

一种基于绝缘体上 Ge 的碰撞电离晶体管

沈路 1, 李好晨 2, 杨拥军 1

(1.中国电子科技集团公司 第十三研究所, 石家庄 050051;

2.西安科技大学 电气与控制工程学院, 西安 710054)

摘要: 碰撞电离晶体管 (IMOS) 在高速、低功耗领域具有很好的应用前景。以优化传统 IMOS 的工作电压为目的, 介绍了一种基于绝缘体上 Ge 的碰撞电离晶体管(GOI IMOS), 利用 Synopsys 公司的 ISE_TCAD 对 GOI IMOS 的性能进行仿真分析与验证。结果表明, GOI IMOS 相比于传统的绝缘体上 Si 的碰撞电离晶体管(SOI IMOS)可在更低的源漏偏压下工作, 同时该器件能够实现大的开态电流与陡峭的亚阈值摆幅; 另外, GOI IMOS 的源漏偏压和栅长均对该器件阈值电压有较大的影响, p 型 GOI IMOS 阈值电压的绝对值随着源漏电压和栅长的增大而减小。以上工作可为 IMOS 的设计、仿真、制备提供一定的理论指导。

关键词: 碰撞电离晶体管 (IMOS); 绝缘体上 Ge (GOI); 雪崩击穿; 阈值电压; 亚阈值摆幅

中图分类号: TN32 文献标识码: A 文章编号: 1671-4776(2017)09-0581-04

An Impact Ionization MOS Based on Germanium on Insulator

Shen Lu1, Li Yuchen2, Yang Yongjun1

(1.The 13th Research Institute, CETC, Shijiazhuang 050051,China; 2. School of Electrical and Control Engineering, Xi'an University of Science and Technology, Xi'an 710054,China)

Abstract:The impact ionization MOS (IMOS) has a good application prospect in the field of high speed and low power. An impact ionization MOS based on germanium on insulator(GOI IMOS) was proposed to optimize the supply voltage of the conventional IMOS. The performance of the GOI IMOS was simulated, analyzed and verified by using the ISE_TCAD of the Synopsys. The results show that compared with the conventional IMOS based on silicon on insulator (SOI IMOS), the GOI IMOS can work under lower source drain bias voltage, and realize a larger on state current and an abrupt sub threshold swing. In addition, the source drain bias voltage and gate length of the GOI IMOS have a great effect on its threshold voltage. The absolute value of the threshold voltage of the p type GOI IMOS decreases with the increase of the source drain bias voltage and gate length. The above work provides a theoretical reference for the design, simulation and fabrication of IMOS.

Key words:impact ionization MOS (IMOS); germanium on insulator (GOI); avalanche breakdown; threshold voltage; sub threshold swing

DOI:10.13250/j.cnki.wndz.2017.09.001EEACC:2560S

石墨烯对多孔硅光学性能的影响

钱栋梁, 葛道晗, 程广贵

(江苏大学 微纳米科学技术研究中心, 江苏 镇江 212013)

摘要: 采用电化学腐蚀法, 通过改变腐蚀电流密度制备出不同孔径的多孔硅衬底。通过荧光分光光度计对多孔硅进行光致发光性能测试, 测试结果发现腐蚀电流密度会对其光致发光性能产生影响, 当腐蚀电流密度为 30 mA/cm² 时, 制备出的多孔硅光致发光性能较好。通过湿法转移法将化学气相沉积(CVD)法制备出的石墨烯转移到多孔硅表面, 利用喇曼光谱对石墨烯进行质量及层数检测。通过荧光分光光度计及傅里叶变换红外光谱仪 (FTIR) 对复合材料进行表征。结果表明石墨烯可以改变多孔硅表面态, 使多孔硅的光致发光性能得到极大的提高。研究成果为多孔硅应用到光学传感器中提供了新的研究方向。

关键词: 石墨烯; 多孔硅; 电流密度; 复合材料; 光致发光

中图分类号: TB33;TN304.18 文献标识码: A 文章编号: 1671-4776(2017)09-0585-06

Effect of the Graphene on Optical Properties of the Porous Silicon

Qian Dongliang, Ge Daohan, Cheng Guanggui

(Research Center of Micro/Nano Science & Technology, Jiangsu University, Zhenjiang 212013, China)

Abstract: By using the electrochemical etching method and changing the corrosion current density, the porous silicon substrates with different pore sizes were prepared. The photoluminescence property of the porous silicon was measured by the fluorescence spectrophotometer. The results show that the corrosion current density has an effect on the photoluminescence property of the porous silicon. When the corrosion current density is 30 mA/cm², the photoluminescence property of the prepared porous silicon is better. The graphene was prepared by the chemical vapor deposition (CVD) method and then transferred to the surface of the porous silicon by the wet transfer method. The quality and layer number of the graphene were detected by the Raman spectroscopy. The composites were characterized by the fluorescence spectrophotometer and Fourier transform infrared spectrometer (FTIR). The results show that the graphene can change the porous silicon surface state and greatly improve the photoluminescence property of the porous silicon. The research results provide a new research direction for the application of the porous silicon in optical sensors.

Key words: graphene; porous silicon; current density; composite; photoluminescence

DOI:10.13250/j.cnki.wndz.2017.09.002EEACC:0580

可延展柔性电子基底微观分析

潘开林, 杨帆, 秦晴, 李婷婷, 曹威武

(桂林电子科技大学 机电工程学院, 广西 桂林 541004)

摘要: 可延展柔性电子产品在可穿戴电子、柔性显示和医疗等领域中具有很大的应用潜力。在可延展柔性电子的应用中,可延展柔性电子基底与互连导线之间的可靠性研究受到越来越广泛的关注。以可延展柔性电子界面为研究对象,从微观机理出发讨论可延展柔性电子界面的可靠性问题,运用分子动力学(MD)的方法建立基底的微观模型。用掺杂的方式优化基底的各项性质,以提高可延展柔性电子界面的可靠性。在聚二甲基硅氧烷(PDMS)基底中掺杂 SiO₂ 纳米粒子后的复合物,经分子动力学仿真分析得出,基底热膨胀系数随着掺杂 SiO₂ 原子数分数的增大而减小;杨氏模量随着掺杂 SiO₂ 原子数分数的增大而增大。这说明加入 SiO₂ 可以很好地提高 PDMS 的机械特性和降低基底的热膨胀系数,使优化后的基底更加适合与互连导线结合,提高整体的可靠性。

关键词: 可延展电子; 柔性电子; 分子动力学模拟; 纳米粒子; 聚二甲基硅氧烷(PDMS)

中图分类号: TB34 **文献标识码:** A **文章编号:** 1671-4776(2017)09-0591-06

Micro Analysis of the Substrate for Stretchable and Flexible Electronics

Pan Kailin, Yang Fan, Qin Qing, Li Tingting, Cao Weiwu

(School of Mechanical and Electronic Engineering, Guilin University of Electronic Technology, Guilin 541004, China)

Abstract: Stretchable and flexible electronic devices have great application potential in the fields of wearable electronics, flexible displays and medical treatment and so on. In practical application of the stretchable and flexible electronics, the study for the reliability between the stretchable and flexible electronic substrate and interconnect wires is concerned more and more. With the stretchable and flexible electronic interface as the research object, the reliability of the interface was discussed from the microscopic mechanism, the microscopic model of the substrate was established by using the molecular dynamics (MD) method. The properties of the substrate were optimized by doping to improve the reliability of the stretchable and flexible electronic interface. The MD simulation analysis of the composite after doping with SiO₂ nanoparticles on PDMS substrates was carried out. The results show that with the increase of the atom fraction of the doped SiO₂, the substrate thermal expansion coefficient decreases and Young's modulus increases, indicating that the addition of SiO₂ can improve the mechanical properties of PDMS and reduce the thermal expansion coefficient of the substrate, the optimized substrate is more suitable for combination with interconnect wires, and the reliability is improved.

Key words: stretchable electronics; flexible electronics; molecular dynamics simulation; nanoparticle; polydimethylsiloxane (PDMS)

DOI:10.13250/j.cnki.wndz.2017.09.003EEACC:0585

MOEMS 集成波长选择开关的设计及研究

时建^{1, 2}, 梁静秋¹, 陈成¹, 吕金光¹, 秦余欣¹, 高丹^{1, 2}

(1.中国科学院 长春光学精密机械与物理研究所 应用光学国家重点实验室, 长春 130033;

2.中国科学院大学, 北京 100049)

摘要: 研究一种基于电磁驱动微光机电系统(MOEMS)光开关阵列的串联集成波长选择开关结构, 经过理论分析与计算, 得出螺旋形线圈在相同电流密度下相比于八边形和四边形线圈能得到更大的电磁力; 通过模态分析得到在设计的悬臂结构下, 支撑臂响应时间约为 22 ms。采用溅射、光刻、腐蚀和电铸等 MOEMS 工艺完成了光开关悬臂的制作, 并通过制作对准标记及采用可见光与红外光相结合的装调方法, 完成了 1×8 阵列的波长选择开关系统集成。经过测试得到, 开关上升和下降的时间均约为 20 ms, 当电流为 0~4 A 时, 支撑臂的挠度为 1~28 mm, 能达到系统光路转换的目的。该波长选择开关能够在 2 V 电压下, 实现对 8 个不同波长信道的任意选择, 其最大的插入损耗为 1~741 dB, 信道均匀性达到 0~55 dB; 插入损耗的测试结果与计算结果较吻合。

关键词: 波分复用; 波长选择开关; 微光机电系统(MOEMS); 光通信; 电磁驱动

中图分类号: TN256; TH703 文献标识码: A 文章编号: 1671-4776(2017)09-0597-08

Design and Study of MOEMS Integrated Wavelength Selective Switches

Shi Jian^{1,2}, Liang Jingqiu¹, Chen Cheng¹, Lü Jinguang¹, Qin Yuxin¹, Gao Dan^{1,2}

(1.State Key Laboratory of Applied Optics, Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Science, Changchun 130033, China; 2.University of Chinese Academy of Sciences, Beijing 100049, China)

Abstract: A series structure integrated wavelength selective switch based on electromagnetic drive micro optical electromechanical system (MOEMS) optical switch array was studied. Theoretical analysis and calculation shows that the spiral coil can obtain more electromagnetic force than the octagonal and quadrilateral coils at the same current density. Through the modal analysis, the response time of about 22 ms of the support arm for the designed cantilever structure was obtained. The optical switch cantilever was fabricated by MOEMS technology, such as sputtering, photolithography, etching and electroforming. By making the alignment mark, the 1×8 array wavelength selective switch system integration was completed with the aligning and installing methods combing with visible and infrared lights. The test results show that the rise time and fall time of the switch are both about 20 ms. The deflection of the support arm is 1~28 mm at the current of 0~4 A, which satisfies the demand of system optical path conversion. The wavelength selective switch can achieve arbitrary selection of eight different wavelength channels at 2 V voltage. The maximum insertion loss is 1~741 dB and the channel uniformity reaches 0~55 dB. The test results of the insertion loss are in good agreement with its calculated results.

Key words: wavelength division multiplexing; wavelength selective switch; micro optical electromechanical system (MOEMS); optical communication; electromagnetic drive

DOI:10.13250/j.cnki.wndz.2017.09.004EEACC:4140; 2575

核磁共振陀螺仪研究进展

程翔¹, 刘华¹, 王咄¹, 王帝¹, 李绍良², 赵万良², 成宇翔²

(1.上海交通大学 电子信息与电气工程学院, 上海 200240;

2.上海市航天控制技术研究所 上海市空间智能控制技术重点实验室
上海惯性工程技术研究中心, 上海 201109)

摘要: 核磁共振陀螺(NMRG)是基于量子原理的陀螺仪, 具有高精度、体积小、抗干扰能力强等特点, 是陀螺仪发展的重点方向之一。简要回顾了核磁共振陀螺的发展历史, 介绍了20世纪有代表性的研究成果。叙述了核磁共振陀螺的基本工作原理和硬件系统构成。按照4种不同的技术路径: 微型核磁共振陀螺、无自旋弛豫交换(SERF)核自旋陀螺、芯片级组合原子导航仪和基于金刚石氮空位的核磁共振陀螺, 重点阐述近年来国外研究机构在核磁共振陀螺研究领域取得的最新成果, 之后再介绍了近年来国内研究机构取得的主要研究成果。最后总结了核磁共振陀螺技术的最新发展趋势。

关键词: 核磁共振陀螺(NMRG); 原子自旋; 原子陀螺; 微陀螺仪; 量子原理

中图分类号: V241.5 文献标识码: A 文章编号: 1671-4776(2017)09-0605-07

Research Progress in Nuclear Magnetic Resonance Gyroscopes

Cheng Xiang¹, Liu Hua¹, Wang Po¹, Wang Di¹, Li Shaoliang², Zhao Wanliang², Cheng Yuxiang²

(1.School of Electronic Information and Electrical Engineering, Shanghai Jiaotong University,

Shanghai 200240, China;2.Shanghai Engineer Research Center of Inertia,Shanghai Key

Laboratory of Space Intelligent Control Technology, Shanghai Institute of Spaceflight

Control Technology, Shanghai 201109, China)

Abstract:The nuclear magnetic resonance gyroscope (NMRG)based on the quantum principle has features of high precision, compact size, strong anti interference ability and so on, and is one of the most important development directions of gyroscopes. The development history of the NMRG is briefly reviewed,and the representative researches in the 20th century are introduced. The basic operational principle and hardware system structure of the NMRG are described. The newest research achievements of the NMRG attained by foreign research institutes are mainly described according to four technical paths: micro NMRG, spin exchange relaxation free (SERF) atomic spin gyroscope, chip scale combinatorial atomic navigator (C SCAN) and NMRG based on nitrogen vacancy in diamond. The research achievements attained by domestic research institutes are also introduced. Finally,the development trend of the NMRG in the future is summarized.

Key words:nuclear magnetic resonance gyroscope(NMRG); atomic spin; atomic gyroscope; micro gyroscope; quantum principle

DOI:10.13250/j.cnki.wndz.2017.09.005EEACC:2575

磁致伸缩振动能量采集器的研究进展

曹淑瑛, 孙帅帅, 郑加驹, 王雪源, 韩恭万, 刘璐

(河北工业大学 电磁场与电器可靠性省部共建重点实验室, 天津 300130)

摘要: 磁致伸缩振动能量采集器作为一种新形式的能量采集器, 具有高机电转化效率、高鲁棒性和低输出阻抗等特性。阐述了磁致伸缩式振动能量采集器的基本工作原理, 按照其基本结构和工作方式将其归纳为直驱式和悬臂梁式两大类, 详细介绍了这两类振动能量采集器的最新研究进展, 综合归纳了其机械结构和工作的特点, 比较分析了其输出电压、输出功率、功率密度和机电转换效率等发电性能, 总结了这两类磁致伸缩振动能量采集器的优缺点以及应用场合。最后, 从采集器的换能材料、磁路设计、环境适应性以及结构微型化方面进一步探讨了目前研究中所存在的不足之处, 并对其今后的发展趋势进行了展望。

关键词: 磁致伸缩; 振动; 能量采集; 直驱式; 悬臂梁

中图分类号: TM919; TH703 文献标识码: A 文章编号: 1671-4776(2017)09-0612-09

Research Progress of Magnetostrictive Vibration Energy Harvesters

Cao Shuying, Sun Shuaishuai, Zheng Jiaju, Wang Xueyuan, Han Gongwan, Liu Lu

(Province Ministry Joint Key Laboratory of Electromagnetic Field and Electrical Apparatus Reliability,

Hebei University of Technology, Tianjin 300130, China)

Abstract: As a new form of energy harvester, magnetostrictive vibration energy harvesters have the characteristics such as high electromechanical conversion efficiency, high robustness and low output impedance. The basic working principle of magnetostrictive vibration energy harvesters is described. According to the basic structure and working method of magnetostrictive harvesters, they are classified as the driven directly and cantilever magnetostrictive vibration energy harvesters. The latest research progresses for the two kinds of harvesters are introduced in detail, their characteristics of the mechanical structure and work are summarized, and their generating performances such as the output voltage, output power, power density and electromechanical conversion efficiency are compared and analyzed. The advantages, disadvantages and applications for the two kinds of harvesters are summarized. Finally, the shortcomings of the current research are further discussed from the energy conversion material, magnetic circuit design, environmental adaptability and miniaturization of the structure for the harvesters. The development trend of the magnetostrictive vibration energy harvesters is also prospected.

Key words: magnetostriction; vibration; energy harvesting; driven directly mode; cantilever

DOI:10.13250/j.cnki.wndz.2017.09.006EEACC:8460;2575

热边界层发展对微通道中纳米流体传热的影响

王淑香¹, 童军杰¹, 徐立²

(1. 广州航海学院 船舶与海洋工程学院, 广州 510725;

2. 广东省计量科学研究院, 广州 510405)

摘要: 对加热长度为 4~5 mm、水力直径为 130 μm 的微通道芯片中纳米流体的换热情况进行了实验研究, 比较了纯水和不同质量分数纳米流体在微通道中的换热性能, 分析了热边界层发展对纳米流体换热性能的影响。实验发现, 在热边界层发展段, 纳米粒子的加入可使通道的局部换热系数得到提高, 且沿着工质的流动方向, 换热系数提高的幅度逐渐减小。在热边界层发展阶段, 工质的进口速度越大, 纳米流体换热系数提高的幅度也越大。最后通过理论分析对产生上述实验现象的原因进行了合理解释, 并得出热边界层越薄, 纳米流体对于局部换热系数的影响越大, 对于传热的强化效果也越好。

关键词: 微通道; 纳米流体; 入口效应; 热边界层; 强化传热

中图分类号: O35; TH703 文献标识码: A 文章编号: 1671-4776(2017)09-0621-06

Effects of the Thermal Boundary Layer Development on
Nanofluids Heat Transfer in Micro Channels

Wang Shuxiang¹, Tong Junjie¹, Xu Li²

(1. School of Naval Architecture and Ocean Engineering, Guangzhou Maritime University, Guangzhou 510725, China; 2. Guangdong Provincial Institute of Metrology Introduction, Guangzhou 510405, China)

Abstract: The heat transfer characters of nanofluids in the micro channel chip with the heating length of 4~5 mm and hydraulic diameter of 130 μm was studied. The heat transfer performances of the pure water and nanofluids with different mass fractions were compared. The effects of the thermal boundary layer development on the heat transfer performance of the nanofluids were analyzed. The experimental results show that the addition of the nanoparticles can improve the local heat transfer coefficient of the micro channel in the thermal boundary layer development zone, and the increase amplitude of the heat transfer coefficient decreases gradually along the direction of refrigerant flow. In the thermal boundary layer development zone, the higher the refrigerant inlet velocity, the larger the increase amplitude of the heat transfer coefficient of nanofluids. Finally, the reasonable explanation for experimental results was proposed by the theoretical analysis. It is concluded that in thinner thermal boundary layer, the nanofluids have greater impact on the local heat transfer coefficient, and the heat transfer enhancement is better.

Key words: micro channel; nanofluid; entrance effect; thermal boundary layer; heat transfer enhancement

DOI:10.13250/j.cnki.wndz.2017.09.007PACC:0340G;0710C

氧化钨纳米纤维的制备及其对 H₂S 的气敏特性

杨洁, 张萌, 邵燕, 孙永娇, 位子涵, 胡杰

(太原理工大学 信息工程学院 微纳系统研究中心, 太原 030024)

摘要: 利用静电纺丝法制备了氧化钨 (WO₃) 纳米纤维。使用 X 射线衍射仪 (XRD) 和扫描电子显微镜 (SEM) 对样品的物相结构和微观形貌进行表征。分析结果表明: 制备的 WO₃ 纳米纤维由众多纳米颗粒组装而成, 且平均直径约为 200 nm。同时, 研究了基于 WO₃ 纳米纤维的气体传感器对 H₂S 的气敏特性。实验结果表明: 在工作温度为 150 °C 时, 该传感器对体积分数为 2×10^{-5} 的 H₂S 气体的响应达到 72, 响应时间和恢复时间分别为 4 s 和 21 s, 且检测极限为 5×10^{-9} , 表明该传感器在低体积分数 H₂S 气体检测方面有实际应用价值。

关键词: 静电纺丝法; WO₃ 纳米纤维; 气体传感器; 气敏特性; H₂S

中图分类号: TB383 文献标识码: A 文章编号: 1671-4776(2017)09-0627-06

Preparation of Tungsten Oxide Nanofibers and Its Gas

Sensing Properties to H₂S

Yang Jie, Zhang Meng, Shao Yan, Sun Yongjiao, Wei Zihan, Hu Jie

(Micro and Nano System Research Center, College of Information Engineering,

Taiyuan University of Technology, Taiyuan 030024, China)

Abstract: The tungsten oxide (WO₃) nanofibers were prepared by the electrospinning method. The phase structure and microtopography of the sample were characterized by the X ray diffractometer (XRD) and scanning electron microscope (SEM). The measured results show that the prepared WO₃ nanofibers are assembled by numbers of nanoparticles with the average diameter of about 200 nm. Meanwhile, the gas sensing properties of the gas sensor based on WO₃ nanofibers to H₂S were investigated. The experimental results show that the gas sensing response of the sensor to H₂S with the volume fraction of 2×10^{-5} reaches 72 at the operating temperature of 150 °C, the response time and recovery time are 4 s and 21 s, respectively, and the detection limit is 5×10^{-9} , which demonstrates that the gas sensor has a practical application value for the detection of H₂S with low volume fraction.

Key words: electrospinning method; tungsten oxide nanofiber; gas sensor; gas sensing property; H₂S

DOI:10.13250/j.cnki.wndz.2017.09.008 PACC:6146

基于梳齿式电容加速度计的深硅刻蚀

任子明 a,b, 白冰 a,b, 王任鑫 a,b, 张国军 a,b

(中北大学 a.仪器科学与动态测试教育部重点实验室;

b. 电子测试技术重点实验室, 太原 030051)

摘要: 梳齿式电容加速度计对梳齿的形貌有很高的要求, 如需要梳齿侧壁具有良好的垂直度和粗糙度等。利用深硅刻蚀机对梳齿结构进行加工需要对刻蚀参数进行分析和调整。以 SF₆ 和 C₄F₈ 为刻蚀气体, 设定深硅刻蚀中极板功率、腔室压力、刻蚀/钝化周期、气体流量等工艺参数, 着重研究了刻蚀速率、垂直度、粗糙度、光刻胶选择比、均匀性等直接影响刻蚀形貌的几项因素, 得到了宽 5 3 μm、深 50 μm 的沟槽结构, 且垂直度为 89 5°, 侧壁凸起高度为 83 69 nm, 而预期目标为垂直度 90° ± 2°, 侧壁凸起高度小于 120 nm, 故结果符合要求。最终将调整好的工艺用于刻蚀 SOI 片上的梳齿结构, 得到了良好的形貌。

关键词: 深硅刻蚀; 梳齿结构; 刻蚀速率; 垂直度; 选择比; 均匀性

中图分类号: TN305.7 文献标识码: A 文章编号: 1671-4776(2017)09-0633-06

Deep Silicon Etching Based on Comb Tooth Capacitance Accelerometer

Ren Ziming,a,b, Bai Bing,a,b, Wang Renxina,b, Zhang Guojuna,b

(a.Key Laboratory of Instrumentation Science & Dynamic Measurement of Ministry of Education;

b.Science and Technology on Electronic Test and Measurement Laboratory, North

University of China, Taiyuan 030051,China)

Abstract:The comb capacitive accelerometer has high requirements for morphology of the combs, such as good verticality and roughness of side walls. The etching parameters should be analyzed and adjusted for the fabrication of the comb structure using the deep silicon etching machine. Using SF₆ and C₄F₈ as etching gas, setting the process parameters of the deep silicon etching such as the plate power, chamber pressure, etching/passivation cycle and gas flow, the several factors of the etching rate, verticality, roughness, selection ratio of photoresist and uniformity affecting the etching morphology directly were emphatically studied. The groove structure with 5 3 μm wide and 50 μm deep was obtained, the verticality was 89 5°, the sidewall bump height was 83 69 nm, and the expected goals for the verticality and sidewall bump height were 90°±2°and less than 120 nm, respectively, so the results meet the requirements. Finally, the adjusted process was applied to etch the comb structure on SOI wafers and a good morphology was also obtained.

Key words:deep silicon etching; comb structure; etching rate; verticality; selection ratio; uniformity

DOI:10.13250/j.cnki.wndz.2017.09.009EEACC:2575F

CMP 中 TEOS 去除速率的一致性

张凯 1,2, 刘玉岭 1,2, 王辰伟 1,2, 牛新环 1,2, 江自超 1,2, 韩丽楠 1,2

(1. 河北工业大学 电子信息工程学院, 天津 300130;

2. 天津市电子材料与器件重点实验室, 天津 300130)

摘要: 针对 300 mm 正硅酸乙酯 (TEOS) 镀膜片在化学机械平坦化 (CMP) 过程中中心去除速率快而边缘去除速率慢的问题, 研究了抛光头摆动位置、抛光头不同区域压力和非离子型表面活性剂对 TEOS 去除速率一致性的影响。实验结果显示, 抛光头距抛光盘中心越远, 中心去除速率越慢, 去除速率一致性越好; 增加抛光头边缘压力, 加快了边缘去除速率, 提高了去除速率一致性; 增加非离子表面活性剂添加量, 提高了温度分布均匀性, 进而改善去除速率一致性。与初始工艺对比, 在抛光头摆动位置距抛光盘中心 7.2~8.2 英寸 (1 英寸=2.54 cm)、抛光头边缘压力增加 20%、添加非离子表面活性剂体积分数 1.5% 条件下, 片内非均匀性 (WIWNU) 降低了 60~9%。

关键词: 正硅酸乙酯 (TEOS); 化学机械平坦化 (CMP); 非离子型表面活性剂; 去除速率一致性; 片内非均匀性 (WIWNU)

中图分类号: TN305.2 文献标识码: A 文章编号: 1671-4776(2017)09-0639-06

Uniformity of TEOS Removal Rate in the CMP Process

Zhang Kai^{1,2}, Liu Yuling^{1,2}, Wang Chenwei^{1,2}, Niu Xinhuan^{1,2}, Jiang Zichao^{1,2}, Han Linan^{1,2}

(1. School of Electronic and Information Engineering, Hebei University of Technology, Tianjin 300130, China;

2. Tianjin Key Laboratory of Electronic Materials and Devices, Tianjin 300130, China)

Abstract: Based on the problem that the removal rate of the 300 mm ethyl silicate (TEOS) blanket wafer was fast in the center and slow on the edge in the chemical mechanical planarization (CMP) process, the effects of the polishing head sweep position, pressures in different regions of polishing head and nonionic surfactants on the TEOS removal rate uniformity were studied. The experimental results show that by increasing the distance between the polishing head and the center of the polishing disk, the removal rate decreases at the wafer center, and the removal rate uniformity improves. The removal rate on the wafer edge increases and the removal rate uniformity improves by increasing the pressure of the polishing head edge. The uniformity of temperature distribution improves by adding nonionic surfactants, and thus the removal rate uniformity improves. Compared with the original process, when the distance between the head sweep position and the polishing disk center is 7.2-8.2 inches (1 inch=2.54 cm), the pressure of the polishing head edge increases 20% and the nonionic surfactant is added with the volume fraction of 1.5%, the within wafer nonuniformity (WIWNU) is reduced by 60~9%.

Key words: ethyl silicate (TEOS); chemical mechanical planarization (CMP); nonionic surfactant; removal rate uniformity; within wafer nonuniformity (WIWNU)

DOI:10.13250/j.cnki.wndz.2017.09.010EEACC:2550E

高深宽比石英结构的 NLD 刻蚀

吴亚宁¹, 张伟², 王逸群², 黄健¹, 缪小虎², 王进², 金晓盛²

(1. 上海大学 材料科学与工程学院, 上海 200436;

2. 中国科学院 苏州纳米技术与纳米仿生研究所 纳米加工平台, 江苏 苏州 215123)

摘要: 基于磁中性环路放电 (NLD) 等离子体刻蚀机的原理, 研究了 Ar 和 C4F8 混合气体氛围下, 射频 (RF) 天线功率、偏置电源功率、气压和 C4F8 体积流量等工艺参数对 NLD 刻蚀石英的影响, 最终获取优化的工艺参数, 用于高深宽比石英结构的制备。结果表明, 随着 RF 天线功率的增加, 石英刻蚀速率逐渐降低, 偏压不断减小; 增加偏置电源功率, 刻蚀速率及偏压持续增大, 刻蚀比不断增大; 随着反应压强的增加, 偏压变大, 而刻蚀速率一直降低; C4F8 体积流量增加, 偏压一直增大, 石英刻蚀速率先是快速上升而后逐渐变小。在优化的工艺参数下, 刻蚀速率为 439 nm/min, 深宽比可以达到 10 : 1。

关键词: 磁中性环路放电 (NLD) 等离子体; Ar+C4F8; 石英; 高深宽比; 刻蚀

中图分类号: TN305.7 文献标识码: A 文章编号: 1671-4776(2017)09-0645-05

NLD Etching of a High Aspect Ratio Quartz Structure

Wu Yaning¹, Zhang Wei², Wang Yiqun², Huang Jian¹, Miao Xiaohu², Wang Jin², Jin Xiaosheng²

(1.School of Materials Science and Engineering, Shanghai University, Shanghai 200436,China;

2.Nano Fabrication Facility, Suzhou Institute of Nano Tech and Nano Bionics (SINANO), Chinese Academy of Sciences, Suzhou 215123, China)

Abstract:Based on the principle of the magnetic neutral loop discharge (NLD) plasma etcher, the effects of the process parameters on the NLD etching of quartz were studied in the mixed gas ambience of Ar and C4F8, such as the radio frequency (RF) antenna power, bias supply power, pressure and volume flow rate of C4F8. Finally, the optimized parameters for the preparation of the high aspect ratio quartz structure were obtained. The results show that with the increase of the RF antenna power,the etching rate of the quartz and the bias voltage gradually decrease. With the increase of the bias power, the bias voltage and etching rate of the quartz continue to increase, and the selectivity increases.With the increase of the pressure, the bias voltage increases, and the etching rate of the quartz decreases. With the increase of the volume flow rate of C4F8, the bias voltage increases, the etching rate of the quartz quickly increases firstly and then gradually decreases. Under the optimized process parameters,the etching rate is 439 nm/min, and the aspect ratio reaches 10 : 1.

Key words:magnetic neutral loop discharge (NLD) plasma; Ar+C4F8; quartz; high aspect ratio; etching

DOI:10.13250/j.cnki.wndz.2017.09.011EEACC:2550