

金刚石半导体材料和器件的研究现状

陈亚男^{1a,1b,2}, 张焯^{1a,1b,2}, 郁万成^{1a,1b,2}, 龚猛^{1a,1b,2}, 杨霏³,
刘瑞³, 王嘉铭³, 李玲³, 金鹏^{1a,1b,2}, 王占国^{1a,1b,2}

(1.中国科学院 半导体研究所 a.半导体材料科学重点实验室; b.低维半导体材料与器件北京市重点实验室, 北京 100083;2.中国科学院大学 材料科学与光电技术学院, 北京 101408; 3.全球能源互联网研究院, 北京 102211)

摘要: 简述了金刚石半导体材料的主要制备方法, 以及掺杂技术及其在器件制备中应用的研究现状。重点介绍了微波等离子体化学气相沉积(MPCVD)法制备高质量金刚石的优势以及在生长速率、晶体尺寸和晶体质量等方面的研究进展及阻碍因素, 并探讨了实现金刚石大尺寸高质量生长的方法。通过对金刚石进行掺杂, 可使其呈现p型和n型导电。总结了金刚石p型、n型掺杂及共掺杂的研究现状, 并分析了金刚石在掺杂过程中出现的问题, 探讨了p型掺杂和n型掺杂的研究方向。最后给出了金刚石在电力电子器件、探测器和场发射器件中的应用现状, 并对金刚石的未来发展方向作出了展望。

关键词: 金刚石; 迁移率; 微波等离子体化学气相沉积(MPCVD); 掺杂; 器件

中图分类号: TN304.18 文献标识码: A 文章编号: 1671-4776(2017)04-0217-12

Research Status of the Diamond Semiconductor

Materials and Devices

Chen Ya'nan^{1a,1b,2}, Zhang Ye^{1a,1b,2}, Yu Wancheng^{1a,1b,2}, Gong Meng^{1a,1b,2},
Yang Fei³, Liu Rui³, Wang Jiaming³, Li Ling³, Jin Peng^{1a,1b,2}, Wang Zhanguo^{1a,1b,2}

(1.a.Key Laboratory of Semiconductor Materials Science; b.Beijing Key Laboratory of Low Dimensional Semiconductor Materials and Devices, Institute of Semiconductors, Chinese Academy of Sciences, Beijing 100083, China; 2. College of Materials Science and Opto Electronic Technology, University of Chinese Academy of Sciences, Beijing 101408, China; 3.Global Energy Interconnection Research Institute, Beijing 102211, China)

Abstract: The main preparation method of the diamond semiconductor material, the research status of doping techniques and their application in the device fabrication are briefly described. The advantages of the microwave plasma chemical vapor deposition (MPCVD) method for high quality diamond preparation are mainly presented. The research advances and obstacles about the growth rate, growth size and quality of diamond are introduced, and some methods to obtain large size high quality diamond semiconductor materials are discussed. Besides, the diamond can show p type and n type conductivity through doping. The research statuses of p type doping, n type doping and co doping for diamond are summarized. The problems in the doping of diamond are analyzed, and the research trends of the p type doping and n type doping are discussed. Finally, the application statuses of diamond semiconductor in the fields, such as power electronic devices, detectors and field emission devices, are introduced, and the future development directions of diamond are prospected.

Key words: diamond; mobility; microwave plasma chemical vapor deposition(MPCVD); doping; device

DOI:10.13250/j.cnki.wndz.2017.04.001EEACC:2520C

用于 FET 的 PECVD SiNx 掺杂 MoS₂ 的有效性可控性

战俊 1,2, 粟雅娟 1, 罗军 1, 贾昆鹏 1, 段宁远 1,2, 闫祥宇 1,2

(1.中国科学院 微电子研究所 微电子器件与集成技术重点实验室, 北京 100029;
2.中国科学院大学, 北京 100049)

摘要: 通过化学气相沉积(CVD)工艺成功生长出少层 MoS₂ 薄膜, 用 Raman 光谱仪对材料进行表征, 验证了三层 MoS₂ 材料的存在。基于 CVD 生长出的三层 MoS₂ 薄膜材料完成了背栅场效应晶体管(FET)的制造工艺研发。对 MoS₂ FET 器件进行了电学特性表征, 研制的 MoS₂ FET 器件的开关比可达到 1.45×10^6 , 器件的电子载流子场效应迁移率约为 $1 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ 。对等离子增强化学气相沉积(PECVD)氮化硅(SiNx)工艺掺杂 MoS₂ 材料进行了研究, 掺杂后器件的驱动电流提高了 3 倍多, 验证了 SiNx 掺杂 MoS₂ 材料的有效性。通过控制 PECVD SiNx 时间工艺参数对 SiNx 薄膜厚度与掺杂浓度的关系进行了研究, 随着 SiNx 薄膜厚度增加器件的驱动电流逐渐增强, 验证了 SiNx 掺杂 MoS₂ 材料的可控性。最后, 对 PECVD SiNx 工艺掺杂 MoS₂ 材料的机理进行了讨论。

关键词: 二硫化钼场效应晶体管(MoS₂ FET); 掺杂; 二维(2D)半导体材料; 过渡金属硫化物(TMD); 等离子体增强化学气相沉积(PECVD)

中图分类号: TN386; TN305.3 文献标识码: A 文章编号: 1671-4776(2017)04-0229-06

Effectiveness and Controllability of SiNx Doped MoS₂ by PECVD for FETs

Zhan Jun^{1,2}, Su Yajuan¹, Luo Jun¹, Jia Kunpeng¹, Duan Ningyuan^{1,2}, Yan Xiangyu^{1,2}

(1.Key Laboratory of Microelectronics Devices and Integrated Technology, Institute of Microelectronics, Chinese Academy of Science, Beijing 100029, China; 2.University of Chinese Academy of Science, Beijing 100049, China)

Abstract: Few layers molybdenum disulfide (MoS₂) film was successfully synthesized by the chemical vapor deposition (CVD) process, and was characterized by the Raman spectrometer. The MoS₂ film is 3 layers. Based on the 3 layer MoS₂ film synthesized by the CVD, the fabrication process of the back gate field effect transistor (FET) was successfully developed. The electrical properties of the MoS₂ FET were characterized. The on/off ratio and electronic carrier field effect mobility of the obtained device can reach 1.45×10^6 and about $1 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$, respectively. The MoS₂ material doped by the plasma enhanced chemical vapor deposition (PECVD) silicon nitride (SiNx) process was researched. The driven current of the device after doping increases by more than 3 times, validating the effectiveness of the MoS₂ material doped by SiNx. By controlling the time parameters of the PECVD SiNx process, the relation between the SiNx film thickness and doping concentration was studied. With the increase of the SiNx film thickness, the driven current of the device is enhanced gradually, validating the controllability of the MoS₂ material doped by SiNx. Finally, the mechanism of the MoS₂ doped material by PECVD SiNx process was discussed.

Key words: molybdenum disulfide field effect transistor (MoS₂ FET); doping; two dimensional (2D) semiconductor material; transition metal dichalcogenide (TMD); plasma enhanced chemical vapor deposition (PECVD)

DOI:10.13250/j.cnki.wndz.2017.04.002EEACC:2560S; 2550B

全固态量子点太阳能电池的研究进展

杨博, 白一鸣, 程泰, 吴高, 陈诺夫, 谭占鳌

(华北电力大学 新能源电力系统国家重点实验室, 北京 102206)

摘要: 从光电转换原理出发, 阐述了全固态量子点太阳能电池的一般结构与工作机理, 并展示了电池所用材料的能带结构和载流子迁移过程。然后围绕半导体 p-n 结模型描述了量子点太阳能电池的工作特性及重要的性能参数, 进而系统地介绍了电池各功能层的常用制备方法。在此基础上, 对 PbS 和 Sb₂S₃ 两种材料体系的量子点太阳能电池的国内外研究进展进行了全面的回顾, 从器件结构的优化到材料制备工艺的完善, 再到各种量子点表面修饰方法的采用, 总结了这两种量子点太阳能电池的发展过程与最新成果, 并分析了目前阻碍其发展的重要因素, 最后对全固态量子点太阳能电池的前景进行了展望。

关键词: 量子点; 全固态; 太阳能电池; PbS; Sb₂S₃

中图分类号: TM914.4 文献标识码: A 文章编号: 1671-4776(2017)04-0235-08

Research Progress of All Solid State Quantum

Dot Solar Cells

Yang Bo, Bai Yiming, Cheng Tai, Wu Gao, Chen Nuofu, Tan Zhan'ao

(State Key Laboratory of Alternate Electrical Power System with Renewable Energy Sources, North China Electric Power University, Beijing 102206, China)

Abstract: Based on the principle of photoelectric conversion, the general structure and working mechanism of the all solid state quantum dot solar cells are demonstrated, and the energy band structures and carrier transport processes of the materials used in all solid state quantum dot solar cells are shown. Then, a semiconductor p-n junction model is used to describe the operating characteristics and important performance parameters of the quantum dot solar cells, and the common preparation methods of each function layer are systematically introduced. On this basis, from the device structure optimization to the improvement of the material preparation process and the adoption of the various quantum dot surface modification methods, the domestic and overseas research progresses of the PbS and Sb₂S₃ quantum dot solar cells are comprehensively reviewed. Then the development processes and latest achievements of them are summarized, and the important factors to hinder their developments are analyzed. Finally, the prospects of the all solid state quantum dot solar cells are expected.

Key words: quantum dot; all solid state; solar cell; PbS; Sb₂S₃

DOI:10.13250/j.cnki.wndz.2017.04.003EEACC:8420

空心碳纳米球在锂离子电池中的性能

黄求来,罗海东

(湖南中移通信技术工程有限公司, 长沙 410000)

摘要: 为了探究高性能的锂电池负极新型碳基材料, 通过高温退火碳包铜纳米颗粒材料制备得到空心碳纳米球, 该材料的平均粒径为 20 nm, 这比其他空心碳球的平均粒径都要小, 碳层厚度为 1~3 nm, 喇曼强度比值为 1/06, 比表面积为 300 m²·g⁻¹。空心碳纳米球作为锂电池负极材料表现出出众的电化学性能, 在 186 mA·g⁻¹ 的电流密度下比容量达到 400 mA·h·g⁻¹, 在不同的电流密度下具有良好的比容量, 循环 100 次的容量保持率为 100%, 这些优异的电化学性能与空心碳纳米球的高比表面积、空心结构和非常小的粒径有关, 这些结果表明空心碳纳米球是一种具有潜力的锂电池负极材料。

关键词: 锂离子电池; 空心碳纳米球; 化学气相沉积 (CVD) 法; 负极材料; 电化学性能

中图分类号: TB383 文献标识码: A 文章编号: 1671-4776(2017)04-0243-06

Properties of Hollow Carbon Nanospheres in

Lithium Ion Batteries

Huang Qiulai, Luo Haidong

(Hunan Zhongyi Communication Technology Engineering Co., Ltd., Changsha 410000, China)

Abstract: For the exploration of the novel carbon based anode materials for lithium batteries with good performances, the hollow carbon nanospheres were obtained by high temperature annealing the Cu/C core-shell nanoparticles. The average particle size of the hollow carbon nanospheres is 20 nm and smaller than that of other hollow carbon spheres. The thickness of the carbon layer is 1-3 nm, the Raman intensity ratio is 1/06, and the specific surface area is 300 m²·g⁻¹. The hollow carbon nanospheres exhibit superior electrochemical performances used as anode materials for lithium batteries. The specific capacity reaches 400 mA·h·g⁻¹ at the current density of 186 mA·g⁻¹. There are still good specific capacities at different current densities, and the capacity retention rate is 100% after 100 cycles. The excellent electrochemical properties of the hollow carbon nanospheres are related to the high specific surface area, hollow structure and very small particle size. These results indicate that the hollow carbon nanosphere is a promising anode material for lithium batteries.

Key words: lithium ion battery; hollow carbon nanosphere; chemical vapor deposition (CVD) method; anode material; electrochemical property

DOI:10.13250/j.cnki.wndz.2017.04.004PACC:6146

利用光波导谐振腔替代长光纤的光电振荡器

陈猛, 钱坤, 唐军, 刘文耀, 郑永秋

(中北大学 仪器科学与动态测试教育部重点实验室, 太原 030051)

摘要: 提出了一种利用光学谐振腔代替长光纤作为光电振荡器系统延时器件, 以提高微波品质因子的方案。此方案中, 光子可以在谐振腔中多次循环传播, 2 英寸 (1 英寸=2.54 cm) 的平面光波导谐振腔, 最高可以使系统产生 1.923 ns 的延时、输出频谱宽度为 0.52 MHz 的微波信号, 微波的品质因子达 12 077, 光学谐振腔的延时效果等效于 388.7 m 长光纤。通过在系统中加入光波导谐振腔, 产生了 1.2 GHz 的微波信号, 中心频率 1.2 GHz 处其相位噪声为 -93 dBc/Hz@10 kHz。此方案的优势在于: 使用光学谐振腔代替长光纤作为光电振荡器的延时器件时, 可以减小长光纤容易受外界环境温度和应力等的影响, 降低微波信号的相位噪声。

关键词: 光电振荡器; 光学谐振腔; 延时效应; 相位噪声; 微波品质因子

中图分类号: TN752 文献标识码: A 文章编号: 1671-4776(2017)04-0249-05

Optoelectronic Oscillator Using an Optical Waveguide Resonant Cavity
Instead of the Long Optical Fiber

Chen Meng, Qian Kun, Tang Jun, Liu Wenyao, Zheng Yongqiu

(Key Laboratory of Instrumentation Science & Dynamic Measurement of Ministry of Education,
North University of China, Taiyuan 030051, China)

Abstract: A new method was proposed to improve the microwave quality factor by using optical resonant cavities instead of long optical fibers as the delay device of optoelectronic oscillators. In this scheme, the photons can be circularly transmitted in the resonant cavity for many times. A 2 inches (1 inch=2.54 cm) plane waveguide resonator cavity can make the system produce the optimal microwave signal with the photon delay of 1.923 ns and output spectrum width of 0.52 MHz. The microwave quality factor reaches 12 077, and the delay effect of the optical resonant cavity is equivalent to that of the 388.7 m long fiber. By adding an optical waveguide resonant cavity in the system, the 1.2 GHz microwave signal with the phase noise of -93 dBc/Hz@10 kHz at the center frequency of 1.2 GHz is generated. The advantages of this scheme are that using of optical resonant cavities instead of long optical fibers as the delay devices of optoelectronic oscillators can reduce the susceptibility of the long fiber to the environmental temperature and stress and decrease the phase noise of microwave signals.

Key words: optoelectronic oscillator; optical resonant cavity; time delay effect; phase noise; microwave quality factor

DOI:10.13250/j.cnki.wndz.2017.04.005EEACC:1230B

基于改进 PSO 算法优化 RF MEMS 功分器设计

回海生, 刘建霞, 梁军

(太原理工大学 信息工程学院, 太原 030024)

摘要: 为了实现对射频微电子机械系统(MEMS) 波段威尔金森功分器电路的精确设计和优化, 使达到的设计目标满足性能要求, 采用先进设计系统(ADS)软件对工作频段为 32~36 GHz 的 RF MEMS 功分器进行了建模仿真, 并得到初始的电路设计参数。通过使用结合柯西变异的改进的粒子群优化 (PSO) 算法对 RF MEMS 功分器的初始电路设计参数进行优化, 采用矩阵实验室 (MATLAB) 软件和高频结构仿真器 (HFSS) 软件进行联合仿真实现优化过程, 最终得到满足设计目标的 RF MEMS 功分器的性能曲线, 以及对应的功分器优化后的电路设计参数。结果表明, 优化后的 RF MEMS 功分器回波损耗比设计目标优化了 2~5 dB, 插入损耗优化了 0~3 dB, 隔离度达到了 -20 dB 的设计要求。最终通过仿真验证了改进的 PSO 算法能够快速有效地对 RF MEMS 功分器的电路参数进行优化达到 RF MEMS 功分器设计的性能要求。

关键词: 粒子群优化 (PSO) 算法; 射频微电子机械系统 (RF MEMS); 功分器; 先进设计系统 (ADS); 高频结构仿真器 (HFSS)

中图分类号: TH703; TN772 文献标识码: A 文章编号: 1671-4776(2017)04-0254-07

Design of the RF MEMS Power Divider Based on an Improved PSO Algorithm

Hui Haisheng, Liu Jianxia, Liang Jun

(College of Information Engineering, Taiyuan University of Technology, Taiyuan 030024)

Abstract: To realize the precise design and optimization of the Ka band RF micro electromechanical system (MEMS) Wilkinson power divider circuit and achieve the design goal to meet the performance requirements, the modeling and simulation of the RF MEMS power divider with the operating frequency band of 32-36 GHz were carried out by using the advanced design system(ADS) software, and the initial circuit design parameters were obtained. By using the improved particle swarm optimization (PSO) algorithm combined with Cauchy mutation, the initial circuit design parameters of the RF MEMS power divider were optimized. The optimization process was implemented by using matrix laboratory (MATLAB) software and high frequency structure simulator (HFSS) software joint simulation method. Finally, the performance curves for the design requirement of the RF MEMS power divider and the optimized circuit design parameters were obtained. The results show that the return loss of the optimized RF MEMS power divider is improved 2~5 dB, the insertion loss is improved 0~3 dB, and the isolation reaches the design requirement of -20 dB. Finally, the simulation results verify that the improved PSO algorithm can quickly and efficiently optimize the circuit parameters of the RF MEMS power divider, and achieve the required performances of the design of the RF MEMS power divider.

Key words: particle swarm optimization (PSO) algorithm; radio frequency micro electromechanical system (RF MEMS); power divider; advanced design system (ADS); high frequency structure simulator (HFSS)

DOI:10.13250/j.cnki.wndz.2017.04.006EEACC:2575

一种高 g 值压阻式加速度传感器

肖咸盛, 卞玉民

(中国电子科技集团公司 第十三研究所, 石家庄 050051)

摘要: 基于压阻效应, 利用微电子机械系统(MEMS)技术, 研制了一种可用于多领域的高 g 值加速度传感器。加速度传感器采用四端全固支八梁结构, 利用力学计算、ANSYS 仿真和工艺约束相结合的方法确定了结构参数。通过对压敏电阻的数量、结构和布放位置的分析与设计, 进一步减小了加速度传感器的横向灵敏度。采用硅-硅键合与共晶键合相结合工艺制作了圆片级气密封装的加速度传感器芯片, 并用塑封工艺实现了加速度传感器芯片的封装, 易于批量生产和工业应用。最后, 对加速度传感器的性能进行了测试, 结果表明灵敏度为 $1.5 \sim 2 \mu\text{V/g}$, 一阶固有频率大于 200 kHz, 在 $1.5 \times 10^5\text{g}$ 量程内正常并有效工作, 抗过载大于 $2.5 \times 10^5\text{g}$ 。

关键词: 高 g; 压阻效应; 加速度传感器; 微电子机械系统 (MEMS); 圆片级封装

中图分类号: TH824.4;TH703 文献标识码: A 文章编号: 1671-4776(2017)04-0261-07

A High g Piezoresistive Accelerometer

Xiao Xiansheng, Bian Yumin

(The 13th Research Institute, CETC, Shijiazhuang 050051, China)

Abstract: Based on the piezoresistive effect and micro electro mechanical system (MEMS) technology, a high g piezoresistive accelerometer used in many fields was researched. A four terminal fixed eight beam structure was adopted in the accelerometer. The structure parameters of the accelerometer were obtained through the mechanical calculation, ANSYS simulation and process constraint. The transverse sensitivity of the accelerometer is further reduced by the analysis and design of the number, structure and layout of the piezoresistances. The accelerometer chips with the wafer level hermetic packaging were fabricated by using a combined technology of Si-Si bonding and eutectic bonding, and the accelerometer dies were packaged by the plastic package process for batch production and industrial applications. Finally, the performances of the accelerometer were tested. The results show that the sensitivity is $1.5 \sim 2 \mu\text{V/g}$ and the first order inherent frequency is larger than 200 kHz. The accelerometer can work well in the measure range of $1.5 \times 10^5\text{g}$, and withstand the overload attack over $2.5 \times 10^5\text{g}$.

Key words: high g; piezoresistive effect; accelerometer; micro electromechanical system (MEMS); wafer level packaging

DOI:10.13250/j.cnki.wndz.2017.04.007EEACC:2575

4H SiC 中 Al 离子注入及其二次高温退火技术

郑柳, 潘艳, 夏经华, 刘瑞, 杨霏

(全球能源互联网研究院 功率半导体研究所, 北京 102209)

摘要: 在 4H SiC 中进行 Al 离子注入, 并进行了二次高温退火技术研究。样品中 Al 离子的注入浓度为 $3 \times 10^{19} \text{ cm}^{-3}$, 对样品进行首次高温退火工艺后, 在不同条件下对样品进行二次退火。退火后对样品进行霍尔测试和二次离子质谱(SIMS)测试。测试结果显示, 二次退火工艺有助于进一步提升 Al 离子在碳化硅中的有效电激活率。在 $1850 \text{ }^\circ\text{C}$ 下进行 3 min 首次退火后, 1#样品的有效空穴浓度只有 $3.23 \times 10^{17} \text{ cm}^{-3}$ 。在 $1850 \text{ }^\circ\text{C}$ 下进行 3 min 的二次退火后, 2#样品的有效空穴浓度增大到了 $6.4 \times 10^{18} \text{ cm}^{-3}$ 。同时二次退火导致了 Al 离子总剂量的降低, 二次退火时间越长, 温度越高, Al 离子总剂量降低越显著。

关键词: 4H SiC; Al 离子注入; 二次高温退火; 霍尔测试; 二次离子质谱(SIMS); 空穴浓度; 激活率

中图分类号: TN305.3; TN304.24 文献标识码: A 文章编号: 1671-4776(2017)04-0268-05

Al Ion Implantation in 4H SiC and Its Secondary High Temperature Annealing Technology

Zheng Liu, Pan Yan, Xia Jinghua, Liu Rui, Yang Fei

(Institute of Power Semiconductors, Global Energy Interconnection Research Institute, Beijing 102209, China)

Abstract: The Al ion implantation in 4H SiC was carried out and the secondary high temperature annealing technology was studied. The implantation concentration of Al ions in the samples are $3 \times 10^{19} \text{ cm}^{-3}$. After the first high temperature annealing process, the samples were treated by the secondary annealing in different conditions, and then they were characterized by Hall test and secondary ion mass spectrometry(SIMS) test. The testing results show that the secondary annealing process is helpful to further improve the effective electrical activation rate of Al ions in silicon carbide. The effective hole concentration of the sample 1# is only $3.23 \times 10^{17} \text{ cm}^{-3}$ after the first annealing process at $1850 \text{ }^\circ\text{C}$ for 3 min, and the effective hole concentration of the sample 2# increases to $6.4 \times 10^{18} \text{ cm}^{-3}$ after the secondary annealing process at $1850 \text{ }^\circ\text{C}$ for 3 min. At the same time, the secondary annealing process results in the decrease of the implanted Al ions total dose, which becomes more serious as the secondary annealing time is longer and the temperature is higher.

Key words: 4H SiC; Al ion implantation; secondary high temperature annealing; Hall test; secondary ion mass spectrometry(SIMS); hole concentration; activation rate

DOI:10.13250/j.cnki.wndz.2017.04.008EEACC:2550A

超临界 CO₂ 清洗技术在 CMOS 图像
传感器中的应用

黄洛俊^{1,2}, 康恒^{1,2}, 程嵩^{1,2}, 李勇滔^{1,3}, 夏洋^{1,3}, 景玉鹏^{1,3}

(1.中国科学院 微电子研究所, 北京 100029;2.中国科学院大学, 北京 100029;

3.集成电路测试技术北京市重点实验室, 北京 100088)

摘要: 针对传统去离子水和高纯氮气组合的两相流清洗方法对 CMOS 图像传感器上颗粒污染物清洗良率不足的问题, 采用了一种喷嘴式超临界二氧化碳(SSCO₂)清洗的方法来清洗 CMOS 图像传感器。相比传统的水气两相流清洗方法, 本方法利用了 SSCO₂ 的表面张力小、溶解度高和扩散能力强等优点。实验结果显示, 喷嘴式超 SSCO₂ 清洗方法对 CMOS 图像传感器的像素点表面以及像素点之间直径大于 300 nm 的颗粒污染物可以进行有效清除, 相对于传统的两相流清洗方法其清洗效果有明显的提高。该实验表明这种清洗方式在 CMOS 图像传感器清洗方面具有良好的应用前景。

关键词: 清洗; 超临界二氧化碳(SSCO₂); CMOS 图像传感器; 两相流; 颗粒污染物

中图分类号: TN305.97 文献标识码: A 文章编号: 1671-4776(2017)04-0273-06

Application of the Supercritical CO₂ Cleaning Technology in
CMOS Image Sensors

Huang LuoJun^{1,2}, Kang Heng^{1,2}, Cheng Song^{1,2}, Li Yongtao^{1,3}, Xia Yang^{1,3}, Jing Yupeng^{1,3}

(1.Institute of Microelectronics, Chinese Academy of Sciences, Beijing 100029, China;

2.University of Chinese Academy of Sciences, Beijing 100029, China;

3.Beijing Key Laboratory of IC Test Technology, Beijing 100088, China)

Abstract: The traditional two phase flow cleaning method combined deionized water with high purity nitrogen has some deficiencies in the removal of the particle contaminants on CMOS image sensors. To solve this problem, the CMOS image sensor was cleaned by the nozzle typed supercritical carbon dioxide (SSCO₂) cleaning method. Compared with the traditional water nitrogen two phase flow cleaning method, the SSCO₂ cleaning method has the unique properties, such as low surface tension, high solubility and diffusivity. The experiment result shows that the particle contaminants with a diameter of more than 300 nm from pixels and between pixels in the CMOS image sensors are effectively eliminated by the nozzle typed SSCO₂ cleaning method. Compared with the traditional two phase flow cleaning method, the cleaning effect of this method is improved obviously. The experiment shows that this method has a good application prospect in cleaning of CMOS image sensors.

Key words: cleaning; supercritical carbon dioxide(SSCO₂); CMOS image sensor; two phase flow; particle contaminant

DOI:10.13250/j.cnki.wndz.2017.04.009EEACC:2550

直流电压对无颗粒纳米银墨水 EHD

微喷行为的影响

邢博 1, 左春桢 1,2, 黄凤立 1, 鹿业波 1, 胡光山 1,
汤成莉 1, 张礼兵 1

(1. 嘉兴学院 机电工程学院, 浙江 嘉兴 314001;

2. 浙江工业大学 特种装备制造与先进加工技术教育部/浙江省重点实验室, 杭州 310000)

摘要: 研究了直流电压对无颗粒纳米银导电墨水在电流体动力 (EHD) 近场微喷印中喷射行为的影响。结果表明供墨压力和电极间距一定时, 随着直流电压增大, 喷嘴尖端弯液面拉长, 轮廓由曲面先后演变为脉动泰勒锥和稳定泰勒锥状。直流电压过大导致泰勒锥失稳倾斜。在不同弯液面形状下, 墨滴喷射方式依次为: 脉动微滴落、脉动锥射流、稳定锥射流、多股锥射流。在 1 500~3 500 V 内锥射流较稳定, 且该范围内随着直流电压升高, 泰勒锥高度减小, 锥尖角度增大。基板移动速度一定时, 随着直流电压增大, 基板上沉积的线条连续性增强, 线条宽度增加。供墨压力增大使上述喷射模式的诱导直流电压降低, 但射流更易失稳, 导致喷印质量下降。

关键词: 直流电压; 无颗粒; 纳米银导电墨水; 电流体动力 (EHD); 微喷行为

中图分类号: TN601 文献标识码: A 文章编号: 1671-4776(2017)04-0279-06

Effect of the DC Voltage on EHD Micro Jetting Behavior of

the Non Particle Nano Silver Ink

Xing Bo1, Zuo Chuncheng1,2, Huang Fengli1, Lu Yebo1, Hu Guangshan1,

Tang Chengli1, Zhang Libing1

(1.College of Mechanical and Electrical Engineering, Jiaxing University, Jiaxing 314001, China;

2.Key

Laboratory of Special Purpose Equipment and Advanced Manufacturing Technology of Ministry of Education & Zhejiang Province, Zhejiang University of Technology, Hangzhou 310000, China)

Abstract:The effect of the DC voltage on the jetting behavior of the non particle nano Ag conductive ink during electrohydrodynamics (EHD) near field micro jet printing was investigated. The experiment results show that under the certain ink supply pressure and electrode spacing, the meniscus on the nozzle tip is elongated with the increase of the DC voltage, and the side profile of the meniscus evolves from the curve to the pulsant Taylor cone and then to the stable Taylor cone. The excessive DC voltage resulted in the unstable and slant Taylor cone. The jetting behavior of the ink droplet in different meniscus shapes presents, in order, the pulsant micro dripping, pulsant Taylor cone jetting, stable cone jetting and multi cone jetting. In the DC voltage range of 1 500-3 500 V, the Taylor cone jetting is stable, the height of the Taylor cone decreases and the angle of cone tip increases with the increase of the DC voltage. Under the certain moving speed of the substrate, the continuity and line width of the deposited lines on the substrate increase with the increase of the DC voltage. The increase of the ink supply pressure results in the decrease of the induction DC voltages for the above jetting modes and the unstable jetting, thus the decrease of jet printing quality.

Key words:DC voltage; non particle; nano Ag conductive ink; electrohydrodynamics(EHD); micro jetting behavior

DOI:10.13250/j.cnki.wndz.2017.04.010EEACC:0180

衬底温度对 PVT 法生长 AlN 晶体自发形核的影响

史月增, 金雷, 齐海涛, 张丽, 程红娟, 徐永宽

(中国电子科技集团公司 第四十六研究所, 天津 300220)

摘要: 通过热力学理论对物理气相传输 (PVT) 法 AlN 晶体生长过饱和度进行分析, 分别从软件模拟和晶体生长实验对衬底表面的温度分布进行调控, 进而控制衬底表面 AlN 晶体生长的驱动力。理论上, 采用 Comsol 模拟软件对坩埚结构的温度分布进行模拟仿真, 模拟结果表明: 复合型衬底可以显著改变衬底表面的温度分布, 达到改变衬底表面 AlN 气氛的过饱和度的目的; 实验上, 采用 PVT 法 AlN 晶体的生长实验验证了软件模拟结果。采用复合型衬底生长 AlN 晶体时, 通过对衬底表面的温度分布调控可有效控制晶体生长驱动力, 进而实现形核位置和形核数量的控制。经过 6~8 h AlN 晶体生长后, 可获得尺寸约为 12 mm、厚度约为 3 mm 的 AlN 单晶。喇曼光谱和 XRD 双晶摇摆曲线测试结果表明晶体质量良好。

关键词: 物理气相传输 (PVT); 复合型衬底; 驱动力; AlN 晶体; 形核

中图分类号: O782.9 文献标识码: A 文章编号: 1671-4776(2017)04-0285-06

Effect of the Substrate Temperature on the Spontaneous Nucleation
of AlN Crystals Grown by the PVT Method

Shi Yuezeng, Jin Lei, Qi Haitao, Zhang Li, Cheng Hongjuan, Xu Yongkuan

(The 46th Research Institute, CETC, Tianjin 300220, China)

Abstract: The supersaturation of AlN crystals grown by the physical vapor transport (PVT) method was analyzed by thermodynamic theory. The temperature distribution of the substrate surface was controlled by the software simulation and crystals growth experiment, thereby controlling the driving force of the AlN crystal growth on the surface of the substrate. Theoretically, the temperature distribution of the crucible was simulated by Comsol software. The simulation results indicate that the temperature distribution of the substrate can be well altered by the complex substrate to achieve the purpose of changing the supersaturation of AlN on the substrate surface. Experimentally, the simulation result was verified by PVT AlN crystals growth experiment. When the AlN crystals are grown on the complex substrate, the driving force of crystal growth can be effectively controlled by controlling the temperature distribution of the substrate surface, and then the nucleation site and number of the AlN crystals can be regulated. The AlN single crystal with the size of about 12 mm and thickness of about 3 mm was obtained within 6-8 h growth duration. The Raman spectrum and XRD rolling curve test results show that the crystal quality is well.

Key words: physical vapor transport (PVT); complex substrate; driver force; AlN crystal; nucleation

DOI:10.13250/j.cnki.wndz.2017.04.011EEACC:0510