Abstract: The composite nano polymer film was prepared by filling the barium titanate (BaTiO_3) nanoparticles with high dielectric constant into the room temperature vulcanized silicone rubber. The composite nano polymer film was adopted as the friction negative material, and the Ag coated polyester conductive textile was used as the friction positive material and electrode material, then a contact separation triboelectric nanogenerator was designed. The influences of the composite nano polymer film on the output performances of the triboelectric nanogenerator under different mass fractions of BaTiO_3 nanoparticles were discussed experimentally and theoretically. The experiment results show that under the test frequency of 3 Hz and test pressure of 100 N, the output open circuit voltage and output short circuit current of the triboelectric nanogenerator reach 466 V and $14.3 \mu\text{A}$ respectively with the mass fraction of 10% BaTiO_3 nanoparticles, which are 1.37 times and 1.34 times those of the triboelectric nanogenerator based on the pure silicone rubber film, respectively. An important approach was presented from the viewpoint of material modification to improve the output performances of the triboelectric nanogenerator.

Key words: triboelectric nanogenerator; dielectric constant; nanoparticle; composite film; power generation efficiency

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基于磁梯度场超高分辨的高灵敏加速度传感方法

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摘要: 报道了一种基于永磁体磁梯度场超高分辨检测机理的加速度传感方法。实验中, 通过在聚二甲基硅氧烷 (PDMS) 柔性薄膜材料中心上表面嵌入永磁体, 固定 PDMS 薄膜周边, 悬空永磁体结构, 制备了悬臂梁式永磁体质量块结构。通过仿真得到永磁体磁梯度场线性分布区域, 并在磁梯度场线性分布区域固定磁检测单元, 通过检测永磁体在加速度作用下的微位移引起的磁场变化, 实现对加速度信息的传感检测。静态测试结果表明在 $0 \sim 866\text{g} \sim 1\text{g}$ 的测试范围内, 加速度传感灵敏度为 $4 \sim 68 \text{Gs/g}$, 加速度的检测分辨能力近似为 $93 \mu\text{g}$ 。

关键词: 加速度传感方法; 磁梯度场; 聚二甲基硅氧烷 (PDMS) 薄膜; 重力梯度

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High Sensitivity Acceleration Sensing Method Based on the Magnetic Gradient Field Ultrahigh Resolution

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Abstract: A acceleration sensing method based on the ultrahigh resolution detection mechanism of the magnetic gradient field of the permanent magnet was reported. In the experiment, by embedding the permanent magnet on the upper surface of the polydimethylsiloxane (PDMS) flexible film material center and fixing the periphery of the PDMS film, the permanent magnet was suspended, and then the cantilever beam type permanent magnet mass block structure was prepared. The linear distribution region of the magnetic gradient field for the permanent magnet was obtained by the simulation, and the magnetic detection unit was fixed in the linear region of the magnetic gradient field. By detecting the magnetic field variation caused by the micro displacement of the permanent magnet under the acceleration, the sensing detection of the acceleration information was realized. The static test results show that in the range of $0 \sim 866\text{g} \sim 1\text{g}$, the acceleration sensing sensitivity is $4 \sim 68 \text{Gs/g}$, and the acceleration detection resolution is approximate to $93 \mu\text{g}$.

Key words: acceleration sensing method; magnetic gradient field; polydimethylsiloxane (PDMS) film; gravity gradient

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硅基 MEMS 环形波动陀螺谐振结构的研制

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摘要: 根据固体波动陀螺的工作机理与振动特性, 提出并制作了一种新颖的电容式全对称硅基 MEMS 环形波动陀螺谐振结构。设计了全对称双 U 形弹性梁环形敏感结构并进行了动力学分析。分析结果表明其工作模式的谐振频率为 10 193 0 与 10 198 0 kHz, 频率差为 5 Hz, 表明该敏感结构在结构设计上具有高灵敏度。研究了基于深反应离子刻蚀 (DRIE) 与阳极键合技术的玻璃上硅 (SOG) 结构加工制造流程, 并成功制作了该环形谐振结构。模态响应测试表明该硅基 MEMS 环形波动陀螺敏感结构的工作模式谐振频率为 10 985 0 和 10 962 5 kHz, 与动力学仿真分析结果的相对误差为 7 21%, 表明该陀螺谐振结构设计合理, 加工工艺流程可行。

关键词: 微电子机械系统 (MEMS); 环形波动陀螺; 谐振结构; 深反应离子刻蚀 (DRIE); 玻璃上硅 (SOG) 结构

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Development of a Resonant Structure for Si Based
MEMS Ring Vibration Gyroscopes

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Abstract:Based on the working principle and dynamics characteristics of solid vibration gyroscopes, a novel fully symmetric resonant structure of the capacitive Si based MEMS ring vibration gyroscope was proposed and fabricated. A fully symmetric ring sensitive structure with a dual U shaped elastic beam was designed, and the dynamics analysis was carried out. The analysis results show that the resonant frequencies of the working modes are 10 193 0 and 10 198 0 kHz, and the frequency difference is 5 Hz, indicating that the sensitive structure has higher sensitivity in the structural design. The fabrication process of the silicon on glass (SOG) structure was studied with the deep reactive ion etching (DRIE) and anodic bonding technology, and the ring resonant structure was successfully fabricated. The modal response test shows that the working mode resonant frequencies of the sensitive structure for the Si based MEMS ring vibration gyroscope are 10 985 0 and 10 962 5 kHz, and the relative error is 7 21% between the modal response test result and dynamic simulation analysis result, indicating that the design of the gyroscope resonant structure is reasonable and the fabrication process is feasible.

Key words:micro electromechanical system (MEMS); ring vibration gyroscope; resonant structure; deep reactive ion etching (DRIE); silicon on glass(SOG) structure

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BiFeO₃ 纳米纤维压力传感器的研制

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摘要: 制作了一种 BiFeO₃ 纳米纤维压力传感器和测试装置, 用测试装置对压力传感器进行测试, 并对测试数据进行分析。采用 BiFeO₃ 纳米纤维作为敏感材料, 利用微电子机械系统 (MEMS) 加工工艺制备出带有叉指电极的硅基底, 用静电纺丝设备将 BiFeO₃ 纳米纤维铺设到叉指电极上面, 再将 PDMS 薄膜覆盖在纳米纤维上制成压力传感器。在磁感应强度 0 和 80 mT 下, 用自制的测试装置分别采集 25 °C 和 80 °C 下 0~20 kPa 的输出电压。得知输入压力与输出电压基本呈线性关系, 温度和磁场的变化对传感器的影响不大, BiFeO₃ 纳米纤维压力传感器的最大输出电压达到了 0.91 mV。

关键词: BiFeO₃ 纳米纤维; 压力传感器; 测试系统; 敏感材料; 微电子机械系统 (MEMS) 加工工艺

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Development of a Pressure Sensor Based on BiFeO₃ Nanofibers

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Abstract: A BiFeO₃ nanofiber pressure sensor and test device were developed, the pressure sensor was tested by the test device, and the test data were analyzed. The BiFeO₃ nanofibers were used as sensitive materials, the silicon substrate with the fork electrodes was prepared by the micro electromechanical system (MEMS) processing technology, the BiFeO₃ nanofibers were laid on the fork electrodes using the electrostatic spinning equipment, and the PDMS membranes were covered on the nanofibers, then the pressure sensor was fabricated. Under the magnetic induction intensities of 0 and 80 mT, the output voltages of 0-20 kPa under 25 °C and 80 °C were collected by a homemade test device, respectively. It is found that the input pressure shows linear relationship with the output voltage, and the changes of temperature and magnetic field have little effect on the sensor, and the maximum output voltage of the BiFeO₃ nanofiber pressure sensor reaches 0.91 mV.

Key words: BiFeO₃ nanofiber; pressure sensor; test system; sensitive material; micro electromechanical system (MEMS) processing technology

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无线无源气体传感器的制备和测试

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摘要: 介绍了氨气传感器的制备和测试, 利用原位聚合法将聚苯胺以多壁碳纳米管为核心进行聚合反应制备出介电纳米复合材料, 将制备的介电纳米复合材料喷涂到传感器上作为气体传感器的敏感层, 从而制备了复合材料的氨气传感器。作为对照组, 采用相同的方法制备了纯聚苯胺敏感材料, 在聚合过程中未掺入多壁碳纳米管, 制备了纯聚苯胺敏感材料的氨气传感器。实验结果表明, 多壁碳纳米管的适量掺入有效提高了传感器的灵敏度。在最佳温度 45 °C 下, 复合材料的氨气传感器对体积分数为 3×10^{-4} 的 NH_3 的灵敏度为 12 070 MHz, 约为纯聚苯胺传感器的 4 2 倍。聚苯胺和多壁碳纳米管的介电纳米复合材料对 NH_3 具有很好的选择性。

关键词: 无线无源传感器; 聚苯胺; 碳纳米管; 原位聚合; LC 谐振; 气敏特性

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Fabrication and Test of a Wireless Passive Gas Sensor

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Abstract:The fabrication and test of the ammonia gas sensor were introduced. The dielectric nanocomposites were prepared through the polymerization reaction of polyaniline with the multi walled carbon nanotube as the core by the in situ polymerization. By spraying the dielectric nanocomposites on the sensor as the sensitive layer of the gas sensor, the ammonia gas sensor with composite materials was prepared. As a control group, the pure polyaniline sensitive materials were prepared by the same method, while the multi walled carbon nanotubes were not doped during the polymerization process, and then the ammonia sensor with pure polyaniline gas sensitive materials was prepared. The experimental results show that the sensitivity of the sensor is improved effectively by doping the moderate amount of multi wall carbon nanotubes. At the optimum temperature of 45 °C, the sensitivity of the ammonia gas sensor with composite materials to NH_3 with the volume fraction of 3×10^{-4} is 12 070 MHz, which is about 4 2 times that of the pure polyaniline sensor. The dielectric nanocomposites with polyaniline and multi walled carbon nanotubes have better selectivity to NH_3 .

Key words:wireless passive sensor; polyaniline; carbon nanotube; in situ polymerization; LC resonant; gas sensing property

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基于 SERS 技术的微量食品添加剂高灵敏检测方法

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摘要: 提出一种基于表面增强喇曼散射 (SERS) 效应的高灵敏、快捷、便携式的微量食品添加剂检测方法。采用光纤球结构, 设计研发了一种光纤球结构表面包覆银纳米颗粒的高灵敏便携式 SERS 信号检测探针, 并利用 parylene C 纳米薄膜包覆银纳米结构, 实现了该探针的可重复性应用及测试。实验中, 激光从光纤探针末端输入, 激发探针表面银纳米结构从而增强食品添加剂的喇曼信号, 然后通过光纤球聚集喇曼信号, 并从光纤末端收集测试喇曼信号, 实现了对浓度为 10-12 mol/L 的微量 R6G 分子的检测, 并实现了对常用食品中食品添加剂的检测。此探针具有便携、高效、快速、高灵敏检测特性, 能够得到广泛应用, 从而提高对食品安全的检测能力。

关键词: 表面增强喇曼散射 (SERS) 技术; 食品添加剂; 银纳米颗粒; 食品安全; 光纤探针
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High Sensitive Detection Method of Micro Food Additives

Based on the SERS Technology

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Abstract: A highly sensitive, fast and portable detection method for the micro food additives based on surface enhanced Raman scattering (SERS) effect was proposed. Using the fiber ball structure, a highly sensitive and portable SERS signal detection probe based on the fiber ball structure coated with the silver nanoparticles was designed and developed. The parylene C nano film was coated on the silver nanostructure to achieve the repeatability application and test of the probe. In the experiment, when the laser was inputted from the fiber probe end, the silver nanostructure on the probe surface was excited to enhance the Raman signals of the food additives. Then the Raman signals were gathered by the fiber ball, and were collected and tested through the end of the fiber probe. The detection of the micro R6G molecular with the concentration of 10-12 mol/L was realized, and the detection of the food additives in usual food was also realized. This probe has the portability, high efficiency, rapidity, high sensitive detection characteristics, and can be widely used to improve the detection ability of the food safety.

Key words: surface enhanced Raman scattering (SERS) technology; food additives; silver nanoparticle; food safety; fiber probe

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不同络合剂对铜布线 CMP 抛光液性能的影响

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摘要: 分别选用 FA/O 螯合剂和甘氨酸作为络合剂配置铜布线 CMP 抛光液, 研究对比了两种抛光液的抛光速率、静态腐蚀溶解速率、平坦化以及稳定性。速率实验表明, 抛光液中加入 FA/O 螯合剂和甘氨酸都可以显著提高铜的抛光速率, 基于甘氨酸配置的抛光液静态腐蚀溶解速率为 335 ± 1 nm, 明显高于基于 FA/O 螯合剂配置的抛光液 (89 ± 2 nm)。平坦化实验表明, 基于甘氨酸配置的抛光液对铜线条高低差的修正能力差, 需要加入缓蚀剂, 而基于 FA/O 螯合剂配置的无缓蚀剂碱性抛光液能够有效修正铜线条高低差。稳定性实验表明, 基于 FA/O 螯合剂配置的无缓蚀剂碱性铜抛光液稳定时间只有 1 天, 而基于甘氨酸配置的碱性铜抛光液稳定时间为 5 天。通过实验研究发现, 抛光液中 FA/O 螯合剂与 H₂O₂ 发生化学反应也是导致抛光液不稳定的原因。

关键词: FA/O 螯合剂; 平坦化; 稳定性; 甘氨酸; 缓蚀剂

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Effects of Different Complexing Agents on the Performance of the
Cu Interconnection CMP Slurry

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Abstract: The Cu interconnection CMP slurries were prepared using the FA/O chelating agent and glycine, respectively. The polishing rate, static corrosion dissolution rate, planarization and stability of the two slurries were studied and compared. The rate experiment shows that the FA/O chelating agent and glycine can significantly improve the copper polishing rate. The static corrosion rate of the slurry based on the glycine is 335 ± 1 nm, which is significantly higher than that (89 ± 2 nm) of the slurry based on the FA/O chelating agent. The planarization experiment shows that the slurry based on the glycine has a poor ability of revising the height difference of copper lines, and needs adding the corrosion inhibitor. However, the alkaline slurry without the corrosion inhibitor based on the FA/O chelating agent can effectively correct the height difference of copper lines. The stability experiment shows that the settling time of the alkaline copper slurry without the corrosion inhibitor based on the FA/O chelating agent is only 1 day, while the settling time of the alkaline copper slurry based on the glycine is 5 days. The experimental study shows that the chemical reaction of the FA/O chelating agent and H₂O₂ is another reason for the instability of the slurry.

Key words: FA/O chelating agent; planarization; stability; glycine; corrosion inhibitor

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纳米增材制造

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摘要: 增材制造技术(3D打印技术)是一种与减材制造相反的、根据三维数据把材料集中一体的加工过程。根据成型特点,常见的有几种不同的增材制造工艺,如光固化成型、材料挤出、粉末床熔合、片层压、定向能量沉积等。结合现有的技术发展,重点概述纳米增材制造(ANM)中的一些关键技术的原理和应用,如双光子聚合(TPP)、选择性激光熔化(SLM)、熔融沉积成型(FDM)、直接墨水书写(DIW)、浸蘸笔纳米加工(DPN)、扫描隧道显微镜(STM)和电流体动力喷射打印(E-jet)等技术,并对纳米增材制造技术的发展进行了展望:纳米3D打印技术将与多种制造技术相融合发展,在材料、装备上将取得突破性进展,并将在纳电子器件、生物芯片、新能源等领域广泛应用,最终将建立其纳米3D打印的标准体系。

关键词: 减材制造; 纳米3D打印; 纳米增材制造(ANM); 纳米技术; 制造技术

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Additive Nanomanufacturing

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Abstract: The additive manufacturing technology (3D printing technology) is the opposite of the subtractive manufacturing, and can be defined as a collection technology for joining materials to fabricate objects according to 3D data. According to forming characteristics, there are several different kinds of additive manufacturing processes, such as photopolymerization, material extrusion, powder bed fusion, sheet lamination and directed energy deposition. Combined with existing technology development, the principles and applications of the key technologies for the additive nanomanufacturing(ANM) are emphatically introduced, including the two photon polymerization(TPP), selective laser melting(SLM), fused deposition modeling(FDM), direct ink writing(DIW), dip pen nanolithography(DPN), scanning tunneling microscope (STM) and electrohydrodynamic jet printing (E-jet). The development of the additive manufacturing technology is prospected. The 3D nano printing technology will be integrated with a variety of manufacturing technologies, will make breakthrough in materials and equipment, and will be applied in the fields of nanoelectronic devices, biochips and new energy. Finally, the standard system of the 3D nano printing will be established.

Key words: subtractive manufacturing; 3D nano printing; additive nanomanufacturing(ANM); nanotechnology; manufacturing technology

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基于湿法与氧自由基活化工艺的
低温硅-硅键合技术

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摘要: 针对传统的低温硅-硅键合技术中, 由于等离子体轰击硅片表面而导致硅面损伤、键合面积小、键合强度低等技术难题, 通过研究 3 种不同的活化方式对粗糙度、键合面积、键合强度的影响, 从而得出湿法与氧自由基相结合的活化方式是实现低温硅-硅键合技术的最佳方式。结果表明, 在双同心的环形网状电极间充入一定量的氧气, 在直流电压下产生的高能氧自由基在电场作用下通过接地筛网, 并以低入射角度到达硅片表面, 这种活化处理的方式可以有效保护硅面免受高能粒子的损伤。键合强度可达 10 MPa 以上, 键合面积可达 98%, 漏率可达 $1 \sim 6 \times 10^{-10} \text{ Pa} \cdot \text{cm}^3/\text{s}$ 。这种低温硅-硅键合技术可应用于压力传感器、电容加速度传感器和陀螺仪等器件。

关键词: 低温硅-硅键合; 等离子体; 湿法; 氧自由基; 活化方式

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Low Temperature Si-Si Bonding Technology Based on the Combination
of the Wet and Oxygen Radical Activation Processes

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Abstract: In order to solve the technical problems of the silicon surface damage, small bonding area and low bonding strength caused by the plasma bombardment of the silicon surface in the traditional low temperature Si-Si bonding technology, the effects of three different activation modes on the roughness, bonding area and bonding strength were studied. Then it is concluded that the combination of wet method and oxygen radical activation processes is the best method to realize the low temperature Si-Si bonding. The results show that the double concentric ring shaped mesh electrode is filled with a certain amount of oxygen, the high energy oxygen radicals generated at DC voltage pass through the grounded screen under the influence of the electric field and reach the surface of the silicon wafer at a low incident angle. The activation treatment can effectively protect the silicon surface from being damaged by energetic particles. The bonding strength can reach more than 10 MPa, the bonding area can reach 98%, and the leak rate can reach $1 \sim 6 \times 10^{-10} \text{ Pa} \cdot \text{cm}^3/\text{s}$. The low temperature Si-Si bonding technology can be applied to the pressure sensor, capacitance acceleration sensor, gyroscope and other devices.

Key words: low temperature Si-Si bonding; plasma; wet method; oxygen radical; activation mode

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