THz InP HEMT 和 HBT 技术的最新研究进展

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摘要：概述了太赫兹（THz）InP 技术的优势、应用前景及美国的发展规划。重点对国外 THz InP 高电子迁移率晶体管（HEMT）和异质结双极晶体管（HBT）的技术进展和突破进行了详细阐述，其中国外 HEMT 和 HBT 器件的工作频率都达到了 1 THz 以上，国外报道的 650 GHz 以上的 InP 太赫兹单片集成电路（TMIC）很多，包括低噪声放大器和功率放大器等，并且性能优异。介绍了我国 THz InP 技术的研究现状，国内 InP HEMT 和 HBT 器件的工作频率最高可达 600 GHz，电路的工作频率在 300 GHz 左右。最后，对国内外的最新技术水平进行了对比，并在对比的基础上针对存在的问题提出了我国在 THz InP 领域的发展建议。

关键词：太赫兹（THz）技术；InP 高电子迁移率晶体管（HEMT）；InP 异质结双极晶体管（HBT）；InP 器件；低噪声放大器；功率放大器
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Latest Research Progress of THz InP HEMT and HBT Technologies

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Abstract:Advantages and application prospects of the teraherta(THz) InP technology and its development programs in the United States are introduced briefly. Development status and breakthroughs of the THz InP high electron mobility transistor (HEMT) and heterojunction bipolar transistor(HBT) technologies in foreign countries are illustrated in detail. The working frequencies of the HEMT and HBT devices are above 1 THz, and many InP THz monolithic integrated circuits (TMICs) above 650 GHz are reported in foreign countries, including low noise amplifiers and power amplifiers, and these devices have excellent properties. The domestic research status of the THz InP technology is introduced. The working frequencies of the InP HEMT and HBT devices are up to 600 GHz, while the working frequencies of the corresponding circuits are about 300 GHz. Finally, the latest technology progresses at home and abroad are compared, and development suggestions for the THz InP technology in our country are presented.

Key words:terathertz(THz) technology; InP high electron mobility transistor (HEMT); InP heterojunction bipolar transistor(HBT); InP device; low noise amplifier; power amplifier
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大功率分布反馈半导体激光器研究进展

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摘要：介绍了分布反馈半导体激光器(DFB LD)的工作原理，分析了不同的光栅阶数及耦合机制对 DFB LD 激光输出特性的影响。重点评述了大功率 DFB LD 研究发展状况，从结构特性及技术手段等方面详细分析了不同技术方案的优势与不足：大功率二次外延 DFB LD 对光栅和有效光场耦合较好，但二次外延对技术控制精度要求极高且会引入缺陷；表面金属光栅边发射 DFB LD 避免了二次外延，但制作金属光栅时会出现欧姆接触电阻大和阈值特性劣化等问题；大功率表面光栅面发射 DFB LD 虽然在获得高功率高质量光束方面有很大优势，且避免了二次外延，但存在光栅的表面耦合系数较低等技术难题。最后总结分析大功率 DFB LD 技术发展趋势，对其广阔的应用前景进行展望。

关键词：半导体激光器；高功率；波长稳定性；分布反馈；光栅；二次外延
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Research Progress of High Power Distributed Feedback Semiconductor Lasers

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Abstract:The working principle of the distributed feedback semiconductor laser (DFB LD) is introduced, and the influences of different grating orders and coupling mechanisms on the laser output characteristic of the DFB LD are analyzed. The development of the high power DFB LD is reviewed emphatically, and the advantages and disadvantages of different approaches are analyzed in detail in terms of structural characteristics and technical means. The high power epitaxial regrowth DFB LD can provide high efficient coupling between gratings and active optical field. However, the epitaxial regrowth has some shortcomings, such as high control precision of technology and introducing defects. The surface metal grating edge emission DFB LD avoids epitaxial regrowth, however has some problems, such as large Ohmic contact resistance and threshold characteristic deterioration during the metal grating fabrication. The high power surface grating surface emission DFB LD has great advantages in obtaining high power and high quality beams without epitaxial regrowth, but has some technical problems such as low surface coupling coefficient of the grating. Finally, the development trend of high power DFB LD technology is summarized and analyzed, and its broad application is prospected.

Key words:semiconductor laser; high power; wavelength stability; distributed feedback; grating; epitaxial regrowth
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Cu2O 颗粒的制备及其吸附性能

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摘要：通过液相还原法制备了 Cu2O 颗粒，利用扫描电子显微镜（SEM）以及 X 射线衍射（XRD）等手段对粒径的大小、微结构以及组分进行了测试和分析。测试结果表明：Cu2O 颗粒为组分单一、表面含有大量孔隙的八面体结构。颗粒的粒径大小并不均匀，分布在几十纳米到 1 微米之间。同时研究了 Cu2O 颗粒的吸附特性，发现 Cu2O 颗粒对甲基橙具有良好的吸附能力。在吸附 160 min 后，甲基橙的吸附率为 67 5%，而且其最高吸附率可达 94 86%。Cu2O 颗粒的吸附性能可能主要来源于颗粒上的孔隙结构。拟合结果表明 Cu2O 颗粒的吸附过程符合伪一级动力学方程，这说明 Cu2O 颗粒的吸附机制主要是物理吸附。

关键词：Cu2O 颗粒；液相还原法；微结构；表面形貌；吸附特性
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Preparation and Absorption Properties of Cu2O Particles

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Abstract:The Cu2O particles were prepared with the liquid phase reduction method. The size, microstructure and composition of the particles were tested and analyzed by scanning electron microscope（SEM）and X ray diffraction（XRD）. The test results show that the Cu2O particles are the porous octahedral structure with uniform composition. The particle size is not uniform in the range from a few dozen nanometers to one micrometer. At the same time, the absorption property of the Cu2O particles was investigated. It is found that the Cu2O particles have a good absorption capacity for the methyl orange. The absorption rate for the methyl orange is 67 5% after absorption for 160 min, and the maximum absorption rate can reach 94 86%. The absorption capacity of the Cu2O particles mainly results from the porous structures of particles. The fitting result shows that the absorption process of the Cu2O particles conforms to the pseudo first order kinetics equation, indicating the absorption mechanism of the Cu2O particles is mainly physical absorption.

Key words:Cu2O particle; liquid reduction method; microstructure; surface morphology; absorption property
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基于多苯烯丙基醚无氟抗粘的巯基-烯
纳米压印光刻胶

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摘要：为了减小纳米压印光刻胶与模板间的接触黏附力，合成了一种无氟抗粘巯基 烯纳米压印光刻胶。以Ａ,Ａ,A′ 三(4 羟苯基) 1 乙基 4 异丙苯（TPA）和溴丙烯为原料，采用相转移催化法制备了一种功能性单体Ａ,Ａ,A′ 三(4 丙烯基苯基醚) 1 乙基 4 异丙苯（TPAE），并将其按特定配比与三羟甲基丙烷三(3 巯基丙酸酯)和光引发剂配制成纳米压印光刻胶。实时傅里叶红外光谱（FT IR）分析表明，当辐射剂量为 200 mJ/cm2 时，双键的转化率为 78 0%，巯基的转化率为 78 1%。胶膜的去离子水接触角为 90°。纳米压印光刻胶脱模后的图形结构规整，保真度高，具有良好的脱模性能。

关键词：紫外纳米压印；光刻胶；巯基 烯反应；无氟抗粘；脱模
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"Thiol Ene" Nanoimprint Lithography Resist with the Fluoride Free Anti Sticking Property Based on Polyphenyl Allyl Ether

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Abstract:In order to reduce the contact adhesion between the nanoimprint lithography resist and mold, a “thiol ene” nanoimprint lithography resist with fluorine free anti sticking property was synthesized. A functional monomer A,A,A′ tris(4 propenenylphenyl ether) 1 ethyl 4 isopropylbenzene (TPAE) was synthesized with the phase transfer catalysis method using A, A, A′ tris (4 hydroxyphenyl) 1 ethyl 4 isopropylbenzene (TPA) and allyl bromide as raw mate rials. The nanoimprint lithography resist was obtained via mixing TPAE, trimethylolpropane tris (3 mercaptopropionate) and photoinitiator with specific proportion. The real time Fourier transform infrared spectroscopy（FT IR）analysis shows that with an irradiation dose of 200 mJ/cm2, the double bond conversion rate and thiol conversion rate are 78 0% and 78 1%, respectively. The deionized water contact angle of the resist film surface is 90°. The nanoimprint lithography resist after demolding has a regular pattern structure, high fidelity and outstanding demolding property.

Key words:ultraviolet nanoimprint lithography; photoresist; thiol ene reaction; fluorine free anti sticking; demolding
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SOI 高温压阻式压力传感器的设计与制备

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摘要：设计并制备了一种基于绝缘体上硅（SOI）材料、量程为 5 Pa～1 8 MPa 的压阻式压力传感器。在设计方面，通过有限元分析软件和经典理论相结合分析敏感膜片的力学性能和电学性能，得到敏感膜片的尺寸和表面电势的分布；在工艺方面，设计了基于标准微电子机械系统（MEMS）工艺的制作流程；在芯片的封装方面，为保证敏感芯片与外界的电气互连，采用了引线键合工艺，同时装配温度补偿电路和信号调理电路降低了传感器的温漂，保证传感器的输出。制备后的压力传感器在温度压力复合平台进行标定和温度测试，结果显示传感器在设计量程范围内具有较好的精度并且可在-50～205 ℃内稳定工作。

关键词：绝缘体上硅（SOI）；压力传感器； 压敏电阻；引线键合；有限元分析
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Design and Preparation of a High Temperature SOI Piezoresistive Pressure Sensor

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Abstract:A kind of piezoresistive pressure sensor with a range of 5 Pa-1 8 MPa was designed and prepared based on the silicon on insulator（SOI）material. In the aspect of design, the mechanical and electrical properties of the sensitive diaphragm were analyzed by combining the finite element analysis software and classical theory, and the size of the sensitive diaphragm and the distribution of the surface potential were obtained. In the aspect of technology, the production process based on the standard micro electromechanical system (MEMS) technology was designed. In the aspect of chip packaging, the wire bonding process was used to ensure the electrical interconnection between the sensitive chip and peripheral. Meanwhile, the temperature compensation circuit and signal conditioning circuit were assembled to reduce the temperature drift of the sensor and ensure the output of the sensor. The calibration and temperature testing of the fabricated pressure sensor were carried out in the temperature pressure composite platform. The results show that the sensor has good precision in the design range and works steadily in the range of -50-205 ℃.

Key words:silicon on insulator（SOI）; pressure sensor; piezoresistance; wire bonding; finite element analysis
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平面氧化硅光波导环形谐振腔的温度特性

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摘要：温度变化会在氧化硅光波导谐振腔中引起极化误差，该极化误差所引起的偏振波动噪声是限制谐振式集成光学陀螺长期稳定性的主要因素。通过对反射式和透射式两种结构的谐振腔分别进行主动温控实验，成功测得了谐振腔的温度特性，并对其进行了详细分析。由实验分析结果可知：随着光波导谐振腔的温度变化，两种结构的谐振腔谐振曲线的峰值都呈周期性变化，谐振腔的主次偏振态之间的相位差在 0~2π内波动，且主次偏振态之间的相位差为π时，次偏振态对主偏振态的影响最小。由进一步的分析可知，透射式谐振腔中次主偏振态的强度比例越小，相应地由温度波动引起的谐振频率偏差越小。相比于反射式谐振腔，透射式谐振腔在抑制陀螺的偏振波动噪声方面具有更好的优势。

关键词：氧化硅；谐振腔；光波导；温度特性；谐振式微光学陀螺
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Temperature Characteristics of the Planar Silica Optical Waveguide Ring Resonator

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Abstract:The temperature variation will cause the polarization error in the silica optical waveguide resonator, the polarization fluctuation noise caused by the polarization error is the main limiting factor of the long term stability of the resonant integrated optical gyroscope. Through the active temperature control experiments of the reflective and transmissive resonators respectively, the temperature characteristics of the resonators were successfully measured and analyzed in detail. The experimental analysis results show that with the temperature variation of the optical waveguide resonator, the resonance curve peak values of the two resonators change periodically, and the phase difference between the primary and secondary polarization states of the resonator fluctuates from 0 to 2π. When the phase difference between the primary and secondary polarization states is π, the influence of the secondary polarization state on the primary polarization state is minimal. Further analysis shows that the intensity ratio between the secondary and primary polarization states of the transmissive resonator is smaller, correspondingly, the resonant frequency deviation caused by temperature variation is smaller. The transmissive resonator has advantages in suppressing the polarization fluctuation noise of the gyroscope than the reflective resonator.

Key words:silica；resonator；optical waveguide；temperature characteristic；resonant micro optical gyroscope
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一种基于微熔技术的 MEMS 大量程压力传感器

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摘要：基于半导体硅的压阻效应，研制了一种 MEMS 大量程压力传感器。为了实现大量程压力测量，采用了不锈钢材质制作了压力敏感膜片。利用有限元分析软件对传感器敏感芯体进行了结构建模仿真分析和优化设计。采用玻璃微熔技术将敏感电阻粘结固定在不锈钢敏感膜片上。利用成熟的微电子机械系统（MEMS）加工工艺，完成了可以在高温下工作的绝缘体上硅(SOI)敏感电阻的制作。采用激光焊接方法将敏感芯体焊接到传感器基座上，提高了结构的机械强度。信号调理采用了压力信号专用集成电路(ASIC)，具有高精度的放大和温度补偿功能。完成了整体封装和调试后，对压力传感器的主要性能指标进行了测试，结果表明压力传感器的工作温度为-55~150 ℃，压力量程 0~42 MPa，精度<0 5%。

关键词：微熔；微电子机械系统（MEMS）；大量程；压力传感器；绝缘体上硅(SOI)
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A MEMS Pressure Sensor for Wide Measurement Range Based on Micro Fused Technology

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Abstract:A MEMS pressure sensor for wide measurement range was developed based on the piezoresistive effect of semiconductor silicon. The pressure sensitive membrane was fabricated with stainless steel material for meeting the wide measurement range requirement. The structural modeling simulation analysis and optimal design of the sensor sensitive core were carried out by finite element analysis software. The sensitive resistances were stuck to the stainless steel sensitive membrane by the glass micro fused technology. The silicon on insulator (SOI) sensitive resistance working at high temperature was fabricated using the mature micro electromechanical system（MEMS）technology. The sensitive core was welded to the sensor pedestal with the laser welding method to improve the mechanical strength of the structure. Signal conditioning was carried out by the pressure signal application specific integrated circuit (ASIC) with high precision amplification and temperature compensation functions. After the overall packaging and commissioning, the main performance parameters of the pressure sensor were tested. The test results show that the work temperature of the pressure sensor is -55-150 ℃, the pressure measurement range is 0-42 MPa, and the measurement accuracy is less than 0 5%.

Key words:micro melting; micro electromechanical system（MEMS）; wide measurement range; pressure sensor; silicon on insulator (SOI)
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原子层沉积制备氮化钛薄膜及其表征

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摘要：宽禁带半导体 TiN 作为扩散阻挡层以及场效应管的门电极在集成电路中发挥重要作用。通过原子层沉积（atomic layer deposition，ALD）技术沉积不同循环次数 TiN 薄膜，采用四探针测试仪、台阶仪、扫描电子显微镜（SEM）、原子力显微镜（AFM）对薄膜进行了表征，确定了薄膜电阻率、生长速率、表面粗糙度与工艺条件的依赖关系。实验结果表明，ALD 可实现膜厚精确控制、大面积均匀性优异、电阻率较小的薄膜制造，沉积薄膜的最小粗糙度为 0　101 nm，电阻率为 5 μΩ·cm，薄膜稳定生长速率为 0　025 nm/cycle。

关键词：TiN；原子层沉积（ALD）；电阻率；粗糙度；生长速率
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Preparation and Characterization of Titanium Nitride Thin Films by the Atomic Layer Deposition

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Abstract:The wide bandgap semiconductor TiN plays an important role in integrated circuits as the diffusion barrier layer and gate electrode of field effect transistors. The TiN thin films were deposited by the atomic layer deposition (ALD) technology with different cycles. The films were characterized by the four probe tester, step profiler, scanning electron microscope (SEM) and atomic force microscope (AFM), and the dependency relationships of the thin film resistivity, growth rate, surface roughness and technological condition were determined. The experimental results show that the film with advantages of film thickness precise control, excellent large area uniformity and low resistivity can be fabricated by the ALD. The minimum roughness of the deposited thin films is 0　101 nm, the resistivity is 5 μΩ·cm, and the film steady growth rate is 0　025 nm/cycle.

Key words:TiN; atomic layer deposition（ALD）; resistivity; roughness; growth rate
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碱性 CMP 表面活性剂对硅衬底表面状态的影响

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摘要：主要研究了硅衬底碱性精抛液中表面活性剂对硅衬底表面粗糙度、表面缺陷以及抛光雾的影响。实验结果表明，随着硅衬底精抛液中表面活性剂体积分数由 0%增加到 1%，表面粗糙度和表面缺陷数量都呈现出迅速降低的变化趋势，表面活性剂对降低表面粗糙度和减少表面缺陷效果明显。但是当表面活性剂体积分数大于 5%时，抛光后硅衬底的表面粗糙度和表面缺陷数量都略有升高。表面活性剂体积分数为 5%时，表面粗糙度及表面缺陷数量最小。由抛光雾实验可以看出，随着表面活性剂体积分数的增加，硅衬底精抛后的抛光雾值先降低后升高，进一步验证了当表面活性剂体积分数为 5%时，抛光后硅衬底的表面状态最好。

关键词：碱性抛光液；硅衬底；化学机械抛光（CMP）；表面粗糙度；表面缺陷；抛光雾
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Effect of Surfactant on Silicon Substrate Surface State After Alkaline CMP

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Abstract:The effects of the surfactant in the fine polishing alkaline slurry on the surface roughness, surface defect and polishing haze of the silicon substrate were mainly studied. The experiment results show that when the volume fraction of the surfactant increases from 0% to 1%, the surface roughness and surface defect number decrease rapidly. The surfactant has obvious effect on reducing the surface roughness and surface defect. While the volume fraction of the surfactant is above 5%, the surface roughness and surface defect number of the silicon substrate after polishing increase slightly. When the volume fraction of the surfactant is 5%, the surface roughness and surface defect number are minimal. The polishing haze experiment shows that with the increase of the surfactant volume fraction, the polishing haze value of the silicon substrate after fine polishing decreases firstly and then increases, further indicating that when the volume fraction of the surfactant is 5%, the surface state of the silicon substrate after polishing is optimal.

Key words:alkaline slurry; silicon substrate; chemical mechanical polishing(CMP); surface roughness; surface defect; polishing haze
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仿生增材制造

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摘要：仿生增材制造（仿生 3D 打印）是指受到生物结构和功能的启发而设计出具有仿生结构和功能的三维图形的一种新技术，采用增材制造工艺加工而成的构件具有特殊的仿生性能。结合现有的研究进展，从形态仿生、结构仿生、功能仿生等角度出发，重点介绍了仿生增材制造在仿生器件（仿生器官模型、仿生导板器械和植入物、仿生组织工程支架以及仿生组织器官）、仿生组织微环境、仿生美学、仿生性能（力学仿生、光学仿生、表面功能仿生）以及 4D 仿生打印等领域的最新研究进展。同时简要地总结了现阶段仿生增材制造的发展趋势和挑战，为仿生设计、仿生增材制造以及应用提供借鉴和参考。

关键词：3D 打印；仿生增材制造；纳米技术；仿生组织器官；4D 仿生打印
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Biomimetic Additive Manufacturing

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Abstract:Biomimetic additive manufacturing (biomimetic 3D printing) is a novel technology for designing three dimensional graphics with biomimetic structures and functions inspired by biological structures and functions, and components printed by additive manufacturing have specific biomimetic properties. Combining with the current research progress, the latest research progresses of biomimetic additive manufacturing in the fields of biomimetic devices (biomimetic organ model, biomimetic surgical guide plates and implants, tissue engineering scaffolds and biomimetic tissue organs), biomimetic tissue microenvironment, biomimetic aesthetics, biomimetic properties (mechanical biomimetic, optical biomimetic, surface functional biomimetic) and 4D biomimetic printing are emphatically introduced from the aspects of the morphological bionic, structural bionic, functional bionic and so on. Meanwhile, the development trends and challenges of biomimetic additive manufacturing at the present stage are briefly summarized, providing refe rences for biomimetic design, biomimetic additive manufacturing and applications.

Key words:3D printing; biomimetic additive manufacturing; nanotechnology; biomimetic tissue organ; 4D biomimetic printing
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大尺寸β Ga2O3 晶片的机械剥离及性能

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摘要：针对β Ga2O3 单晶易解理的特性，研究了晶体形状对其（100）主解理面的机械剥离影响。结果表明，棱角较为平缓的体单晶机械剥离时容易出现碎裂，而棱角尖锐的体单晶极易实现机械剥离，并且成功剥离出尺寸大于 30 mm×10 mm 的β Ga2O3 单晶片。测试了剥离的β Ga2O3 单晶片微观形貌、表面粗糙度、晶体质量以及位错。结果显示，剥离的β Ga2O3 单晶片具有高的表面质量；原子力显微镜（AFM）测试表明，晶片整体表面粗糙度小于 1 nm，存在 0 5~1 nm 厚的原子台阶；晶片 X 射线衍射（XRD）摇摆曲线测试显示，其半高宽（FWHM）值低至 50 arcsec，表明晶体具有较高的质量；对晶片进行位错腐蚀，结果显示制备的β Ga2O3 晶片具有较低的位错密度，约为 6×104 cm-2。

关键词：β Ga2O3；单晶；晶体加工；机械剥离；表面质量
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Mechanical Lift off and Performances of Large Size β Ga2O3 Crystal Wafers

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Abstract:Based on the characteristic that the β Ga2O3 single crystal can be easily cleaved, the effect of the crystal shape on the mechanical lift off performed on the (100) main cleavage plane of the β Ga2O3 single crystal was investigated. The results show that the bulk single crystal with flat edges is prone to chipping, while the single crystal with sharp edges is easy to be mechanically lifted off. A β Ga2O3 single crystal wafer with a size larger than 30 mm×10 mm was successfully lifted off. And the micro morphology, surface roughness, crystalline quality and dislocations of the lifted off β Ga2O3 single crystal wafer were then measured. The result indicates that the lifted off β Ga2O3 single crystal wafer has a high surface quality. The atomic force microscope (AFM) measurement result shows that the overall surface roughness of the lifted off crystal wafer is less than 1 nm and the atomic steps with a thickness of 0 5-1 nm are found. The X ray diffraction (XRD) rocking curve shows that the full width at half maximum (FWHM) is measured as low as 50 arcsec, indicating a high quality of the lifted off crystal wafer. The dislocation erosion was performed for the wafer. And the result shows that the lifted off β Ga2O3 single crystal wafer has a low dislocation density of about 6×104 cm-2.

Key words:β Ga2O3; single crystal; crystal processing; mechanical lift off; surface quality
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钨酸锰纳米线的水热法制备与表征

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摘要：以 MnCl2，MnC2O4 和 Na2WO4 为反应前驱体，以 KOH 为矿化剂，在没有采用任何表面活性剂和模板的条件下，采用水热法成功制备出 MnWO4 晶体。用 X 射线衍射(XRD)和透射电子显微镜(TEM)对制备出的 MnWO4 晶体的结构和形貌进行了表征，并对 MnWO4 晶体的形成机理进行了初步探讨。结果表明，反应前驱体和 pH 值可以控制 MnWO4 晶体的一维取向生长。当以 MnCl2 作为锰源，随着 pH 值的升高，制得的 MnWO4 晶体的形貌由球形向棒状转变，制得的 MnWO4 纳米棒的长度约为 200 nm，直径约为 30 nm。而当采用 MnC2O4 作为锰源，当 pH 值升高时，制得的 MnWO4 晶体的形貌由纳米棒向纳米线转变，最终制得的 MnWO4 纳米线的长度为 1～1　5 μm，直径为 20～50 nm。

关键词：钨酸锰（MnWO4）；纳米线；水热法；纳米棒；形貌表征
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Hydrothermal Preparation and Characterization of MnWO4 Nanowires

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Abstract:Using MnCl2, MnC2O4 and Na2WO4 as precursors and KOH as mineralizer, MnWO4 crystallites were successfully prepared with the hydrothermal method without any surfactants and templates. The structure and morphology of the prepared MnWO4 crystallites were characterized by the X　ray diffraction (XRD) and transmission electron microscopy (TEM). The formation mechanism of the MnWO4 crystallites was preliminarily discussed. The results show that the pH value and precursor can control the one　dimensional orientation growth of the MnWO4 crystallites. When MnCl2 is used as the manganese source, the morphology of the prepared MnWO4 crystallites changes from sphericity to rod shape with the increase of the pH value, the length and diameter of the prepared MnWO4 nanorods are about 150 nm and 30 nm, respectively. When MnC2O4 is used as the manganese source, the morphology of the prepared MnWO4 crystallites changes from nanorod to nanowire with the increase of the pH value. Finally, the length and diameter of the prepared MnWO4 nanowires are 1-1　5 μm and 20-50 nm, respectively.

Key words:MnWO4; nanowire; hydrothermal method; nanorod; morphology characterization
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