

旋涂法制备量子点 LED 功能层材料的研究进展

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摘要: 综述了采用旋涂法制备的量子点发光二极管 (QLED) 中各功能层材料的研究进展, 对可旋涂制备的多种载流子注入层和传输层材料的特性及应用进行了对比总结。多项研究表明: 对于电子传输层(ETL), ZnO 和 TiO₂ 等无机金属氧化物材料在电子迁移率及器件可靠性方面都要优于有机材料; 对于空穴传输层(HTL), 则是具有较高空穴迁移率及成膜质量好的聚[双(4-苯基)(4-丁基苯基)胺] (Poly TPD)、聚(9-乙烯咔唑) (PVK) 等有机聚合物材料应用更为广泛; 而 MoO_x 和 WO_x 等无机金属氧化物材料则由于其能级匹配和可靠性方面的优势更多用于空穴注入层。随着技术的成熟及 QLED 应用中对高效率和高可靠性的要求, 无机金属氧化物材料在 QLED 中的应用将越来越广泛, 结合成本低廉的旋涂法, 将有力地推动 QLED 的商业化。

关键词: 量子点发光二极管 (QLED); 旋涂法; 电子传输层(ETL); 空穴传输层(HTL); 电子迁移率; 空穴迁移率

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Research Progress on Functional Layer Materials of Quantum

Dot LEDs Fabricated by the Spin Coating Method

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Abstract: The research progress on each functional layer material of quantum dot light emitting diodes (QLEDs) fabricated by the spin coating method are reviewed. The characteristics and applications of various materials for carrier injection layers and transport layers prepared by spin coating are compared and summarized. Numerous studies show that the inorganic metal oxide materials (ZnO, TiO₂, etc) are superior to organic materials in the electron mobility and device reliability as the electron transport layer (ETL), and the organic polymer materials (poly [double(4-phenyl)(4-butyl phenyl)amine] (Poly TPD), poly(9-vinyl carbazole) (PVK), etc) with higher hole mobility and better film quality are more widely used as the hole transport layer (HTL). Moreover, a few inorganic metal oxide materials such as MoO_x and WO_x, etc are widely used as the hole injection layer due to their better energy level matching and higher reliability. With the technology maturity and the demands of higher efficiency and higher reliability in QLEDs applications, inorganic metal oxide materials prepared by low cost spin coating method will become more and more widespread, which will promote the commercialization of QLEDs.

Key words: quantum dot light emitting diode (QLED); spin coating method; electron transport layer (ETL); hole transport layer (HTL); electron mobility; hole mobility

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Pt/Yb₂O₃/Pt 的阻变性质

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摘要: 采用电子束蒸发的方法制备了 Yb 薄膜, 对这些样品在不同条件下进行退火, 得到 Yb₂O₃ 薄膜。用热蒸发法在衬底和薄膜表面分别制备了 Pt 电极, 用原子力显微镜 (AFM) 观察了薄膜的表面形貌, 发现随着退火时间延长和退火温度升高, 薄膜的表面粗糙度增加。采用电流-电压法研究了 Pt/Yb₂O₃/Pt 结构的阻变性质。研究发现, 阻变性质与制备薄膜的衬底温度和后期退火温度有直接关系。用不同的电流原理仔细分析电流性质之后发现, 制备的薄膜内部有一定的缺陷, 出现阻变现象, 这些薄膜的缺陷态决定了阻变性质。如果选择合适的条件, Yb₂O₃ 可以作为阻变存储器薄膜。

关键词: Yb₂O₃ 薄膜; 阻变存储器(RRAM); 阻变性质; 稀土氧化物, 电流-电压法

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Resistive Switching Property of Pt/Yb₂O₃/Pt

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Abstract:The Yb thin films were prepared with the electron beam evaporation method. The samples were annealed at different conditions to obtain Yb₂O₃ films. The Pt electrodes were prepared on the substrate and the surface of the film by the thermal evaporation method, respectively. The surface morphology of the film was observed by the atomic force microscopy (AFM). It is found that the surface roughness of the film increases with the increases of the annealing time and annealing temperature. The resistive switching properties of the Pt/Yb₂O₃/Pt structure were studied by the current voltage method. The research result shows that the resistive switching property is directly related to the substrate temperature of the film preparation and the later annealing temperature. The properties of the current were carefully analyzed by different current principles. It is found that there are some defects inside the prepared films, which form the phenomenon of resistive switching, and the defect state of these films determines the resistive switching property. If the appropriate conditions are selected, Yb₂O₃ can be used as a resistive switching memory film.

Key words:Yb₂O₃ film; resistance random access memory(RRAM); resistive switching property; rare earth oxide; current voltage method

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碳纳米管在气敏传感器应用中的研究进展

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摘要: 以具有大的表面积及特殊的中空结构的碳纳米管(CNT)作为气敏传感器敏感层材料为基础, 介绍了CNT在开发不同类型气敏传感器技术方面的最新进展。综述了CNT及以贵金属、金属氧化物、聚合物改性的CNT作为气敏传感器材料的研究现状, 并以气敏传感器的灵敏度和响应速度为标准, 对比了CNT与三种CNT复合材料作为气敏传感器敏感层的优缺点。总结了每种传感器的设计方法、制作工艺和传感机理, 提出了CNT气敏传感器当前面临的技术挑战, 并对以后CNT作为气敏传感器材料的发展进行展望。

关键词: 碳纳米管(CNT); 气敏传感器; 贵金属; 金属氧化物; 聚合物

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Research Progress of Carbon Nanotubes in the Application of Gas Sensors

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Abstract:Based on the carbon nanotubes (CNTs) with large surface area and special hollow structure as sensitive layer materials of gas sensors, the latest progresses of CNTs in the technology development of different types of gas sensors are introduced. Then the research status of CNTs and CNTs modified by the precious metal, metal oxide and polymer as materials of gas sensors are summarized. Besides, the advantages and disadvantages of CNTs and three kinds of CNTs composite materials as sensitive layers of gas sensors are compared with the sensitivity and response speed of the gas sensor as the standard. The design method, fabrication process and sensing mechanism of each of these sensors are summarized. The current technical challenges of the CNTs gas sensors are proposed and the future development of CNTs as materials of gas sensors is prospected.

Key words:carbon nanotube(CNT) ; gas sensor; precious metal; metal oxide; polymer

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基片集成波导式高温压力传感器的制备与测试

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摘要: 提出了一种新的无线无源高温压力传感器结构, 该传感器的结构主要由含有内置空腔的基片集成圆波导 (SICW) 谐振器和集成于波导上金属面的缝隙天线两部分组成。共面波导天线 (CPW) 发出的频率电磁信号通过缝隙天线耦合到传感器内部, 并经由缝隙天线反馈到共面波导天线。当外部压力作用于传感器的空腔上表面时, 传感器的有效介电常数发生变化, 从而导致传感器的谐振频率发生变化。传感器的试样通过高温共烧陶瓷 (HTCC) 微组装工艺与丝网印刷技术相结合进行制备。实验过程中, 共面波导天线与网络分析仪进行连接, 通过网络分析仪对天线的 S11 参数进行测试, 进而可以从频率曲线中对传感器的谐振频率进行提取。通过对制备的传感器进行不同温度下的压力测试, 发现提出的压力传感器在 800 °C 高温下仍然可以正常工作, 在 800 °C 时传感器的测试灵敏度为 0.1245 MHz/kPa。

关键词: 基片集成圆波导 (SICW); 高温共烧陶瓷 (HTCC); 无线无源; 高温压力传感器; 共面波导天线

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Preparation and Test of the High Temperature Pressure Sensor

Based on Substrate Integrated Waveguides

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Abstract:A new wireless passive high temperature pressure sensor structure was proposed. It was mainly composed of a substrate integrated circular waveguide (SICW) resonator with a built in cavity and a slot antenna integrated on the metal surface of the waveguide. The frequency electromagnetic signals from the coplanar waveguide antenna (CPW) coupled to the inside of the sensor and fed back to the coplanar waveguide antenna through the slot antenna. When the external pressure applied on the upper surface of the sensor cavity, the effective dielectric constant of the sensor changed, leading to the change of the resonant frequency of the sensor. The sample of the sensor was prepared by the high temperature co fired ceramics (HTCC) micro assembly process and the screen printing technique. During the experiment, the CPW antenna was connected with the network analyzer, and the S11 parameter of the antenna was tested by the network analyzer, then the resonant frequency of the sensor was extracted from the frequency curves. The pressure sensor was tested at different temperatures. It is found that the proposed pressure sensor can work well at the high temperature of 800 °C, and the test sensitivity of the sensor is 0.1245 MHz/kPa at 800 °C.

Key words:substrate integrated circular waveguide (SICW); high temperature co fired ceramics (HTCC); wireless passive; high temperature pressure sensor; coplanar waveguide antenna

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高 g 微机械加速度传感器芯片盖帽封装设计

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摘要: 为了提高高 g 微机械加速度传感器在极端恶劣环境中应用的可靠性,根据自制的高 g 微机械加速度传感器芯片,研究设计了一种新型“台阶式”传感器芯片的盖帽封装结构。利用圆片级键合工艺和有限元分析(FEA)方法确定了盖帽封装结构材料与尺寸的设计方案。优化微电子机械系统(MEMS)加工工艺流程完成对盖帽封装结构的加工,并通过数字电子拉力机对实现圆片级盖帽封装的传感器芯片进行键合强度测试。测试结果表明,键合强度为 35 000 kPa,远大于抗过载封装设计要求下的键合强度值(401 2 kPa),证明了盖帽封装结构设计的可行性和可靠性。

关键词: 微机械; 盖帽封装; 有限元分析(FEA)方法; 圆片级; 键合强度

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Design of the Cap Package of High g Micromachine
Acceleration Sensor Chips

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Abstract: In order to improve the reliability of high g micromachine acceleration sensors in extreme environments, a new cap package structure of the sensor chip with "stairs type" was researched and designed based on the home made high g micromachine acceleration sensor chip. The design schemes of the cap packaging material and dimension were determined by using the wafer level bonding process and finite element analysis(FEA) method. The process flow of the micro electromechanical system (MEMS) was optimized to complete the processing of the cap package structure. The bonding strength test of the sensor chip with wafer level cap package was completed by the digital rally. The test results show that the bonding strength is 35 000 kPa and is much larger than the bonding strength value (401 2 kPa) under anti overload packaging design requirements. The feasibility and reliability of the new cap package structure were proved.

Key words: micromachine; cap package; finite element analysis(FEA) method; wafer level; bonding strength

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一种挡板结构被动式微混合器的设计与仿真

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摘要: 基于在微通道内设置障碍物可以提高混合效率的方法, 以 T 型方波通道微混合器为基础, 设计了一种新型的、具有挡板结构的被动式微混合器, 并采用有限元方法建立了仿真模型, 分析比较了 T 型直通道微混合器、T 型方波通道微混合器和具有挡板结构的 T 型方波通道微混合器在不同雷诺数 (Re) 下器件内流体的流动特性和混合效率。研究表明, 具有挡板结构的 T 型方波通道微混合器在挡板阻塞比为 1/4 时具备最优的综合性能, 也即在较宽 Re 值范围 (5~60) 内可实现流体的快速、高效混合, 混合效率高于 95%。

关键词: 微混合器; 混合效率; 挡板; 雷诺数; 有限元方法

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Design and Simulation of a Passive Micromixer with Baffle Structure

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Abstract: Based on the method of setting obstacles in the microchannel to improve mixing efficiency, a new type of passive micromixer with baffle structure based on a T type square wave channel micromixer was designed and the simulation model was established by the finite element method. The flow characteristics and mixing efficiencies of the fluids of the T type straight channel micromixer, T type square wave channel micromixer and T type square wave channel micromixer with baffle structure were analyzed and compared at different Reynolds numbers (Re). The research results show that the T type square wave channel micromixer with baffle structure has the best comprehensive performance at the baffle blockage ratio of 1/4, in which case, the fluids can be quickly and efficiently mixed in a wide range of Re values (5-60) with a mixing efficiency of greater than 95%.

Key words: micromixer; mixing efficiency; baffle; Reynolds number; finite element method

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自供能传感器能量采集技术的研究现状

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摘要: 归纳了国内外自供能微电源技术的研究现状, 阐述了环境能量采集技术结构设计与能量转换机理。当前能量采集器主要依靠特殊功能材料完成能量转换, 耦合方式包括: 压电效应、磁致伸缩效应、摩擦发电效应、热释电效应、静电效应、光电效应等。能量来源包括: 振动机械能、磁场能、摩擦能、温差能、风能、海洋能和太阳能等。能量采集器的结构形式有单一能量转换和复合能量转换等。为了提高能量采集装置的发电性能, 研究重点是结构优化设计、换能材料改性、降低储能电路自损耗等。自供能微电源未来的发展趋势包括增强环境自适应能力、改进自供电能量转换效率、加快实用化步伐等。

关键词: 能量采集技术; 低功耗系统; 环境能源; 微机电系统(MEMS); 微电源

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Research Status of the Self Powered Sensor Energy

Harvesting Technology

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Abstract: The research status of the self powered micro power technology at home and abroad is summarized, and the structural design and energy conversion mechanism of the environmental energy harvesting technology are expounded. The energy harvester mainly depends on the special functional materials to realize the energy conversion. The main coupling modes include the piezoelectric effect, magnetostrictive effect, triboelectric effect, pyroelectric effect, electrostatic effect, photoelectric effect and so on. The energy sources include the vibration mechanical energy, magnetic field energy, friction energy, temperature difference energy, wind energy, ocean energy, solar energy and so on. The structures of the energy harvester usually are the single and composite energy conversion forms. In order to improve the power generation performances of energy harvesting devices, the structural optimization design, modification of transducer materials, self loss reduction of energy storage circuits and so on are mainly researched. The future development trends of the self powered micro power include enhancing the environment self adaptability, improving the conversion efficiency of self powered energy, accelerating the practical process and so on.

Key words: energy harvesting technology; low power consumption system; ambient energy; micro electromechanical system (MEMS); micro power

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基于双拱形结构的压电-摩擦复合纳米发电机

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摘要: 提出了一种基于双拱形结构的压电-摩擦复合纳米发电机的制备方法, 利用锆钛酸铅(PZT)颗粒/碳纳米管(CNT)/聚二甲基硅氧烷(PDMS)形成的混合压电薄膜与铝电极作为压电层; 利用倒模工艺形成带有均匀梯形微结构的 PDMS 薄膜, 与铝电极形成摩擦层, 其中, 中间铝电极为共享电极。同时, 通过聚对苯二甲酸乙二醇酯(PET)膜实现双拱形结构, 使压电层与摩擦层能够协同工作, 提高输出电性能。研究表明, 采用双拱形结构的复合纳米发电机, 其压电单元的开路电压和短路电流值分别增加了 52.7% 和 34.1%; 摩擦单元的开路电压和短路电流值分别增加了 75.2% 和 43.2%。压电单元和摩擦单元整流后混合输出的电能能够点亮 10 盏 LED 灯, 存储在电容中能够为液晶显示屏(LCD)的正常工作提供电能。因此, 该复合纳米发电机能够作为绿色能源供给器件被广泛应用。

关键词: 压电纳米发电机; 摩擦纳米发电机; 双拱形结构; 复合机制; 整流

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A Piezoelectric Triboelectric Hybrid Nanogenerator

Based on the Double Arched Structure

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Abstract:A fabrication method of a piezoelectric triboelectric hybrid nanogenerator based on the double arched structure was presented. The piezoelectric layer was composed of the aluminum electrode and the hybrid piezoelectric film formed with $\text{PbZr}_{0.52}\text{Ti}_{0.48}\text{O}_3$ (PZT) particles, carbon nanotubes (CNTs) and polydimethylsiloxane (PDMS). The triboelectric layer was made of the aluminum electrode and the PDMS film with the uniform trapezoid body micro structures formed by the reverse mould technology. Among them, the middle aluminum electrode was the shared electrode. Meanwhile, the double arched structure was achieved by poly ethylene terephthalate (PET) film to realize the cooperative work between the piezoelectric layer and triboelectric layer and increase the output electrical performances. The study results show that for the hybrid nanogenerator with the double arched structure, the open circuit voltage and short circuit current of the piezoelectric unit increase by 52.7% and 34.1%, respectively. Correspondingly, the open circuit voltage and short circuit current of the triboelectric unit increase by 75.2% and 43.2%, respectively. The mixed output electrical energy of the rectified piezoelectric and triboelectric units can light up 10 LED lights, and can be stored in the capacitors to provide the electrical energy for normal working of the liquid crystal display (LCD). Therefore, the hybrid nanogenerator can be widely used as a green energy supply device.

Key words:piezoelectric nanogenerator;triboelectric nanogenerator; double arched structure; hybrid mechanism; rectification

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应用于蓝宝石直接键合的减薄抛光工艺

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摘要: 蓝宝石晶片的总厚度差 (TTV) 和表面粗糙度是影响蓝宝石键合成败的关键因素。研究了减薄抛光工艺对蓝宝石衬底的作用机理, 结合实际加工要求选择不同粒径磨料组合和适当的压力条件对蓝宝石晶片进行减薄。之后对减薄后的蓝宝石晶片进行抛光, 通过控制抛光液流速、抛光盘转速、抛光压力得到了低 TTV、低表面粗糙度的蓝宝石晶片。采用测厚仪测量了减薄前后蓝宝石晶片五点不同位置的厚度, 得到了其 TTV 值; 采用原子力显微镜 (AFM) 得到抛光后晶片表面粗糙度, 并且研究了不同工艺条件对减薄抛光速率的影响。最后通过蓝宝石直接键合验证了减薄抛光工艺参数的合理性。

关键词: 蓝宝石; 减薄抛光; 总厚度差 (TTV); 粗糙度; 键合

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Thinning and Polishing Technology for Sapphire Direct Bonding

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Abstract: The total thickness variation (TTV) and surface roughness of the sapphire wafer are the key factors affecting the success or failure of sapphire bonding. The effect mechanism of the thinning and polishing process on the sapphire substrate was studied. The sapphire wafers were thinned according to the actual processing requirements by choosing abrasive combinations with different particle sizes and appropriate pressure conditions. Then the thinned sapphire wafer was polished by controlling the flow rate of the polishing solution, the polishing pad speed and the polishing pressure to obtain the sapphire wafer with low TTV and low surface roughness. The thicknesses of five positions on the sapphire wafer before and after thinning were measured by the thickness gauge, and the TTV value was obtained. The surface roughness of the polished wafer was obtained by the atomic force microscope (AFM). The effects of different processing conditions on the thinning and polishing rate were also studied. Finally, the reasonability of thinning and polishing process parameters was verified by the direct bonding of the sapphire.

Key words: sapphire; thinning and polishing; total thickness variation (TTV); surface roughness; bonding

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可延展电子 Peano 型通用互连结构对角
拉伸延展性分析

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摘要: 运用分形几何学设计了可双轴拉伸的 Peano 型通用互连结构。运用能量法推导了一阶 Peano 型通用互连结构对角方向的拉伸与弯曲位移。根据一阶 Peano 型与二阶 Peano 型的分形几何关系, 推导了二阶 Peano 型通用互连结构对角拉伸刚度。通过数值计算结果与有限元仿真结果进行对比验证, 两者吻合良好。分析表明: 对于 Peano 型通用互连结构在对角拉伸的情况下, 其圆弧的开口与半径越大, 同时在直线段与斜线段不影响应力集中的前提下, 适当提高直线段和斜线段的长度, 其互连结构的延展性越好。

关键词: 可延展电子; 拉伸刚度; 弯曲刚度; Peano 型分形几何学; 通用互连结构

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Diagonal Tensile Ductility Analysis of a Peano Type General
Interconnection Structure for Stretchable Electronics

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Abstract: A Peano type general interconnect structure with biaxial stretch was designed by the fractal geometry. The displacements of stretch and bend of the first order Peano type general interconnection structure at diagonal direction were derived by the energy method. According to the relationship between the first order Peano type fractal geometry and second order one, the diagonal tensile stiffness of the second order Peano type general interconnection structure was deduced. By comparison and verification of the numerical calculation result and finite element simulation result, both are in good agreement. The analysis shows that in the case of the diagonal stretch for the Peano type general interconnection structure, when the line segment and oblique line segment do not affect the accumulation of stress, the length increases of the line segment and oblique line segment can improve the ductility of the interconnection structure, the larger the arc opening and radius are, the better the interconnection structure ductility is.

Key words: stretchable electronics; tensile stiffness; bending stiffness; Peano type fractal geometry; general interconnection structure

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InP 微透镜的设计与制作

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摘要: 高速光电探测器采用芯片背面带微透镜的背入射结构, 利用微透镜对光的汇聚提高芯片与光纤的耦合效率。软件模拟发现, 光敏面直径为 $30\ \mu\text{m}$ 的芯片采用背入射结构时, 其等效光敏面直径大于 $50\ \mu\text{m}$, 并且透镜拱高为 $8\sim 15\ \mu\text{m}$ 时, 能更好实现对光的汇聚。对于 InP 微透镜的制作, 首先要制作出透镜形状的光刻胶胶型, 然后通过电感耦合等离子体(ICP)刻蚀将光刻胶图形转移到 InP 衬底上。光刻胶坚膜温度与坚膜时间对光刻胶形成透镜形状有很大影响。通过优化条件, $150\ ^\circ\text{C}$ 坚膜 3 min 的光刻胶呈规则透镜形状, 并且表面光滑无褶皱。通过调节反应离子刻蚀(RIE)功率和 ICP 功率找到了合适的 InP 刻蚀速率, 调节 Cl_2 和 BCl_3 的体积流量比改变了 InP 和光刻胶的刻蚀选择比, 从而制作出不同拱高的微透镜。

关键词: 微透镜; 高速光电探测器; 磷化铟(InP); 胶型; 电感耦合等离子体 (ICP) 刻蚀

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Design and Fabrication of an InP Microlens

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Abstract: A back illuminated structure with microlens on the back of the chip was used in the high speed photodetector, the coupling efficiency between the chip and fiber was improved by light convergence with the microlens. The software simulation shows that when the back illuminated structure was used in the chip with photosensitive surface with a diameter of $30\ \mu\text{m}$, the diameter of the equivalent photosensitive surface is larger than $50\ \mu\text{m}$ and the arch height of lens is $8\sim 15\ \mu\text{m}$, then the light can converge better. For the fabrication of the InP microlens, the shape of the lens shaped photoresist was fabricated at first, then the photoresist pattern was transferred on the InP substrate by inductively coupled plasma (ICP) etching. The hardening temperature and hardening time of the photoresist have a great influence on the formation of the lens shaped photoresist. Through the optimization of conditions, the photoresist is a regular lens shape after hardening at $150\ ^\circ\text{C}$ for 3 min, and the surface is smooth and no fold. The proper InP etching rate was found by adjusting the reactive ion etching (RIE) power and ICP power, and the etching selectivity of the InP and photoresist can be changed by adjusting the volume flow ratio of Cl_2 and BCl_3 , thus the microlens with different arch heights were fabricated.

Key words: microlens; high speed photodetector; indium phosphide(InP); photoresist shape; inductively coupled plasma (ICP) etching

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