一种垂直递变流速氢化物气相外延(HVPE)反应腔流场分析及大尺寸材料生长*

李成明[1,2],苏 宁[3],李 琳[4],姚威振[1],杨少延[1,5]

(1.中国科学院半导体研究所,中国科学院半导体材料科学重点实验室,北京 100083;2.北京大学东莞光电研究院,广东 东莞 523808;3.沈阳真空技术研究所有限公司,辽宁 沈阳 110042;4.长沙(星沙)经济技术开发区毛塘工业园区湖南信息学院,湖南 长沙 410151;5.中国科学院大学,材料与光电研究中心,北京 100049)

摘 要:以氮化镓(GaN)为代表的第三代半导体材料,是我国重要战略发展方向之一,而氢化物气相外延(HVPE)作为一种重要材料生长技术,是有效制备单晶材料的工艺手段,本文提出了一种分层次递变流速下 HVPE 流场与温度场,在垂直腔结构条件下,模拟从腔体中间区域到边缘区域不同流速层次条件下,腔内材料生长区域反应前驱物分布,得出结论:在边缘喷射区域流速为中心区域流速三倍时,反应前驱物可以有效分布在衬底托盘表面。最后,在蓝宝石衬底 GaN 籽晶表面进行 HVPE 材料生长,获得平均厚度为 20.1μm,均匀性起伏 6.9%的 GaN 单晶,证明理论优化设计下生长出良好的单晶薄膜材料。

关 键 词:氢化物气相外延;反应腔体;氮化镓;数值模拟;喷管

中图分类号:O484.1 **文献标识码**:A **文章编号**:1002-0322(2021)02-0001-05

doi:10.13385/j.cnki.vacuum.2021.02.01

Flow Field Analysis and Large-Scale Material Growth in a Vertical Graded Varying Velocity Hydride Vapor Phase Epitaxy(HVPE) Reactor

LI Cheng-ming[1,2], SU Ning[3], LI Lin[4], YAO Wei-zhen[1], YANG Shao-yan[1,5]

(*1.Key Laboratory of Semiconductor Materials Science, Institute of Semiconductors, Chinese Academy of Sciences, Beijing 10083, China; 2.Dongguan Institute of Opto-Electronics Peking University, Dongguan 523808, China; 3.Shenyang Vacuum Technology Institute Co., Ltd., Shenyang 110042, China; 4. Hunan Institue of Information Technology, Changsha 410151, China; 5.Center of Materials Science and Optoelectronics Engineering, University of Chinese Acasdemy of Sciences, Beijing 100049, China*)

Abstract: Gallium nitride(GaN), as the representative of the wide gap semiconductor materials, is one of the important strategic development directions in our country. As an important material growth technology, hydride vapor phase epitax (HVPE) is an effective method for the fabrication of single crystal materials. In this paper, we propose a new flow field and temperature field of HVPE under the condition of stratified flow rate. The results indicate that the reaction precursors can be effectively distributed on the surface of the substrate susceptor when the flow velocity in the outer jet inlets region is three times that in the center region. Finally, HVPE material was grown on the surface of GaN seed crystal on sapphire substrate, and GaN single crystal with average thickness of 20.1 μm and uniformity fluctuation of 6.9% was obtained, which proved that good single crystal film material was grown under theoretical optimization design.

Key words: HVPE; reactor; gallium nitride(GaN); numerical simulation; nozzle

第三代半导体材料由于其性能多种多样,是我国上升到国家重要战略层面研究课题之一,Ⅲ族氮化物半导体材料是其中一项重要研究内容,而氮化镓(GaN)为其中最重要的标志性材料,其

收稿日期:2020-01-19

作者简介:李成明(1972-),男,辽宁省沈阳市人,副研究员。

* **基金项目**:国家自然科学基金项目(Nos. 61774147),国家重点研发计划(No. 2017YFB0404201),广东省财政补贴项目(粤财工【2015】639 号)。