

## 椭圆柱纳磁体全自旋逻辑器件开关特性

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摘要: 基于自旋传输和磁动力学耦合模型, 研究了纳磁体形状对全自旋逻辑(ASL)器件临界开关电流以及开关延迟时间和功耗的影响。仿真结果显示, 由于椭圆柱纳磁体构成的 ASL 器件易磁化轴方向退磁因子相比长方体纳磁体器件要小, 所以其形状各向异性能和临界开关电流更小。从而在相同的注入电流情况下, 椭圆柱纳磁体构成的 ASL 器件磁矩翻转时间比长方体纳磁体更短, 所以椭圆柱纳磁体开关延迟时间和功耗均小于长方体纳磁体构成的 ASL 器件。上述结论为合理选择纳磁体形状提供了理论依据, 所得结果对 ASL 器件的设计及应用具有重要的意义, 为优化 ASL 器件开关延迟时间和功耗提供了一种新的方法。

关键词: 全自旋逻辑(ASL)器件; 纳磁体形状; 退磁因子; 临界开关电流; 开关特性

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Switching Characteristics of All Spin Logic Devices

Comprised of Elliptic Cylinder Nanomagnets

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Abstract: The effects of the nanomagnet shape on critical switching current, switching delay and power dissipation of all spin logic (ASL) devices were researched based on the spin transport/magneto dynamics coupling model. The simulation results show that compared with the ASL devices comprised of cuboid nanomagnets, the shape anisotropy energy and critical switching current of the ASL devices comprised of elliptic cylinder nanomagnets are lower, which can be attributed to the fact that the demagnetizing factor in the direction of easy axis of elliptic cylinder nanomagnets is lower. Thus the magnetization reversal time of ASL devices comprised of elliptic cylinder nanomagnets is shorter than that of the ASL devices comprised of cuboid nanomagnets under the same inject current. So the switching delay and power dissipation of the ASL devices comprised of elliptic cylinder nanomagnets are less than that of the ASL devices comprised of cuboid nanomagnets. The conclusions mentioned above provide a theoretical foundation for the reasonable selection of the shape of nanomagnets, and the obtained results have great significance for the design and application of ASL devices, which provides a new method for the optimization of switching delay and power dissipation of ASL devices.

Key words: all spin logic(ASL) device; nanomagnet shape; demagnetization factor; critical switching current; switching characteristic

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p 型 PERC 双面太阳能电池背面铝栅线的设计

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摘要: 钝化发射极背面接触 (PERC) 双面太阳能电池 (PERC+) 背面采用丝网印刷铝栅线的设计, 代替常规 PERC 电池背面全铝背场层, 达到背面发电的效果。对不同背面铝栅线宽度的 PERC+ 电池和常规 PERC 电池的电性能及激光开窗截面图进行比较, 发现了不同宽度的铝栅线对电池背面空洞率和局部背表面场 (LBSF) 层的质量有较大影响, 合适的铝栅线宽度能最大程度地保证 PERC+ 电池的转换效率。实验得出在相同的激光开窗工艺下, 当背面铝栅线设计宽度为 250  $\mu\text{m}$  时, PERC+ 电池具有较好的铝栅线高宽比, 烧结后的激光开窗区域形成了良好的 LBSF 层。同时, 所有电池在测试时背景采用不反光黑布。测试结果显示, 最优组的 PERC+ 电池平均正面转换效率达到 21.21%、平均背面转换效率达到 13.97%。

关键词: 钝化发射极背面接触 (PERC) 电池; 双面太阳能电池; 背面金属化; 铝栅线; 空洞; 局部背表面场 (LBSF)

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Design of Rear Aluminum Gridline for p Type

Bifacial PERC Solar Cells

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Abstract: The bifacial passivated emitter rear contact (PERC) solar cell (PERC+) applies a screen printed rear Al gridline instead of the rear full area aluminum (Al) rear layer of conventional PERC cell to achieve the rear power generation. The electrical performances and the laser window cross section views of the PERC+ cells with different rear Al gridline widths and conventional PERC cells were compared. The results indicate that the Al gridlines with different widths have greater effect on the rear void rates of cell and the quality of local back surface field (LBSF) layer. The proper width of the Al gridline can ensure the transfer efficiency of the PERC+ cells furthest. The experiment shows that when the design width of the Al finger grid is 250  $\mu\text{m}$  under the same laser window process, the PERC+ cells have better height width ratio of the Al gridline and a good LBSF layer in the laser window area after firing process. Meanwhile, a non reflecting black cloth was used in the test background when all cells were measured. The test results show that the average front transfer efficiency and average rear transfer efficiency of the optimal group for the PERC+ cells reach 21.21% and 13.97%, respectively.

Key words: passivated emitter rear contact (PERC); bifacial solar cell; rear metallization; Al gridline; void; local back surface field (LBSF)

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## MoSe<sub>2</sub> 薄膜的制备与光电特性

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摘要: 主要研究了硒化钼(MoSe<sub>2</sub>)薄膜的制备及其光电特性。以硒化钼粉末作为原料、采用化学气相沉积 (CVD) 法在 Si 衬底上沉积硒化钼薄膜。利用原子力显微镜(AFM)、X 射线衍射仪(XRD)、霍尔效应仪和 UV-3600 分光光度计分别表征了硒化钼薄膜的表面形貌、晶体结构、光吸收特性和 MoSe<sub>2</sub>/Si 异质结的光电特性。分析可见所制备的硒化钼薄膜由柱状生长的硒化钼纳米颗粒构成, 且这些纳米颗粒具有很强的垂直生长的取向。另外, 还发现该硒化钼薄膜对可见光有很强的吸收和良好的光电特性, 表明硒化钼薄膜在光电器件领域具有很大的应用潜力。

关键词: 硒化钼(MoSe<sub>2</sub>); 化学气相沉积(CVD); 表面形貌; 光吸收; 光电特性

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## Preparation and Photoelectric Characteristics of MoSe<sub>2</sub> Thin Films

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Abstract: The preparation and the optoelectronic characteristics of molybdenum selenide (MoSe<sub>2</sub>) thin films were mainly studied. With MoSe<sub>2</sub> powder as the raw material, the MoSe<sub>2</sub> thin films were deposited on the Si substrate by the chemical vapor deposition (CVD) method. The surface morphology, crystal structure, optical absorption of MoSe<sub>2</sub> thin films and optoelectronic properties of MoSe<sub>2</sub>/Si heterojunction were characterized by atomic force microscope (AFM), X ray diffractometer (XRD), Hall effect instrument and UV-3600 spectrophotometer. It is found that the prepared MoSe<sub>2</sub> thin films are composed of columnar MoSe<sub>2</sub> nanoparticles with a strong orientation of vertical growth. Additionally, the MoSe<sub>2</sub> thin films have strong visible light absorption and good optoelectronic characteristics, indicating that the MoSe<sub>2</sub> thin films have great potential applications in the field of optoelectronic devices.

Key words: molybdenum selenide(MoSe<sub>2</sub>); chemical vapor deposition (CVD); surface morphology; optical absorption; optoelectronic characteristic

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液滴在亲水表面快速铺展过程中的溅射现象

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摘要: 采用格子 Boltzmann 方法, 建立了液滴在亲水固体表面上快速铺展过程的三维非稳态理论模型。研究了液滴铺展的动态过程, 分析了液滴的形貌变化, 比较了固体表面润湿性和液滴的运动黏度对液滴铺展过程的影响, 获得了溅射现象产生的原因。研究表明, 液滴接触到亲水固体表面后, 从底部产生的毛细波是造成液滴颈部断裂和溅射现象的主要原因; 固体表面的接触角越小, 液滴铺展的速度越快, 越容易产生溅射现象; 黏性力在铺展过程中起到减缓液滴铺展的作用, 液滴的运动黏度越大, 越难产生溅射现象。

关键词: 液滴; 铺展; 亲水表面; 溅射现象; 接触角; 格子 Boltzmann 方法

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Ejection Phenomenon of Droplets During the Fast

Spreading on a Hydrophilic Surface

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Abstract: The three dimensional unsteady theoretical model of the droplet fast spreading process on a hydrophilic solid surface was developed by the lattice Boltzmann method. The dynamic process of the droplet spreading was researched, and the morphology change of the droplet was analyzed. The effects of the solid surface wettability and droplet kinematic viscosity on the droplet spreading process were compared, and the causes of the ejection phenomenon were obtained. The research results indicate that after the droplet comes into contact with the hydrophilic solid surface, the capillary wave generated from the bottom of the droplet is a main cause for the droplet neck fracture and ejection phenomenon. The smaller the contact angle on a solid surface is, the faster the velocity of the droplet spreading is, and the more easily the ejection phenomenon generates. The viscosity force slows down the droplet spreading. The larger the kinematic viscosity of droplet is, the more difficultly the ejection phenomenon generates.

Key words: droplet; spreading; hydrophilic surface; ejection phenomenon; contact angle; lattice Boltzmann method

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平面环形谐振腔的腔长对品质因数的增强效应

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摘要:品质因数(Q)是光学谐振腔的重要参数,大尺寸的平面环形谐振腔有着更大的单圈损耗,却具有更高的Q值。针对这个问题,从光子寿命的角度对环形谐振腔耦合结构进行了建模分析与仿真,提出了用等效单位传输损耗参数来表征谐振腔的腔长与品质因数之间的关系。设计、加工了不同腔长(3.1, 9.5, 12.6和18.8cm)的氧化硅光波导环形谐振腔,其中谐振腔的耦合系数保持不变,测试结果显示:随着谐振腔的腔长增加,谐振腔的等效单位传输损耗降低,Q值增大,与仿真结果相符。该结论为高Q值光波导谐振腔的研究提供了一种新的途径。

关键词:谐振腔;品质因数;等效单位传输损耗;腔长;光波导

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Enhancement Effect of Cavity Length on Quality Factor in the

Planar Ring Resonant Cavity

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Abstract: The quality factor (Q) is an important parameter of the optical resonant cavity, and the large size planar ring resonant cavity has larger single lap loss, but has higher Q value. To solve this problem, the modeling analysis and simulation of the coupling structure of the ring resonant cavity were carried out based on the photon lifetime. The relation between the cavity length and the quality factor was characterized by using the equivalent unit transmission loss parameters. The silica optical waveguide type ring resonant cavities with different cavity lengths (3.1, 9.5, 12.6 and 18.8 cm) were designed and fabricated, in which the coupling coefficient of the resonant cavity was kept constant. The test results show that with the increase of the cavity length, the equivalent unit transmission loss of the resonant cavity decreases and the Q value increases, which are consistent with the simulation results. This conclusion provides a new approach for the study of the optical waveguide resonant cavity with high Q value.

Key words: resonant cavity; quality factor; equivalent unit transmission loss; cavity length; optical waveguide

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微型植入式磁力供药系统的制备与测试

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摘要: 设计了一个直径为 1 mm 的新型植入式磁力驱动供药腔, 该供药腔包括磁性薄膜、聚二甲基硅氧烷 (PDMS) 空腔、PDMS 薄膜以及内径为 0.4 mm 的聚四氟乙烯 (PTFE) 导管构成, 通过 O<sub>2</sub> 等离子处理工艺和键合形成空腔。将直流电源与铜线轴相连作为磁场源, 通过其产生的磁场与磁性薄膜之间的磁力作用, 磁性薄膜发生形变。当外部磁场开始工作时, 通过改变电流大小控制药物供给量, 磁性薄膜受到磁场的作用力对腔内的液体药物进行挤压, 药物排出腔外。当外部磁场关闭后, 磁性薄膜不再受到磁场的作用力, 逐渐恢复原状, 停止供药。经过测试, 当磁感应强度达到 100 mT 时, 供药系统的最大供药量为 28.8 μL。

关键词: 植入式供药系统; 磁性薄膜; 聚二甲基硅氧烷 (PDMS) 空腔; 磁场; 供药量

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Preparation and Testing of a Micro Implantable  
Magnetic Drug Supply System

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Abstract:A novel implantable drug supply cavity driven by magnetism was designed with the diameter of 1 mm. The drug supply cavity was composed of a magnetic film, polydimethylsiloxane (PDMS) cavity, PDMS film and polytetrafluoroethylene(PTFE) catheter with an inner diameter of 0.4 mm, and was formed through the O<sub>2</sub> plasma treatment process and bonding process. The DC power source connected with the copper spool can be used as the magnetic field source, and the magnetic film is deformed by the magnetic force between the magnetic field and the magnetic film. When the external magnetic field starts to work, the supply of the drug can be controlled by the current, and the magnetic film gets the force of magnetic field to extrude the liquid drug in the cavity, then the drug was sent out of the cavity. When the external magnetic field is closed, the magnetic film is no longer subject to the force of magnetic field, and gradually restores to the original state as well as stops the supply of drugs. According to the test result, when the magnetic induction intensity reaches 100 mT, the maximum dosage of the drug supply system is 28.8 μL.

Key words:implantable drug supply system; magnetic film; polydimethylsiloxane (PDMS) cavity; magnetic field; drug supply dose

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## 微波在半导体退火工艺中的应用

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摘要: 针对传统快速热处理工艺 (RTP) 在退火过程中引起杂质再扩散导致难以制作浅结器件的问题, 采用了微波退火的方式进行退火, 有效降低了热预算, 能够解决杂质再扩散的问题。相比传统 RTP 退火, 微波的退火机理具有特殊性, 其不仅有微波的热效应还有微波的非热效应, 使微波退火能够在较低的温度下实现杂质激活和晶格修复。实验表明, 在注入能量为 15 keV、注入剂量为  $1 \times 10^{15} \text{ cm}^{-2}$  时, P31 注入的样品经微波退火后其方块电阻均值小于  $200 \ \Omega/\square$ , 片内不均匀度小于 3%, 最高退火温度仅约为  $400 \text{ }^\circ\text{C}$ , 热预算远低于传统 RTP 退火。该实验结果表明, 微波退火的方法在浅结器件的制备工艺中有较大的应用潜力。

关键词: 微波; 退火; 离子注入; 快速热处理工艺 (RTP); 热预算

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Application of Microwave in Semiconductor Annealing Process

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Abstract: Due to the dopant re-diffusion caused by annealing process of the traditional rapid thermal process (RTP), the shallow junction devices cannot be fabricated easily. The annealing was carried out by the microwave annealing to effectively reduce the thermal budget and solve the problem of dopant re-diffusion. Compared to the traditional RTP annealing, the microwave annealing has thermal microwave effect and non-thermal microwave effect, which can realize impurity activation and lattice restoration at low temperature. The experiments show that when the implantation energy and implantation dose are 15 keV and  $1 \times 10^{15} \text{ cm}^{-2}$  respectively, the average square resistance and non-uniformity of the implanting P31 samples annealed by the microwave annealing are less than  $200 \ \Omega/\square$  and less than 3% respectively, and the highest annealing temperature is only about  $400 \text{ }^\circ\text{C}$ . The thermal budget of the microwave annealing is far lower than the traditional RTP annealing. The experimental results show that the microwave annealing method has great potential in the preparation process of the shallow junction devices.

Key words: microwave; annealing; ion implantation; rapid thermal process (RTP); thermal budget

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可循迹纳米台阶标准样版的制备与表征

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摘要: 介绍了纳米几何量量值传递中纳米标准样版的计量与溯源特性。分析了微纳米测量仪器在纳米标准样版几何参量校准中对标准样版循迹结构的具体需求。设计了标准值为 60 nm, 具有可循迹结构的纳米台阶标准样版。为了实现高精度、溯源性表征, 基于计量型纳米测量仪 (NMM), 结合多种定位测量方法, 对加工的纳米台阶标准样版进行测量与评价, 并对其开展区域均匀性和长时间稳定性实验。实验结果表明, 制备的台阶标准样版高度值与设计值基本一致, 设计的循迹结构能有效地协助电荷耦合器件 (CCD) 实现快速循迹与定位, 且采用溅射镀膜工艺优化了标准样版表面结构的特性, 使多种定位测量方法的测量重复性标准偏差均小于 1 nm。

关键词: 量值传递; 刻蚀工艺; 标准样版; 纳米测量仪 (NMM); 溅射镀膜工艺

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Preparation and Characterization of Tracking

Nano Step Standard Templates

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Abstract:The metrological and traceability characteristics of nano standard templates in nano geometric value transfer were introduced. In the geometric parameter calibration of nano standard templates, the specific requirements of the micro and nano measurement instrument on the standard template tracking structure were analyzed. A nano step standard template with a standard value of 60 nm and tracking structures was designed. In order to achieve high precision and traceability characterization, based on the metrological nano measuring machine (NMM), combined with a variety of positioning and measuring methods, the processed nano step standard template were measured and evaluated, and the regional uniformity and long term stability experiments were carried out. The experimental results show that the height value of the prepared nano step standard template is basically the same as the design value. The designed tracking structure can effectively assist the charge coupled device (CCD) to achieve rapid tracking and positioning. And the surface structure characteristics of the standard template were optimized by the sputtering coating process, the measuring repeatability standard deviation of the various positioning and measuring methods are less than 1 nm.

Key words:value transfer; etching process; standard template; nano measuring machine (NMM); sputtering coating process

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KIO<sub>4</sub> 基电解液中 Cu/Ru 电偶腐蚀的控制与分析

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摘要: Ru 作为 14 nm 及以下技术节点的铜互连极大规模集成电路(GLSI)的新型阻挡层材料, 在化学机械平坦化(CMP)工艺中易与 Cu 发生电偶腐蚀, 影响器件的稳定性。采用动电位扫描的电化学方法表征铜钌表面的电化学反应, 进而分析研究 KIO<sub>4</sub> 溶液的 pH 值和浓度对 Cu/Ru 电偶腐蚀的控制及机理。研究表明: pH 值对 Ru 的腐蚀影响较大, 溶液接近中性时, Ru 表面会生成一层致密且不均匀的钝化膜, 此时 Ru 表面腐蚀最小, 腐蚀电流密度最低。随着 KIO<sub>4</sub> 浓度升高, Cu 表面氧化膜加厚, 阻碍化学反应的进行。当 pH 值为 9、KIO<sub>4</sub> 浓度为 0.015 mol/L 时, Cu/Ru 腐蚀电位差由 0.999 V 降至 0.628 V, 实现了 Cu/Ru 电偶腐蚀的控制。

关键词: 钌; 铜; 电化学; 电偶腐蚀; pH 值; 浓度

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Control and Analysis of Cu/Ru Galvanic Corrosion in

KIO<sub>4</sub> Based Electrolyte

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Abstract:The galvanic corrosion between copper and ruthenium will occur during chemical mechanical planarization (CMP) process when ruthenium is used as the new copper interconnection barrier material in the 14 nm and below technical nodes of the great large scale integrated circuit (GLSI), which can influence the stability of the device. The electrochemical reaction of Cu and Ru surface was characterized by the electrochemical potentiodynamic scanning technology, and the control and mechanisms of Cu/Ru galvanic corrosion in different pH values and concentrations of KIO<sub>4</sub> solution were further analyzed. The results show that pH value has a greater effect on the corrosion of Ru. When the solution is near neutral, a compact and inhomogeneous passive film can be generated on the surface of Ru, meanwhile, the corrosion on the surface of Ru and the corrosion current density are minimal. With the increase of KIO<sub>4</sub> concentration, the oxide film on the Cu surface thickens, then the chemical reaction on copper surface will be hindered. The corrosion potential difference between Cu and Ru is reduced from 0.999 V to 0.628 V with the pH value of 9 and KIO<sub>4</sub> concentration of 0.015 mol/L in the solution, achieving the control of galvanic corrosion between Cu and Ru.

Key words:ruthenium; copper; electrochemistry; galvanic corrosion; pH value; concentration

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磁控溅射法低温制备 Al 膜工艺参数的优化

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摘要: 以高纯度铝作为溅射靶材, 高纯度氩气作为溅射气体, 在低温环境下利用直流磁控溅射设备在硅衬底上成功制备了铝膜。通过单一因素控制法研究了溅射功率、腔室压强和基片转速三个关键因素对铝膜的均匀性、致密性和附着性的影响。采用台阶仪、扫描电子显微镜 (SEM) 等测试设备以及磷酸腐蚀速率法、胶带法等测试方法对铝膜质量进行了表征与分析, 得出了不同工艺参数与铝膜的均匀性、致密性和附着性的关系, 并且对结果进行了优化。实验结果表明: 溅射功率和腔室压强影响铝膜的均匀性、致密性和附着性; 基片转速影响铝膜的均匀性和附着性, 并得到了各因素对铝膜质量的影响趋势及影响机理。最终得到制备铝膜的最优工艺参数为溅射功率 300 W、腔室压强  $3 \sim 7 \times 10^{-3}$  Torr (1 Torr=133.3 Pa)、基片转速 6 r/min。

关键词: 磁控溅射; 铝膜; 均匀性; 致密性; 附着性

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Optimization of Process Parameters of Al Films Prepared by Magnetron Sputtering Method at Low Temperature

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Abstract: With the high purity aluminum as the sputtering target and high purity argon as the sputtering gas, the aluminum films were successfully fabricated on a silicon substrate by a DC magnetron sputtering apparatus in a low temperature environment. The influences of three key factors, such as sputtering power, chamber pressure and substrate rotate speed, on the uniformity, compactness and adhesion of the aluminum films were studied by single factor control method. The qualities of the aluminum films were characterized and analyzed by step meter, scanning electron microscope (SEM) and other test equipment, and phosphoric acid corrosion rate method and tape method. The relationships of different process parameters and the uniformity, compactness and adhesion of the aluminum films were obtained, and the results were optimized. The experiment results show that the sputtering power and chamber pressure affect the uniformity, compactness and adhesion of the aluminum films, and the substrate rotate speed affects the uniformity and adhesion of the aluminum films. The influence trend and impact mechanism of various factors on the qualities of aluminum films were obtained. Finally, the optimal process parameters for the preparation of aluminum films are the sputtering power of 300 W, the chamber pressure of  $3 \sim 7 \times 10^{-3}$  Torr (1 Torr=133.3 Pa) and the substrate rotate speed of 6 r/min.

Key words: magnetron sputtering; aluminum film; uniformity; compactness; adhesion

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紫外光照射下 GaN 的电化学性质及 CMP 应用

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摘要: 通过电化学工作站对 2 英寸 (1 英寸=25.4 cm) n 型 GaN 晶圆进行了研究, 结合 X62 型单面抛光机研究 GaN 电化学腐蚀与化学机械抛光 (CMP) 的一致性, 并利用原子力显微镜 (AFM) 检测抛光后晶片的表面形貌。结果表明: 采用 H<sub>2</sub>O<sub>2</sub> 和 NaClO 作为氧化剂时, GaN 的腐蚀速率与氧化剂的体积分数呈反比, 在固定 H<sub>2</sub>O<sub>2</sub> 体积分数的情况下, GaN 腐蚀速率呈现酸性溶液优于碱性溶液、同时二者均优于中性溶液的现象。使用 X62 型单面抛光机对上述电化学腐蚀结果进行验证, 得到与其相一致的规律, 在体积分数为 1% 的 H<sub>2</sub>O<sub>2</sub> 和 pH=5 的情况下, GaN 的去除速率最高, 达到 380±3 nm/h, 同时抛光后的 GaN 表面粗糙度达到 0.063 nm, 扫描范围为 5 μm×5 μm。研究表明电化学腐蚀和化学机械抛光具有一定的 consistency, 在实际应用中具有一定的借鉴意义。

关键词: 电化学腐蚀; GaN; 化学机械抛光 (CMP); 表面粗糙度; 去除速率

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Electrochemical Property and CMP Application of  
GaN Under the UV Irradiation

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Abstract: The 2 inches (1 inch=25.4 cm) n type GaN wafers were studied by the electrochemical workstation. The X62 single side polisher was used to investigate the consistency of electrochemical corrosion and chemical mechanical polishing (CMP) of GaN, and the surface morphology of GaN after CMP was tested by the atomic force microscope (AFM). The results show that with H<sub>2</sub>O<sub>2</sub> and NaClO as oxidizers, the corrosion rate of GaN is inversely proportional to volume fractions of the oxidizers. When the volume fraction of H<sub>2</sub>O<sub>2</sub> is constant, the corrosion rate of GaN in acidic solution is greater than that of GaN in alkaline one, and both of them are greater than that of GaN in neutral solution. The X62 single side polisher was used to verify the electrochemical corrosion results, and the similar phenomena were observed. The removal rate of GaN is the highest and reaches 380±3 nm/h under H<sub>2</sub>O<sub>2</sub> with the volume fraction of 1% and pH=5. At the same time, the surface roughness of GaN after polishing reaches 0.063 nm, and the scan range is 5 μm×5 μm. This research illustrates that the electrochemical corrosion is consistent with CMP to some extent, and has a certain reference in actual application.

Key words: electrochemical corrosion; GaN; chemical mechanical polishing (CMP); surface roughness; removal rate

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可穿戴电子设备及软机器人制造工艺的研究现状

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摘要: 回顾了用于制造可穿戴电子设备及软机器人的材料及制造工艺。总结了应用于可穿戴电子设备及软机器人制造的各种制造工艺, 它们都是将用于实现各功能的元器件通过制造工艺集成在柔性基体或基板中, 这些工艺包括新纳米材料技术、转印技术、形状沉积制造和软光刻技术。描述了这些工艺的特点, 同时指出它们将朝着三维立体化、标准化及工业化的方向发展。为选择可穿戴电子设备及软机器人的制造工艺并开发新工艺提供了参考, 从而能设计制造出新型的柔性设备。

关键词: 可穿戴电子设备; 软机器人; 制造工艺; 柔性基体; 纳米材料; 转印技术; 柔性电子设备

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Research Status of Manufacturing Technology of Wearable

Electronic Equipment and Soft Robots

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Abstract: The materials and manufacturing processes used to make wearable electronic equipment and soft robots are reviewed. A variety of manufacturing processes applied to the manufacture of wearable electronic equipment and soft robots are summarized, and they are used to achieve the functions of the components and devices integrated in the flexible matrix or substrate through the manufacturing process. These processes include the new nanomaterials technology, transfer printing technology, shape deposition manufacturing technology and soft lithography. The characteristics of these processes are described, and it is pointed out that their development will be towards the three dimensional, standardized and industrial direction. It provides a reference for selecting the manufacturing process of wearable electronic equipment and soft robots and developing new processes, thus new and flexible equipment can be designed and manufactured.

Key words: wearable electronic equipment; soft robot; manufacturing process; flexible matrix; nanomaterial; transfer printing technology; flexible electronic equipment

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