

基于天线优化的 GaN/AlGaIn HEMT

太赫兹探测器

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摘要:介绍了一种基于天线优化的 GaN/AlGaIn 高电子迁移率晶体管(HEMT)的高灵敏度室温太赫兹探测器。在太赫兹波辐射下,太赫兹天线可以高效收集太赫兹波的能量进而提高探测器的性能指标。利用有限时域差分(FDTD)法对太赫兹天线的特征尺寸(源、漏极天线之间的间距 L_w 以及栅极天线的栅长 L_g)进行了优化研究。研究表明当 L_g 一定时,探测器的响应度随着 L_w 的减小而增大,并从实验上制备出了响应度为 9.45×10^2 V/W 的室温 GaN/AlGaIn HEMT 太赫兹探测器。对优化后的器件进行了 1×9 线阵列探测器的制备和测试,探测器的电学特性一致性较好,响应度仅有约 10%的误差。

关键词: 探测器; 太赫兹; 高电子迁移率晶体管(HEMT); 自混频; 有限时域差分(FDTD)法

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A GaN/AlGaIn HEMT Terahertz Detector Based on

Optimized Antennas

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Abstract:A high sensitivity room temperature GaN/AlGaIn high electron mobility transistor (HEMT) terahertz detector based on the optimized antenna was introduced. In terahertz wave radiation, the terahertz antenna can efficiently collect the energy of terahertz wave to improve the performance of the detector. The feature sizes of the terahertz antenna (L_w is the gap between the source antenna and drain antenna, and L_g is the gate length of the gate antenna) were optimized by the finite difference time domain(FDTD) method. The results show that response of the detector increases with the decrease of L_w when L_g is a certain value. In the experiment, a room temperature AlGaIn/GaN HEMT terahertz detector with the responsivity of 9.45×10^2 V/W was fabricated. The 1×9 linear array detectors were fabricated and tested by using the optimized devices. The electrical characteristics consistency of the detectors is better, and the responsivity error is only about 10%.

Key words:detector; terahertz; high electron mobility transistor (HEMT); self mixing; finite difference time domain (FDTD) method

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基于石墨烯电极的电子转移动力学研究进展

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摘要: 石墨烯的电化学性能, 特别是基于石墨烯的电子转移动力学, 是石墨烯在电化学传感器、能源存储与转化等方面应用的基础。阐述了石墨烯的电子转移动力学的研究进展。特别是详细描述了石墨烯边缘、基平面以及缺陷密度等对石墨烯电极的电子转移速率的影响。目前, 大部分研究表明, 石墨烯的电子转移源于裸露的石墨烯边缘。但值得注意的是, 石墨烯的基平面也被发现具有高的电化学活性和快速的电子转移速率。此外, 石墨烯的电化学性能还与其缺陷密度密切相关。适当的缺陷密度能够提高石墨烯电子转移速率。

关键词: 石墨烯; 电子转移; 边缘; 基平面; 缺陷密度

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Research Progress of Electron Transfer Kinetics

Based on Graphene Electrodes

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Abstract: The electrochemical properties of graphene, especially the electron transfer kinetics based on graphene, are essential for its potential application in electrochemical sensor, energy storage and conversion. The research progress of the electron transfer kinetics for graphene is described. Particularly, the effects of graphene edge, basal plane and defect density on the electron transfer rate of graphene electrodes are summarized in detail. At present, most studies show that the electron transfer of graphene originates from the exposed graphene edge. It is notable that the basal plane of graphene has high electrochemical active and rapid electron transfer rate. Besides, the electrochemical properties of graphene are also closely related to its defect density. The appropriate defect density can improve the electron transfer rate of graphene.

Key words: graphene; electron transfer; edge; basal plane; defect density

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范德瓦尔斯异质结的研究进展

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摘要: 范德瓦尔斯异质结是二维材料以特定顺序堆叠所形成的人工材料, 其具有优异的光电特性。主要介绍了石墨烯、硫化钼、硒化钼等不同的二维材料构成的范德瓦尔斯异质结的制备方法和注意事项, 以及范德瓦尔斯异质结光电学性质及具体器件性能的研究现状。阐述了范德瓦尔斯异质结层与层之间、单层与多层之间相互作用影响的研究概况, 以及范德瓦尔斯异质结中耦合特性及对光电性质的影响规律。最后指出, 大面积二维材料的制备、层与层之间的能带工程的研究将是范德瓦尔斯异质结研究的关键, 范德瓦尔斯异质结在半导体行业必将具有广阔前景。

关键词: 范德瓦尔斯异质结; 二维材料; 石墨烯; 硫化钼; 硒化钼

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Research Progress of Van Der Waals Heterostructures

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Abstract: The van der Waals heterostructure is a two dimensional material in a specific order of stacking the formation of artificial materials, and has excellent photoelectric properties. The preparation methods and precautions of the van der Waals heterostructures composed by graphene, molybdenum sulfide, molybdenum selenide and other different two dimensional materials are reviewed. At the same time, the optical and electrical properties of the van der Waals heterostructures and the research status of the performances for specific devices are introduced. The researches on the effects of the interaction between monolayer and monolayer or monolayer and multilayers in the van der Waals heterostructures are described, and the coupling characteristics and the influence law of photoelectric properties in van der waals heterostructures are introduced. Finally, it is pointed out that the preparation of large area two dimensional materials and the study of energy band engineering of layers and layers will be the key to the study of van der Waals heterostructures. The van der Waals heterostructures in the semiconductor industry will have broad prospects.

Key words: van der Waals heterostructure; two dimensional material; graphene; molybdenum sulfide; molybdenum selenide

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声表面波驱动的微混合器

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摘要: 基于声表面波(SAW)驱动机理设计并仿真了一种微混合器, 制备了由4个谐振频率为49.1 MHz的铜叉指式换能器(IDT)构成的SAW驱动的微混合器(IDT采用剥离工艺制备, 使用的基片材料为128° YX型铌酸锂, 每个IDT有5个叉指对, 周期为80 μm, 指条宽度为5 μm, 指条厚度为1.6 μm), 搭建了基于SAW微混合器驱动的微混合平台, 实现了3 μL甘油与1 μL墨水两种液滴间的混合以及3 μL蒸馏水液滴和平均直径为1.5 μm的红色微粒之间的混合。实验结果证明, 在驱动功率为9 W、驱动频率为49.13 MHz的电信号激励下, SAW微混合器可实现液滴间以及液滴和微粒间在1 s内的高速混合, 并且液滴内部运动与其位于SAW微混合器的位置有关。

关键词: 声表面波(SAW); 剥离工艺; 叉指结构; 微混合器; 液滴

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A Micro Mixer Based on Surface Acoustic Wave

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Abstract: A micro mixer was designed and simulated based on surface acoustic wave (SAW) driving mechanism. The SAW micro mixer is consisted of four copper interdigital transducers (IDT) with the resonance frequency of 49.1 MHz (With the 128° YX LiNbO₃ as the substrate material, the IDT was fabricated by the lift-off process. Each IDT has five strip pairs, the period of the IDT is 80 μm, the strip width is 5 μm and the thickness is 1.6 μm). A micro hybrid platform based on the SAW micro mixer was constructed. The mixing between a glycerol droplet and an ink droplet, between the red particles and a distilled water droplet were experimentally realized, respectively. The volumes of the glycerol droplet and the distilled water droplet are 3 μL respectively, the volume of the ink droplet is 1 μL and the average diameter of the red particles is 1.5 μm. The experiment results prove that the high speed mixing of two droplets and between one droplet and one particle can all be completed within 1 s under the excitation of the electric signal with the driving power of 9 W and the driving frequency of 49.13 MHz, and the internal motion of the droplet is related with its position in the SAW micro mixer.

Key words: surface acoustic wave(SAW); lift-off process; interdigital structure; micro mixer; droplet

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高灵敏度宽频带一维 MEMS 矢量水听器

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摘要: 针对目前纤毛式 MEMS 矢量水听器灵敏度和带宽的相互制约, 无法实现在高灵敏度的情况下还能有较大的可测带宽。基于此, 设计了一种单梁结构的一维 MEMS 矢量水听器, 经理论分析和 ANSYS 仿真分析, 确定了微结构的尺寸, 仿真结果显示有挖空式结构较无挖空式结构在 X 轴最大应力上提高了 5 12%, 探测带宽增大了 53 26%。并对挖空式微结构进行了工艺设计, 简化了工艺流程, 提高了成品率。最后, 用矢量水听器校准装置进行测量, 实验结果表明, 该一维 MEMS 矢量水听器具有 20~2 000 Hz 的可测带宽, 满足灵敏度每频程 6 dB 的增长趋势, 具有良好的“8”字型指向性, 凹点深度为-32 4 dB。

关键词: 微电子机械系统 (MEMS); 压阻传感器; 一维探测; ANSYS; 共振频率

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A One Dimensional MEMS Vector Hydrophone with High Sensitivity and Broadband

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Abstract: For the mutual constraints between the sensitivity and bandwidth of the current ciliated MEMS vector hydrophone, the hydrophone hasn't the larger measurable bandwidth in the case of high sensitivity. Based on this, a one dimensional MEMS vector hydrophone with single beam structure was designed. The size of the microstructure was determined by theoretical analysis and ANSYS simulation analysis. The simulation results show that the X axis maximum stress of the hollow structure increases by 5 12% and the detection bandwidth increases by 53 26% compared with the no hollow structure. Later, the process design of the hollow microstructure was carried out to simplify the process flow and improve the yield. Finally, the measurement was carried out with a vector hydrophone calibration device. The experimental results show that the one dimensional MEMS vector hydrophone has a measurable bandwidth of 20-2 000 Hz, which satisfies the sensitivity growth trend of 6 dB for each frequency range, and possesses the good "8" shape directivity and the depth of concave point is -32 4 dB.

Key words: micro electromechanical systems (MEMS); piezoresistive sensor; one dimension detection; ANSYS; resonance frequency

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电容式柔性触觉传感器的研究与进展

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摘要: 通过分析电容式触觉传感器的基本工作原理与研究热点, 指出了电容式触觉传感器在结构设计中存在着难以兼顾分辨率、测量精度和灵活性的关键问题。参照电容式触觉传感器内的微电容结构, 从微电容的电极层、介质层和整体结构等三个方面出发, 介绍了国内外电容式柔性触觉传感器近年来在新材料应用、新工艺引入、结构设计和三维力检测等方面的研究进展, 提出可调节测量范围与灵敏度的触觉传感器将是进一步研究的热点。最后结合电容式柔性触觉传感器的实际应用, 指出了未来的电容式触觉传感器正朝着微型化、集成化、透明化与多功能化等方向发展。

关键词: 触觉传感器; 柔性; 微电容; 电极; 介质材料; 灵敏度

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Research and Progress of Capacitive Flexible Tactile Sensors

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Abstract: By analyzing the basic working principle and research hotspot of capacitive tactile sensors, it is pointed out that it is difficult to take into account resolution, measurement accuracy and flexibility in the structural design of capacitive tactile sensors. With reference to the micro capacitance structure in the capacitive tactile sensor, the research progresses of capacitive flexible tactile sensors at home and abroad in recent years, such as application of new materials and introduction of new technology, structural design and three dimensional force detection, are introduced from three aspects of the electrode layer, dielectric layer and whole structure of the micro capacitance in sensors. The tactile sensors with adjustable measuring range and sensitivity will be a hot topic for further research. Finally, combined with the practical application of capacitive flexible tactile sensors, it is pointed out that the future capacitive tactile sensor is moving in the direction of miniaturization, integration, transparency and versatility.

Key words: tactile sensor; flexibility; micro capacitance; electrode; dielectric material; sensitivity

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基于介电电泳的粒子分离微流控芯片实验

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摘要: 根据介电电泳原理, 设计了一种梯形叉指的微电极结构, 用于粒子的连续分离。首先利用 COMSOL 软件分析梯形叉指电极的电场分布, 确定芯片中电场强度最大值和最小值的位置, 并分析粒子在微流控芯片中的受力情况。然后, 采用微电子机械系统(MEMS)工艺, 以氧化铟锡 (ITO) 电极玻璃为基底制备了粒子连续分离的芯片。通过实验选取通道障碍的最优尺寸, 最后用聚苯乙烯小球和酵母菌细胞为样本进行实验并证明, 当混合粒子溶液以 $3 \mu\text{m}/\text{min}$ 的速度通过微通道障碍时, 由于惯性聚焦全部粒子偏向微通道上方运动, 施加 6 V 的峰值电压和 20 kHz 的交流信号, 此时聚苯乙烯小球和酵母菌细胞皆是负介电泳响应, 聚苯乙烯小球所受介电泳力大于流体力便向微通道下方进行偏移, 而酵母菌细胞所受流体力大于负介电泳力, 其仍然在微通道上方, 聚苯乙烯小球和酵母菌细胞分离, 分离效率可达到 92.8%。

关键词: 微流控芯片; 连续分离; 惯性聚焦; 介电电泳; 微电子机械系统 (MEMS); COMSOL
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Particle Separation Microfluidic Chip Experiment

Based on Dielectrophoresis

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Abstract: According to the principle of dielectrophoresis, the trapezoid interdigital microelectrode structure was designed to use for the continuous separation of particles. The COMSOL software was used to analyze the electric field distribution of trapezoid interdigital electrodes and determine the positions of the maximum and minimum electric field intensity on the chip, and the force of the particles in the microfluidic chip was analyzed. With indium tin oxide (ITO) electrode glass as the substrate, the particles continuous separation chip was prepared by the micro electromechanical system (MEMS) technology. The optimal size of channel obstacles was selected through the experiment. The experiment was completed with polystyrene spheres and yeast cells as samples. It is proved that when the mixed particles solution gets through the microchannel barriers in a speed of $3 \mu\text{m}/\text{min}$, all the particles in the microchannel move above due to the inertial focus. When the AC signal with the peak voltage of 6 V and 20 kHz is applied, the polystyrene spheres and yeast cells are negative dielectrophoresis responses. The dielectrophoretic forces of polystyrene spheres in the microchannel are larger than the fluid force, and they shift below. While the yeast cells in the microchannel are still above for the suffered fluid force greater than the negative dielectrophoresis force, thus the polystyrene spheres and yeast cells are separated, and the separation efficiency can reach 92.8%.

Key words: microfluidic chip; continuous separation; inertial focus; dielectrophoresis; micro electromechanical systems (MEMS); COMSOL

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电极和匀气盘结构对 PECVD 氮化硅
薄膜性能的影响

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摘要: 在衬底温度为 400 °C、射频功率为 20 W 的条件下, 通过改变 SiH₄ 和 NH₃ 的体积流量比、电极(圆环和平板电极)和匀气盘结构, 采用等离子体增强化学气相沉积(PECVD)法制备出不同成分的氮化硅薄膜, 测量了薄膜的淀积速率、残余应力以及在 HF 溶液和 KOH 溶液中的腐蚀速率。实验发现: 随着 SiH₄ 和 NH₃ 体积流量比的增大, 薄膜的淀积速率变大; 相同工艺条件下, 采用不同结构的电极淀积的氮化硅薄膜在 KOH 溶液中的腐蚀速率和腐蚀后的表面形貌都没有明显的差异; 相同工艺条件下, 使用圆环电极淀积的氮化硅薄膜具有较小的残余应力; 使用平板电极淀积的氮化硅薄膜在 HF 溶液(HF 和 H₂O 的体积比为 1:50)和缓冲氢氟酸(BHF)溶液中有更好的耐腐蚀性; 匀气盘对淀积的氮化硅薄膜的淀积速率、残余应力、在 HF 和 KOH 溶液中的腐蚀速率几乎没有影响。

关键词: 氮化硅薄膜; 残余应力; 等离子增强化学气相沉积(PECVD); 电极结构; KOH 腐蚀
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Effect of Electrode and Gas Homogenizing Plate Structures on the
Properties of Silicon Nitride Thin Films by PECVD

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Abstract: The silicon nitride films with different compositions were prepared by plasma enhanced chemical vapor deposition (PECVD) method through changing the volume flow ratio of SiH₄ and NH₃, the electrode (ring electrode and plate electrode) and gas homogenizing plate structures at the substrate temperature of 400 °C and RF power of 20 W. The deposition rate, residual stress and corrosion rates in HF solution and KOH solution were measured. The experiment results show that the deposition rate of the thin film increases with the increase of SiH₄ and NH₃ volume flow ratio. There are no significant differences in the corrosion rates in KOH solution and the surface morphologies after corrosion of the silicon nitride film deposited by different electrode structures under the same process conditions. The silicon nitride thin films deposited by the ring electrode have smaller residual stress under the same process conditions. The silicon nitride thin films deposited by the plate electrode show higher corrosion resistance in HF solution (the volume ratio of HF and H₂O is 1:50) and buffered hydrofluoric acid (BHF) solution. The gas homogenizing plate has little influence on the deposition rate, residual stress, corrosion rates in HF solution and KOH solution for the deposited silicon nitride thin films.

Key words: silicon nitride thin film; residual stress; plasma enhanced chemical vapor deposition(PECVD); electrode structure; KOH corrosion

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磁场辅助静电纺丝制备 Fe₃O₄/PVA 纳米纤维

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摘要: 利用静电纺丝法在轴向磁场辅助下成功制备了含有 Fe₃O₄ 颗粒的聚乙烯醇(PVA)磁性纳米纤维, 纤维直径为 250~715 nm。通过引入轴向磁场, 显著降低了制备磁性纳米纤维所需的电压值, 从而大幅降低了实验危险性和操作难度。研究了静电纺丝过程中喷头处三类射流状态, 以及形成稳定泰勒锥射流的实验参数, 分析了轴向磁感应强度与电压值之间的关系, 提出了静电纺丝制备优化实验条件, 为静电纺丝制备 Fe₃O₄/PVA 纳米纤维提供了实验和理论指导。磁场辅助静电纺丝法可应用于各类磁性纳米纤维的制备, 具有较高的工业应用价值。

关键词: 静电纺丝; 磁场; 纳米纤维; 泰勒锥; 纳米颗粒

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Fabrication of Fe₃O₄/PVA Nanofibers by Electrospinning

with a Magnetic Field

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Abstract: The Fe₃O₄/polyvinyl alcohol (PVA) magnetic nanofibers were successfully fabricated by electrospinning with an axial magnetic field. The fiber diameters are 250-715 nm. By introducing the axial magnetic field, the needed voltage is significantly reduced during the fabrication of magnetic nanofibers, and then the experimental risk and operation difficulty greatly decrease. The three modes of jets at the nozzle during the electrospinning and the experiment parameters for forming the stable Taylor cone jet were studied. The relationship between the axial magnetic induction intensity and voltage was analyzed. The optimized experimental conditions of the electrospinning were proposed. This provides the guidelines for experimental and theoretical investigation of Fe₃O₄/PVA nanofibers fabricated by the electrospinning. This approach can be used for fabrication of various kinds of magnetic nanofibers and has a great potential for industrial applications.

Key words: electrospinning; magnetic field; nanofiber; Taylor cone; nanoparticle

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CMP 后清洗中非离子表面活性剂对
Cu 表面状态的影响

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摘要: 为解决化学机械平坦化 (CMP) 后 Cu 表面存在表面粗糙度大、侵蚀等问题, 以表面活性剂为基础研制新型碱性清洗剂。采用对比实验研究了脂肪醇聚氧乙烯醚 (JFC)、聚乙二醇 (PEG)、高碳脂肪醇聚氧乙烯醚 (AEO) 和 FA/O 四种非离子表面活性剂的表面张力, 得出 FA/O 非离子表面活性效果最好且使清洗液表面张力最低。再通过原子力显微镜 (AFM) 测试以及电化学测试, 进一步研究不同体积分数的非离子表面活性剂对 Cu 表面状态的影响, 得出碱性清洗剂选用体积分数为 0~15% 的 FA/O 非离子表面活性剂时最佳。实验结果表明: 当清洗液中 FA/O 表面活性剂体积分数为 0~15%、FA/O II 螯合剂体积分数为 0~0.15% 时, 表面粗糙度为 1~3 nm, 界面腐蚀现象基本不存在。说明表面活性剂增大了清洗液在 CMP 后清洗过程的渗透性与铺展作用, 使 Cu 表面状态得到优化。

关键词: 非离子表面活性剂; 碱性清洗剂; 表面张力; 表面粗糙度; 化学机械平坦化 (CMP) 后清洗

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Effect of Nonionic Surfactant on Cu Surface Condition

During Post CMP Cleaning

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Abstract: A novel alkaline cleaning solution based on surfactant was developed to solve the problems of large surface roughness and erosion on the Cu surface after chemical mechanical planarization (CMP). The surface tensions of four kinds of FA/O nonionic surfactants (JFC, PEG, AEO, FA/O) were researched by the contrast experiments. The result shows that the FA/O nonionic surface active effect is best, and the surface tension of cleaning solution is minimum. Then the influences of nonionic surfactant with different volume fractions on Cu surface condition were further researched by the atomic force microscope (AFM) measurement and electrochemical measurement. It is concluded that the Cu surface condition is best when the volume fraction of FA/O nonionic surfactant is 0~15% in the alkaline cleaning solution. The experiment results show that when the volume fraction of FA/O surfactant is 0~15% and the volume fraction of FA/O II chelating agent is 0~0.15% in the cleaning solution, the surface roughness is 1~3 nm, and the interfacial corrosion phenomenon does not exist. It indicates that the surfactant optimizes the Cu surface condition by increasing the permeability and spreadability of cleaning solution during post CMP cleaning.

Key words: nonionic surfactant; alkaline cleaning solution; surface tension; surface roughness; post chemical mechanical planarization (CMP) cleaning

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抛光垫使用寿命对铜 CMP 平均去除速率一致性的影响

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摘要: 针对抛光垫的使用寿命对铜膜平均去除速率一致性的影响进行研究, 同时采用实时表面形貌控制(RTPC)技术, 对抛光过程中, 铜膜表面形貌进行实时监控。实验结果表明: 抛光垫的使用寿命对铜膜化学机械抛光(CMP)平均去除速率影响很大, 使用前期(抛光垫使用时间 $Tt \leq 500$ pcs), 铜膜平均去除速率稳定, 粗抛一致性良好(片内非均匀性(WIWNNU)为 337%), 粗抛后剩余膜厚范围小于 60 nm。使用后期($Tt > 500$ pcs), 粗抛速率一致性较差, 粗抛后剩余膜厚范围大于 100 nm。抛光垫修整能有效恢复抛光垫表面状态, 采用在线同步修整技术, 可以延长抛光垫使用寿命到 750 pcs 以上。但是过长的修整时间不能保证铜膜良好的平均去除速率一致性, 也会加大抛光垫磨损, 降低使用寿命。

关键词: 抛光垫; 使用寿命; 实时表面形貌控制(RTPC)技术; 平均去除速率一致性; 同步在线修整

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Effect of Polishing Pad Lifetime on the Average Removal Rate

Uniformity of Copper During CMP

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Abstract: The effect of polishing pad lifetime on the average removal rate uniformity of copper film was studied. And the real time profile control (RTPC) technology was adopted to monitor the morphology of copper film in real time during the polishing process. The experimental result shows that the lifetime of polishing pad has a great effect on the average removal rate of copper film during chemical mechanical polishing (CMP). The average removal rate of copper film is stable when the polishing pad is used in early period (the polishing pad lifetime $Tt \leq 500$ pcs). The with in wafer non uniformity (WIWNNU) is 337% during rough polishing, and the remaining thickness range of the copper film is less than 60 nm after rough polishing. However, the removal rate uniformity of copper film during rough polishing is poor in late period ($Tt > 500$ pcs), and the remaining thickness range of the copper film is more than 100 nm after rough polishing. The pad condition can effectively restore the surface state of polishing pad, and the online synchronous condition technology can extend the polishing pad lifetime to 750 pcs or more. However, longer condition time cannot guarantee a good average removal rate uniformity of copper film, and can increase the polishing pad wear and reduce the polishing lifetime.

Key words: polishing pad; lifetime; real time profile control(RTPC) technology; average removal rate uniformity; online synchronous condition

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MEMS 用硅单晶缺陷对各向异性腐蚀的影响

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摘要: 为了满足微电子机械系统 (MEMS) 器件制作要求, 各向异性腐蚀加工后的硅衬底需具有良好的表面质量。针对 MEMS 用硅单晶在各向异性腐蚀加工过程中出现的腐蚀表面粗糙、不平整问题, 采用常规直拉(Cz)单晶、掺锗直拉单晶和磁场直拉单晶等不同工艺制备了多种硅单晶样品, 并测试了其常规电参数、氧杂质浓度和微缺陷等参数。针对各种硅单晶样品, 模拟了器件制作过程中各向异性腐蚀实验, 获得了硅单晶的腐蚀表面情况, 对比得出了影响硅单晶各向异性腐蚀质量的关键因素在于硅单晶内的氧杂质浓度及氧沉淀密度的控制, 并从原子表面能和应力等方面推断晶体中氧沉淀缺陷对各向异性腐蚀质量的影响机理。

关键词: 微电子机械系统 (MEMS); 硅单晶; 各向异性腐蚀; 氧杂质浓度; 微缺陷; 氧沉淀

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Effect of Defects in Silicon Single Crystals for
MEMS on the Anisotropic Etching

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Abstract: In order to meet the production requirement of micro electromechanical system (MEMS) devices, the anisotropic etched silicon substrate is needed to have the good surface quality. The silicon single crystals for MEMS have rough surface and unflatness during the anisotropic etching process. For the problems, the various silicon single crystal samples were fabricated by different technologies, including the regular Czochralski(Cz) crystal method, doped Ge Cz crystal method and magnetic field Cz crystal method; and the regular electrical parameters, oxygen impurity concentration and microdefects and other parameters of all silicon single crystal samples were tested. For the various silicon single crystal samples, the anisotropic etching experiments were simulated in the process of the device fabrication, and the etching surface states of the silicon single crystals were obtained. Through the comparison, it is concluded that the oxygen impurity concentration control and oxygen precipitation density control in the silicon single crystals are the key factors to affect the anisotropic etching qualities of the silicon single crystals. The influence mechanisms of oxygen precipitation defects in the crystal on the anisotropic etching qualities were inferred from the aspects of the atomic surface energy and stress.

Key words: micro electromechanical system (MEMS); silicon single crystal; anisotropic etching; oxygen impurity concentration; microdefect; oxygen precipitation

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