

基于金属亚波长光学结构窄带滤色片的
研究进展（续）

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Research Progress of Narrowband Color Filters Based on Metallic
Subwavelength Optical Structures (Continued)

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基于混合忆阻器-CMOS 逻辑的全加器
电路优化设计

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摘要: 将一种电压阈值型压控双极性忆阻器模型与 CMOS 反相器进行混合设计, 实现了“与”、“或”、“与非”、“或非”基本逻辑门。通过构建“异或”逻辑门新结构, 提出一种基于混合忆阻器-CMOS 逻辑的全加器电路优化设计方案。最后, 分析忆阻器参数 β , V_t , R_{on} 和 R_{off} 对电路运算速度和输出信号衰减幅度的影响, 研究了该优化设计的电路功能和特性, 经验证模拟仿真结果与理论分析结果具有较好的一致性。研究表明: 全加器优化设计结构更简单, 版图面积更小, 所需忆阻器数量减少 22% ± 2%, CMOS 反相器数量减少 50%; 增大参数 β 值可提高运算速度, 增大忆阻值比率 R_{off}/R_{on} 可减小逻辑输出信号衰减度。

关键词: 忆阻器; 混合忆阻器-CMOS 逻辑; 电压阈值; 全加器; 信号衰减

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Optimized Design of Hybrid Memristor // CMOS Logic
Based Full Adder Circuits

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Abstract: Basic logic gates of "AND", "OR", "NAND" and "NOR" were realized by the hybrid design with the combination of a voltage // threshold // type voltage // controlled bipolar memristor model and a CMOS inverter. Then, with the new structure of the "XOR" logic gate, an optimization design scheme of the full adder circuit was put forward based on the hybrid memristor // CMOS logic. Finally, by analyzing the effects of the memristor parameters β , V_t , R_{on} and R_{off} on the circuit operation speed and the attenuation amplitude of the output signal, and the functions and features of the optimization designed circuit were investigated. The simulation results were validated to be in good agreement with the theoretical analysis results. The research results show that the optimally designed full adder circuit has simpler structure and smaller layout area, the required number of the memristor is reduced by 22% ± 2%, and the number of the CMOS inverter is reduced by 50%. Besides, the operation speed can be improved by increasing parameter β , and the attenuation amplitude of the logic output signal can be reduced by increasing the memristor ratio R_{off}/R_{on} .

Key words: memristor; hybrid memristor // CMOS logic; voltage threshold; full adder; signal attenuation

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新一代功率半导体 β - Ga_2O_3 器件进展与展望

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摘要: β - Ga_2O_3 是一种新兴的超宽禁带半导体材料, 具有超宽带隙 4 ~ 8 eV、超高理论击穿电场 8 MV/cm 以及超高的 Baliga 品质因数等优良特性, 作为下一代高功率器件材料其越来越受到人们的关注。首先, 回顾了宽禁带半导体材料 β - Ga_2O_3 的基本性质, 包括 β - Ga_2O_3 的晶体结构和电学性质, 简述了基于 β - Ga_2O_3 制造的功率器件, 主要包括肖特基势垒二极管(SBD)和金属-氧化物-半导体场效应晶体管(MOSFET)。总结回顾了 β - Ga_2O_3 SBD 和 MOSFET 近年来的研究进展, 比较了不同结构器件的特性, 并分析了目前 β - Ga_2O_3 功率器件存在的问题。分析表明, β - Ga_2O_3 用于高功率和高压电子器件具有巨大潜力。

关键词: β - Ga_2O_3 ; 超宽禁带半导体; 功率器件; 肖特基势垒二极管(SBD); 金属-氧化物-半导体场效应晶体管(MOSFET)

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Progresses and Prospects of New Generation Power Semiconductor β - Ga_2O_3 Devices

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Abstract: β - Ga_2O_3 is an emerging ultra wide bandgap semiconductor material with excellent characteristics, such as the ultra wide bandgap of 4 ~ 8 eV, ultra high theoretical breakdown electric field of 8 MV/cm and ultra high Baliga quality factor, and draws more and more attention as the next generation high power device material. Firstly, the basic properties of β - Ga_2O_3 , a wide bandgap semiconductor material, are reviewed including the crystal structure and electrical properties of β - Ga_2O_3 . Besides, the power devices based on β - Ga_2O_3 are briefly described, mainly including Schottky barrier diodes (SBDs) and metal oxide semiconductor field effect transistors (MOSFETs). The recent developments of β - Ga_2O_3 SBDs and MOSFETs are reviewed, the characteristics of different structural devices are compared, and current existing problems of β - Ga_2O_3 power devices are analyzed. The analysis shows that β - Ga_2O_3 has great potential for high power and high voltage electronic devices.

Key words: β - Ga_2O_3 ; ultra wide bandgap semiconductor; power device; Schottky barrier diode (SBD); metal oxide semiconductor field effect transistor (MOSFET)

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单晶硅电池表面织构与光电特性的关系

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摘要: 针对在单晶硅片表面制备陷光织构可提高吸光率, 但同时将导致光生伏特效应被削弱的问题, 定义了电池的光学特性系数和电学特性系数, 以表征电池光电特性。通过采用不同的化学制绒工艺参数, 在单晶硅片表面获得不同尺寸的表面织构, 分析了织构平均高度对电池光电特性和转换效率的影响规律。结果表明: 随着单晶硅片表面织构平均高度的增大, 单晶硅电池的光学特性系数呈现先升高再降低的规律, 电学特性系数呈现逐渐减小的规律; 基于中型金字塔绒织构的硅电池同时兼顾了光学特性和电学特性, 得到最高的光电转换效率为 19.49%。

关键词: 单晶硅电池; 表面织构; 反射率; 少子寿命; 量子效率; 光电特性; 光电转换效率
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Relationship Between the Surface Texture and Photoelectric Characteristics of Monocrystalline Silicon Cells

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Abstract: For the problem that preparing trapped textures on the surface of monocrystalline silicon wafers can increase its absorbance, but meanwhile the photovoltaic effect is weakened inevitably, thus the optical properties coefficient and electrical characteristic coefficient were defined to characterize the photoelectric characteristics of cells. Surface textures of different sizes on the surface of the monocrystalline silicon wafer were obtained by using different chemical texturing process parameters, and the influence rule of the average height of the texture on the photoelectric properties and conversion efficiency of the cells was analyzed. The results show that with the increase of the average height of the surface textures of the monocrystalline silicon wafer, the optical characteristic coefficient of the monocrystalline silicon cell increases first and then decreases, and the electrical characteristic coefficient gradually decreases. Both the optical characteristics and the electrical characteristics were taken into account at the same time in the medium pyramid texture based silicon cell, and the obtained highest photoelectric conversion efficiency is up to 19.49%.

Key words: monocrystalline silicon cell; surface texture; reflectivity; minority life time; quantum efficiency; photoelectric characteristic; photoelectric conversion efficiency

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石墨烯量子点光学非线性特性及其应用进展

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摘要: 石墨烯量子点(GQD)是碳量子点的一种, 不仅具有碳量子点的优良性质, 还具有其他量子点无法比拟的光学特性。概括了石墨烯量子点光学非线性原理特点, 由于其二阶或三阶非线性电极化强度决定非线性光学的特性, 并且其表面导电性呈各向同性, 选择一种更加合理的方法来描述其光学非线性, 由此论述得到其三阶电流的表现形式。随后, 详细阐述了国内外对在光电领域、生物光子领域和催化领域中 GQD 的研究成果, 简要分析了其性能参数、作用特点、潜在能力等, 指出了 GQD 目前面临的关键技术问题, 并对此从制备方案设计和优化作用机制等方面阐述了技术解决途径, 最后对未来 GQD 的应用前景进行了展望。

关键词: 非线性光学; 石墨烯量子点(GQD); 光电领域; 生物光子领域; 催化领域

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Optical Nonlinear Characteristics and Application

Progress of Graphene Quantum Dots

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Abstract: The graphene quantum dot (GQD) is one type of carbon quantum dots, and has the excellent properties of carbon quantum dots and optical properties unmatched by other quantum dots. The characteristics of the optical nonlinear principle of the GQD are comprehensively summarized. The second or third order nonlinear electric polarization strength determines the characteristics of nonlinear optics which is described by a more reasonable method, and the surface conductivity of the GQD is isotropic, thus the expression of its third order current is achieved. Then the research results of the GQD in the field of optoelectronics, biophotonics and catalysis are elaborated in detail. The performance parameters, function characteristics and potential capabilities of the GQD are briefly analyzed, and the key technical problems faced by GQDs are pointed out. The technical solutions are expounded in the aspects of the preparation scheme design and the optimization of the action mechanism. Finally, the application prospect of future GQDs is forecast.

Key words: nonlinear optics; graphene quantum dot(GQD); photoelectric field; biophoton field; catalytic field

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Total Glass Microfluidic Chip Flow Cell for Multiple Detections

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Abstract: Microfluidic chips based on the glass substrate are characterized by optical transparency, good hydrophilic and high strength. A microfluidic chip flow detection cell based on the total glass substrate with replaceable wire electrodes was introduced. The chip cell was prepared by photolithography, wet etching and thermal bonding of the glass substrate. A pair of Pt wire electrodes were precisely positioned parallelly along the two sides of the main microchannel and 190 μm apart from each other by the parallel ridges formed during the wet etching. The total volume of the functional part of the channel is only about 300 nL. Multiple detections including electrochemistry (EC), electrochemiluminescence (ECL) and chemiluminescence (CL) were successfully demonstrated with the chip cell. The effective isolation of the electrodes was achieved by the laminar flow effect in the microchannel. The chip flow detection cell is characterized in robustness, transparency, small dead volume and being compatible with the miniaturized online flow detection, thus can be used for the detection with high sensitive flow biosensors.

Key words: glass chip flow cell; wire electrode; luminal reaction; electrochemistry (EC); electrochemiluminescence (ECL); chemiluminescence (CL)

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多用途全玻璃微流控芯片流通检测池

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摘要:以玻璃为基材的微流控芯片具有光学透明、亲水性好和强度高的特点。介绍了一种具有可更换丝状电极的全玻璃微流控芯片流通检测池。该芯片通过玻璃光刻、湿法刻蚀和热封合制备。一对 Pt 丝电极通过平行的脊突精确定位在检测通道的两侧, 之间相距 190 μm , 流通检测池功能区的总体积仅约为 300 nL。包括电化学(EC)、电化学发光(ECL)及化学发光(CL)的多模式检测均在此池体上进行了成功展示。利用微通道中的层流效应实现了电极之间的有效隔离。该芯片流通检测池具有耐用、透明、死体积小和与微型化在线流动检测相匹配的特点, 可在高灵敏流动生物传感检测中得到应用。

关键词:玻璃芯片流通池; 丝电极; 鲁米诺反应; 电化学(EC); 电化学发光(ECL); 化学发光(CL)

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高分辨率 MEMS 纤毛式湍流传感器

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摘要: 国外的剪切流传感器已经趋于成熟, 但仍存在测试信息量单薄、空间分辨率不高和价格昂贵的缺点。提出了一种新型高分辨率微电子机械系统 (MEMS) 湍流传感器, 通过 MEMS 工艺的微结构实现湍流传感器的高分辨率探测, 同时凭借 Parylene 真空气相沉积技术来实现传感器在海中的绝缘性和抗腐蚀性。经过 5~45 °C 的高低温循环实验, 验证了 MEMS 湍流传感器在复杂环境中的可靠性, 并通过实验测量得到电压形式的湍流数据。

关键词: 纤毛; 高分辨率; 微电子机械系统 (MEMS); 湍流传感器; 压电

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High Resolution MEMS Ciliary Turbulence Sensor

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Abstract: The shear flow sensor tends to be mature gradually at abroad, but has disadvantages of little measurement information, low space resolution and high price. A new high resolution micro electro-mechanical system (MEMS) based sensor for the turbulence was proposed. With the aid of the micro structure prepared by the MEMS process, the high resolution exploration of the sensor for the turbulence was realized. Meanwhile, the Parylene vacuum vapor deposition technology was adopted to achieve the insulation and corrosion resistance of the sensor in the sea. The reliability of the MEMS turbulence sensor in complex environment was verified by high and low temperature cyclic experiments at 5 °C-45 °C, and the turbulence data in the voltage form were obtained by experimental measurements.

Key words: cilia; high resolution; micro electro-mechanical system (MEMS); turbulence sensor; piezoelectricity

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新型电磁铁驱动的撞针式微滴喷射装置

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摘要: 液滴喷射技术具有广泛的应用前景和技术优势, 结合现有技术设计了一种能够实现有效的微滴喷射的装置, 该装置基于电磁铁驱动, 采用撞针式结构。本装置包括电磁铁、滑轨、撞针、喷嘴、弹簧、垫圈等几个主要部分, 通过电磁铁驱动撞针撞击喷嘴从而使液滴从喷嘴中喷射出。整体而言其结构简单、成本较低、易于加工, 可实现液滴稳定喷射。以甘油溶液(丙三醇)作为喷射实验材料, 进行了多粘度溶液及多种喷嘴直径的喷射实验, 并对实验结果进行分析, 总结了该装置液滴喷射的相关性能, 实现了粘度为 0~1 410 mpas 的多种粘度液滴的稳定喷射, 丰富了微滴喷射装置的结构设计。

关键词: 喷射; 撞击; 液滴; 粘度; 喷嘴直径

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New Electromagnet Driven Pin Impact Micro Droplet Ejector

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Abstract: The droplet injection technology has broad application prospects and technical advantages. An effective micro droplet ejector was designed based on the existing technology. The device is driven by the electromagnet and adopts a pin impact structure. The device consists of the electromagnet, slideway, pin, nozzle, spring, washer and other main parts. The electromagnet drives the pin to impact the nozzle so that droplets can be ejected from the nozzle. On the whole, the structure is simple, low in cost, and easy to process. The stable droplet injection can be realized. With the glycerol solution (glycerol) as the spraying experimental material, the spraying experiments of the multi viscosity solution and various nozzle diameter were carried out, and the experimental results were analyzed. The correlative performances of the device for droplet spraying were summarized. The stable spraying of multi viscosity droplets with the viscosity of 0-1 410 mpas was realized, enriching the structure design of the micro droplet ejector.

Key words: injection; impact; droplet; viscosity; nozzle diameter

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Inhibition of N Plasma Treatment for the Improvement of Tungsten Gap Fill

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Abstract: The void free W gap fill was successfully achieved by using the in situ N plasma treatment during the bulk W deposition. With the N plasma treatment, W was transformed to WN_x, acting as the inhibitor to induce the growth delay of structure top W film. Therefore, the structure overhang was eliminated and the void free W film was obtained. The scanning electron microscope (SEM) was utilized to characterize the W gap fill performance. The result shows that with the opening bowing structure, the conventional chemical vapor deposition (CVD) method for the growth of the W film easily leads to serious void; while in the case of applying the N plasma treatment, the W gap fill can get good performance without the void. To illustrate the N plasma treatment mechanism, the scanning transmission electron microscope (STEM) was introduced, and meanwhile the relationship between the bulk W deposition delay time and the N plasma treatment time, N₂ volume flow rate, B₂H₆ flush time and bulk deposition temperature was investigated.

Key words: W gap fill; void; N plasma treatment; WN_x film; delay time; diborane(B₂H₆)

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氮等离子体处理的抑制用于改善钨填充

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摘要:在体钨生长过程中使用原位氮等离子体处理成功实现了无孔洞钨填充。通过氮等离子体处理,钨转化成了氮化钨,其作为抑制剂引起结构顶部钨薄膜的生长延迟。因此,消除了结构顶部薄膜封口,并且实现了无孔洞的钨薄膜生长。使用扫描电子显微镜(SEM)表征钨薄膜的填充能力。结果表明:开口有弓状形貌的结构,使用传统化学气相沉积(CVD)方式生长钨薄膜非常容易导致孔洞;而利用氮等离子体处理能够获得没有孔洞的钨填充。引入扫描透射电子显微镜(STEM)解释氮等离子体处理的机理,同时对体钨生长延迟时间与氮等离子体处理的时间、氮气体积流量、乙硼烷通气时间、体钨生长温度的关系进行了研究。

关键词:钨填充;孔洞;氮等离子体处理;氮化钨薄膜;延迟时间;乙硼烷(B₂H₆)

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结构化晶圆表面厚胶喷涂工艺

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摘要: 采用超声雾化喷涂技术, 以 AZ4620 光刻胶为研究对象, 以硅通孔 (TSV) 刻蚀后的硅片为基材, 在 12 英寸 (1 英寸=2.54 cm) 结构化晶圆表面喷涂光刻胶形成薄膜。分别研究了稀释质量比、超声功率、氮气体积流量、喷嘴与晶圆表面的间距、载台温度等工艺参数对 TSV 硅片表面喷涂质量的影响, 最终通过优化过程工艺参数, 得到表面胶颗粒细小、膜厚均匀性好、台阶覆盖率高的涂覆刻蚀片。实验结果表明, 超声雾化喷涂法可以很好地应用于三维结构表面涂覆, 克服了旋涂方法在三维结构应用中带来的缺陷, 同时有效地提高了光刻胶的利用率, 在集成电路 (IC) 制造和微电子机械系统 (MEMS) 工艺中有着广阔的应用前景。

关键词: 喷胶; AZ4620 光刻胶; 硅通孔 (TSV); 胶颗粒粒径; 台阶覆盖率

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Spray Coating Technique for the Thick Photoresist
on Structured Wafers

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Abstract: With the through silicon vias (TSV) etched silicon wafer as the substrate, the ultrasonic atomizing spraying technique was used to form a film with AZ4620 photoresist on the surface of a 12 inch (1 inch = 2.54 cm) structured wafer. The influences of process parameters, such as the dilution mass ratio, ultrasonic power, volume flow of N₂, the distance between the nozzle and wafer, chuck temperature, etc on the spraying quality of the TSV silicon wafer surface were investigated. Finally, through the optimization of the process parameters, the coating etched wafer with fine surface photoresist particles, good film uniformity and high step coverage rate was obtained. The experiment result shows that the ultrasonic atomizing spraying technique can be well used for surface coating on the three dimensional structure, which overcomes the defects induced by spin coating for the three dimensional structure and effectively improves the utilization ratio of the photoresist, having a broad application prospect in the field of the integrated circuit (IC) production and the process of the micro electromechanical system (MEMS).

Key words: spray coating; AZ4620 photoresist; through silicon vias (TSV); photoresist particle diameter; step coverage

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