

论文

HF酸刻蚀提升熔石英亚表面划痕抗损伤性能的机理

王凤蕊, 郑直, 刘红婕, 黄进, 周信达, 蒋晓东, 吴卫东, 郑万国

中国工程物理研究院激光聚变研究中心, 四川 绵阳 621900

摘要:

用HF酸刻蚀熔石英元件,研究刻蚀对元件后表面划痕的形貌结构及损伤性能的影响,探索损伤阈值提升的原因.时域有限差分算法理论计算结果表明:对于含有50 nm直径氧化锆颗粒的划痕,对入射光调制引发场增强的最大值是入射光强的6.1倍,且最强点位于划痕内部氧化锆颗粒附近,而结构相同但不含杂质的划痕引发的最大场增强为入射光强的3.6倍,最强区位于划痕外围;HF酸刻蚀能够有效去除划痕中的杂质,改变划痕结构,增加其宽深比值,经刻蚀的划痕对入射光调制引发场增强降低到入射光强的2.2倍.实验结果表明,经过深度刻蚀的划痕初始损伤阈值较刻蚀之前提高一倍多;光热弱吸收测试仪测试刻蚀后划痕对1 064 nm激光的吸收最大值仅为230 ppm.HF酸刻蚀同时可以提升元件整体损伤阈值,由于元件上无缺陷区域损伤阈值随刻蚀的深入先增加后降低,因此HF酸刻蚀应进行到元件损伤阈值提升到最大值为止.

关键词: HF酸刻蚀 熔石英 亚表面划痕 损伤特性

Mechanisms of HF Solution Improving Damage Properties of Fused Silica Subsurface Cracks

WANG Feng-rui, ZHENG Zhi, LIU Hong-jie, HUANG Jin, ZHOU Xin-da, JIANG Xiao-dong, WU Wei-dong, ZHENG Wan-guo

Laser Fusion Research Center, China Academy of Engineering Physics, Mianyang, Sichuan 621900, China

Abstract:

Fused silica optic was etched by HF solution, the morphology and damage properties of micro subsurface cracks were studied, and factors increased crack damage properties were explored. Finite difference time domain algorithm was used to calculate light intensification in the vicinity of cracks. Calculation results show that light intensification caused by crack contained with ZrO₂ particle (diameter 50 nm) is 6.1 times of the incident light, and the maximum intensity lies inside the crack and close to the particle. However the light intensification caused by crack with the same structure and without particles inside is 3.6 times of the incident light, and the maximum intensity lies outside the crack. By HF etching, contaminations in crack are eliminated, breath depth ratio of the crack is increased, and light intensification caused by the etched crack is only 2.2 times the incident light. Experimental results also indicate that damage threshold of deeply etched crack is increased by one time, and 1 064 nm absorption of it is only 230 ppm. Damage performance of crack free area is also improved by HF ethcing, but damage threshold of the crack free area does not increase as along as etching proess goes on. It begins to decrease after reaching a maximum value, thus etching process will terminate till damage threshold of the crack free area reaches its maximum value.

Keywords: HF etching Fused silica Subsurface crack Damage properties

收稿日期 2011-09-14 修回日期 2011-11-02 网络版发布日期

DOI: 10.3788/gzxb20124103.0253

基金项目:

国家自然科学基金(61078075,60908023)资助


通讯作者: 蒋晓东(1970-),男,研究员,主要研究方向为新型材料及强激光领域.Email:jiangxdong@163.com

作者简介:

参考文献:

[1] 孙承伟,陆启生,范正修.激光辐照效应[M].北京:国防工业出版社,2002:280-286.

[2] BLOENBERGEN N. Role of cracks, pores, and absorbing inclusions on laser induced damage threshold at surfaces of transparent dielectrics

[J]. *Applied Optics*, 1973, 12(4): 661-664. 

[3] GÉNIN F Y, SALLEO A, PISTOR T V, *et al.* Role of light intensification by cracks in optical breakdown on surfaces

扩展功能

本文信息

- ▶ Supporting info
- ▶ PDF(1714KB)
- ▶ HTML
- ▶ 参考文献

服务与反馈

- ▶ 把本文推荐给朋友
- ▶ 加入我的书架
- ▶ 加入引用管理器
- ▶ 引用本文
- ▶ Email Alert
- ▶ 文章反馈
- ▶ 浏览反馈信息

本文关键词相关文章

- ▶ HF酸刻蚀
- ▶ 熔石英
- ▶ 亚表面划痕
- ▶ 损伤特性


本文作者相关文章

[J]. *Journal of the Optical Society of America A*, 2001, 18(10): 2607-2616. 


[4] STEVENS-KALCEFF M A, STESMANS A, WONG J. Defects induced in fused silica by high fluence ultraviolet laser pulses at 355 nm

[J]. *Applied Physics Letters*, 2002, 80(80): 758-760.

[5] NEAUPORT J, LAMAIGNERE L, BERCEGO L H, *et al.* Polishing-induced contamination of fused silica optics and laser induced damage density at 351 nm


[J]. *Optics Express*, 2005, 13(25): 10163-10171. 

[6] NEAUPORT J, AMBARD C, CORMONT P, *et al.* Subsurface damage measurement of ground fused silica parts by HF etching techniques

[J]. *Optics Express*, 2009, 17(22): 20448-20456. 

[7] XU Shi-zhen, JIANG Xiao-dong, ZHENG Wan-guo, *et al.* Effects of pre-conditioning on 355 nm laser-induced damage growth of fused silica

[J]. *High Power Laser and Particle Beams*, 2010, 22(7): 1436-1440. 徐世珍, 蒋晓东, 郑万国, 等. 预处理对355 nm激光作用下熔石英损伤增长的影响

[J]. *强激光与粒子束*, 2010, 22(7): 1436-1440. 

[8] XU Shi-zhen, LÜ Hai-bing, TIAN Dong-bin, *et al.* Effects of acid etching depth on 355 nm laser induced damage threshold of fused silica

[J]. *High Power Laser and Particle Beams*, 2008, 20(5): 760-764. 徐世珍, 吕海兵, 田东斌, 等. 酸蚀深度对熔石英三倍频激光损伤阈值的影响

[J]. *强激光与粒子束*, 2008, 20(5): 760-764.

[9] SURATWALA T I, WONG L L, MILLER P E, *et al.* Sub-surface mechanical damage distributions during grinding of fused silica

[J]. *Journal of Non-crystalline Solid*, 2006, 352(52-54): 5601-5617.

[10] ZHU Zhi-hong, YE Wei-min, JI Jia-rong, *et al.* Transmission properties research of photonic crystal slab W3 waveguide with the use of the parallel 3D FDTD algorithm

[J]. *Acta Photonica Sinica*, 2006, 35(6): 815-818. 朱志宏, 叶卫民, 季家榕, 等. 用三维并行时域有限差分算法研究光子晶体薄板W3波导传输特性

[J]. *光子学报*, 2006, 35(6): 815-818.

[11] SHENTU Wei-jin, CAI Chun, DAI Jing-cai, *et al.* Boundary condition and initial condition in the time-domain beam propagation methods applied to study planar waveguides

[J]. *Acta Photonica Sinica*, 2005, 34(4): 337-341. 申屠伟进, 蔡纯, 戴劲草, 等. 平面光波导器件时域有限差分束传输法分析中边界和初始条件的处理


[J]. *光子学报*, 2005, 34(4): 337-341.


[12] WANG Feng-rui, HUANG Jin, LIU Hong-jie, *et al.* Laser induced rear-surface-crack damage properties of fused silica etched with HF solution


[J]. *Acta Physica Sinica*, 2010, 59(7): 5122-5127. 王凤蕊, 黄进, 刘红婕, 等. 激光诱导HF酸刻蚀后熔石英后表面划痕的损伤行为研究

[J]. *物理学报*, 2010, 59(7): 5122-5127.

[13] WANG Feng-rui, LIU Hong-jie, HUANG Jin, *et al.* Simulation of light intensification induced by defects of polished fused silica

[J]. *Chinese Physics Letter*, 2011, 28(1): 014206. 

[14] HAMZA A V, SIEKHAUS W J, RUBENCHIK A M, *et al.* Engineered defects for investigation of laser-induced damage of fused silica at 355 nm. *SPIE*, 2002, 4679: 96-107. 

[15] CAMP D W, KOZLOWSKI M, SHCEHAN L M, *et al.* Subsurface damage and polishing compound affect the 355 nm laser damage threshold of fused silica surfaces. *SPIE*, 1998, 3244: 356-364. 

本刊中的类似文章

反馈人	<input type="text"/>	邮箱地址	<input type="text"/>
反馈标题	<input type="text"/>	验证码	<input type="text" value="0152"/>
	<input type="text"/>		