光学 精密工程
OPTICS AND PRECISION ENGINEERING
核心期刊
主管：中国科学院
主办：中国科学院长春光学精密机械与物理研究所
中国仪器仪表学会
主编：曹健林



光学精密工程 2012, 20(1) 58-63 ISSN: 1004-924X CN: 22-1198/TH



现代应用光学

# 准分子激光相位掩模法制备大晶粒尺寸多晶硅薄膜

张健, 林广平, 张睿, 崔国宇, 李传南

吉林大学 电子科学与工程学院 集成光电子学国家重点联合实验室吉林大学实验区,吉林 长春 130012

摘要： 为扩大晶粒尺寸并降低晶粒间界缺陷对多晶硅薄膜晶体管的不良影响,采用准分子激光相位掩模法制备了大晶粒尺寸的多晶硅薄膜。首先,在无相位掩模时利用不同能量密度的准分子激光晶化非晶硅薄膜,通过扫描电镜观测晶粒尺寸确定超级横向生长的能量窗口;然后,在该能量密度下采用周期为1 073 nm的相位掩模板对入射光束进行相位调制,在样品表面形成人工可控的横向温度梯度,使非晶硅熔化并横向生长结晶为多晶硅;最后,对薄膜特性进行测量,并与非晶硅薄膜和超级横向生长制备的多晶硅薄膜进行比较。结果表明:本文方法制作的薄膜的平均晶粒尺寸提高了一个数量级,达到了228.24 nm;薄膜电阻率降低一个数量级,为18.9 Ω·m;且晶粒分布规则有序。该方法能有效提高多晶硅薄膜的电学特性,适用于高质量多晶硅薄膜器件的制作。

关键词： 多晶硅薄膜 准分子激光 相位掩模

## Fabrication of large grain size p-Si film by phase modulated excimer laser crystallization

ZHANG Jian, LIN Guang-ping, ZHANG Rui, CUI Guo-yu, LI Chuan-nan

State Key Laboratory on Integrated Optoelectronics, College of Electronic Science and Engineering, Jilin University, Changchun 130012, China

Abstract: To enlarge the grain size and decrease the effect of the defect between the grain boundaries on a p-Si film transistor, a phase modulated excimer laser crystallization technique is used to fabricate the uniform p-Si film with a large grain size. First, an energy window for super lateral growth is determined by measuring the grain size of p-Si film fabricated with different laser energy intensities. Then, the spatial distribution of the input laser is modulated by a phase mask with a period of 1 073 nm and an artificially controlled lateral temperature gradient is induced on the a-Si film, which leads the a-Si to be melten and crystallized into p-Si grains by super lateral growth. Finally, the characteristics of the prepared p-Si film are measured and compared with those of the a-Si film and the p-Si film fabricated by super lateral growth technique. The results show that the grain size of the p-Si film is 228.24 nm, which is ten times of that fabricated by super lateral growth under the same processing parameters; the electrical resistivity of the prepared sample is 18.9 Ω·m, which is lower by an order magnitude than that prepared by super lateral growth. Furthermore, the distribution of the grain is more uniform than that fabricated by other techniques. The reported technique can increase the electrical characteristics of the p-Si film greatly and is suitable for the fabrication of high quality p-Si devices.

Keywords: polycrystalline silicon film excimer laser phase mask

收稿日期 2011-06-17 修回日期 2011-07-29 网络版发布日期 2012-01-25

基金项目:

国家973重点基础研究发展计划资助项目(No.2010CB327701);吉林省科技厅支撑计划重点资助项目(No.20093056)

通讯作者: 李传南 (1969-),男,江西莲花人,博士,教授,1991年、1997年和2001年于吉林大学分别获得学士、硕士及博士学位,2001年至2003年于香港大学从事博士后研究,主要从事显示技术的研究。

作者简介: 张 健 (1971-),男,吉林长春人,博士,副教授,1993年于南开大学获得学士学位,1996年、2009年于吉林大学分别获得硕士、博士学位,主要从事光纤无源器件,光纤激光器,传感器的研究。E-mail: zhangjian@jlu.edu.cn
林广平 (1986-),男,黑龙江哈尔滨人,硕士研究生,2010年于吉林大学获得学士学位,主要从事多晶硅TFT方面的研究。E-mail: skyjlu@163.com
作者Email: licn@jlu.edu.cn

参考文献：

[1] KUO C C. In situ time-resolved optical measurements of a-Si thin films during excimer laser crystallization[J].*Optik*, 2011,122(8):655-659. [2] KUO C C. Phase transformation mechanism in pulsed excimer laser crystallization of amorphous silicon thin films[J]. *Lasers in Engineering*, 2010, 19 (3-4): 225-238. [3] 刘松林. 多晶硅薄膜ELC制备方法中控制纵向热流的探索[J] .科技创新导报,2010,32:11-13. LIU S L. Investigation in controlling longitudinal heat flow during the fabrication of poly-silicon thin film by ELC technique[J]. *Science and Technology Innovation Herald*,2010,32:11-13.(in Chinese) [4] 尹亮,陈伟平,刘晓为,等. 闭环加速度计CMOS 接口电路 [J].光学 精密工程,2009,17(6):1311-1315. YIN L, CHEN W P,LIU X W, *et al*.. CMOS interface circuit for closed loop accelerometer[J]. *Opt. Precision Eng.*, 2009, 17 (6):1311-1315.(in Chinese) [5] 周春兰,王文静,李海玲,等. 用电学参数表征晶体硅太阳电池特性 [J].光学 精密工程,2008,16(7):1163-1170. ZHOU CH L,WANG W J,LI H L, *et al*.. Characterization of crystalline silicon solar cells by electrical parameters[J]. *Opt. Precision Eng.*, 2008,16(7):1163-1170.(in Chinese) [6] 赵学庆, 刘晶儒 , 易爱平,等. 平滑化窄脉冲高功率准分子激光放大技术 [J].光学 精密工程,2011,19(2): 397-406. ZHAO X Q, LIU J R, YI A P , *et al*.. Amplification of high power short pulse excimer laser with beam smoothing[J].*Opt. Precision Eng.*, 2011, 19(2):397-406.(in Chinese) [7] 薛全喜, 赵学庆, 华恒祺,等. 高功率XeCl准分子激光系统前端平滑实验 [J].光学 精密工程,2011, 19(2):332-339. XUE Q X , ZHAO X Q , HUA H Q ,*et al*.. Seed beam smoothing for high power XeCl excimer laser system[J]. *Opt. Precision Eng.*, 2011, 19(2):332-339.(in Chinese) [8] KAKKAD R, CHOI B D.

Enhancement of solid-phase crystallization kinetics of amorphous silicon by annealing in a high-pressure $H_2O$ ambient [J]. *Journal of the Korean Physical Society*, 2009, 55(1):1-4. [9] JIN B J, Oh S J, KIM D H, *et al*.. Activation behavior of SLS and ELC poly-Si after ion shower doping . *IDW '06: Proceedings of the 13th International Display Workshops*, 2006 ,1-3: 769-772. [10] LIAO Y P , SHAO X B, GAO F L, *et al*.. Nickel-disilicide-assisted excimer laser crystallization of amorphous silicon[J]. *Chinese Physics*, 2006,15(6):1310-1314. [11] CHIKOGA S U, IBARAKI N. Low temperature poly-Si TFT-LCD by excimer laser anneal[J].*Thin Solid Films*,2001,383:19-24. [12] SAMESHIMA T, KOHNO A, SEKIYA M, *et al*.. $SiO_2$ formation by thermal evaporation of SiO in oxygen atmosphere used to fabrication of high performance polycrystalline silicon thin film transistors[J].*Appl.Phys.Lett*,1994,64:1018. [13] KUO Y, KOZLOWSKI P M. Polycrystalline silicon formation by pulsed rapid thermal annealing of amorphous silicon[J]. *Appl. Phys. Lett*. 1996,69:1092. [14] LEE S J, LEE S W, LEE K E, *et al*.. Electrical characterization of polycrystalline silicon thin film transistors crystallized by a new alignment sequential lateral solidification process[J].*Phys.Scr*.,2011,83:055802. [15] SASAKI N, KITANARA K, YAMAMOTO K. Cha racterization of electrochemically-active defects in Si-film laser-crystallized with directional SLS by measuring the stress release during secco etching .*Sid International Symposium Digest of Technical Papers*., 2009,40(13): 632-635. [16] IM J S, KIM H J. On the super lateral growth phenomenon observed in excimer laser-induced crystallization of thin Si films [J].*Appl.Phys.Lett*.,1994,64:2303. [17] SPOSILIM R S, IM J S. Sequential lateral solidification of thin silicon films on $SiO_2$ [J]. *J Appl.Phys*, 1996,69(19):2864-2866. [18] 张健,郑杰,张玉书. 菲波纳契准周期超结构光纤光栅 [J].光子学报,2009,38(8):2050-2054. ZHANG J, ZHENG J,ZHANG Y SH. Fibonacci Quasi-periodic superstructure fiber bragg gratings[J]. *Acta Photonica Sinica*, 2009,38 (8):2050-2054.(in Chinese)

本刊中的类似文章

1．胡云 赵学庆 薛全喜 王大辉 郑国鑫.由级联紫外电光开关控制准分子激光的自发辐射放大[J]. 光学精密工程, 2013,21(1): 13-19

2．王大辉, 赵学庆, 张永生, 孙昱薇, 赵军.电子束泵浦准分子激光放大器的双程光路自动准直[J]. 光学精密工程, 2012,20(7): 1434-1439

3．赵学庆, 刘晶儒, 易爱平, 薛全喜, 华恒祺, 钱航, 郑国鑫, 胡云, 张永生, 黄珂, 黄超, 于力.平滑化窄脉冲高功率准分子激光放大技术[J]. 光学精密工程, 2011,19(2): 397-406

4．薛全喜, 赵学庆, 华恒祺, 郑国鑫, 张永生.高功率XeCl准分子激光系统前端平滑实验[J]. 光学精密工程, 2011,19(2): 332-339

5．郭明金;姜德生;袁宏才.两种封装的光纤光栅温度传感器的低温特性[J]. 光学精密工程, 2007,15(3): 326-330

6．魏仁选, 姜德生, 周租德.准分子激光脉冲直写刻蚀速率与能量密度的关系[J]. 光学精密工程, 2004,12(2): 231-234

7．梁静秋, 姚劲松.准分子激光刻蚀技术在微机械中的应用研究[J]. 光学精密工程, 1999,7(5): 63-66

8．李呈德, 万盈, 左铁钏.实用型准分子激光微细加工机研制[J]. 光学精密工程, 1999,7(1): 79-84

9．郭玉彬, 葛璜.光纤Bragg光栅的研究[J]. 光学精密工程, 1999,7(1): 31-38

10．林广平 张健 张睿 崔国宇 李传南.准分子激光相位掩模制备大晶粒尺寸多晶硅(OFCIO2011会议论文投稿)[J]. 光学精密工程, ,(): 0-0