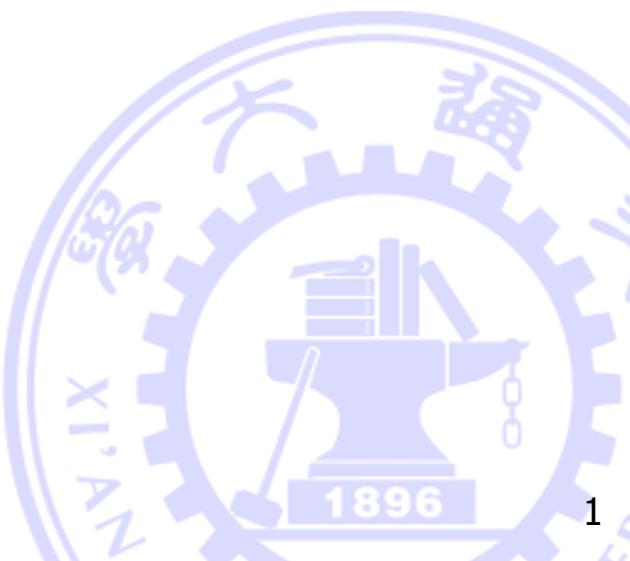




光学元件亚表面损伤研究进展

西安交通大学机械工程学院



研究进展

1. 提出一种全息反演的亚表面损伤检测方法，能够有效地进行多种损伤参数的测量。

- ✓ 通过腐蚀过程的正向仿真和逆向反演，可有效地获得亚表面损伤大小和分布特征；
- ✓ 结合图像处理和腐蚀各向异性，能够快速获得光学元件表面亚表面损伤的信息；
- ✓ 提供一种新型的亚表面损伤的全息反演方法。

2. 推导了磨削样品SR和SSD的理论计算模型，结合试验分析，结果表明：

- ✓ 磨轮转速和 $v_s/v_w \uparrow$ ，或进给速度和磨削深度 \downarrow ，SR和SSD \downarrow ；
- ✓ 最大的影响因子是磨轮转速，其次是进给速度，最后是磨削深度；
- ✓ 磨轮转速和进给速度的交互效应较大；
- ✓ 构建的理论模型能够很好地评估SR和SSD。



研究进展

3. 构建了抛光样品SR和SSD在刻蚀过程中的演化模型，结合试验表明：

- ✓ 随着刻蚀时间的增加，裂纹的宽度逐渐增加，而深度保持不变；
- ✓ 裂纹的SR先急剧增加，而后缓慢增加，最后趋于稳定；
- ✓ 考虑了HF浓度、刻蚀温度和扩散系数对刻蚀速率的影响，所建立的演化模型能够有效评估SR和SSD的变化规律。

4. 得到了抛光样品透射率和激光损伤性能在化学刻蚀过程中的演化规律及机理。

- ✓ 随着刻蚀时间的增加，高裂纹密度的光学元件的透射率先降低后增加；
机理：随着裂纹长度、宽度和高度的增加或者裂纹间距的降低，散射强度比会增加；
- ✓ 随着刻蚀时间的增加，光学元件的激光损伤阈值先增加而后降低；
机理：裂纹或划痕附近的场增强因子会瞬间降低，而沉积物附近的场增强因子会显著增加。裂纹和沉积物的耦合作用会带来更大的场增强因子。

亚表面损伤的研究成果

1. Xiao Huapan, Chen Zhi, Wang, Hairong, et al, Effect of grinding parameters on surface roughness and subsurface damage and their evaluation in fused silica, *Optics Express*, 26(4) 4638-4655, 2018
2. Huapan Xiao, Hairong Wang, Zhi Chen, et al, Effect of brittle scratches on transmission of optical glass and its induced light intensification during the chemical etching, *Optical Engineering*, 56(10) 105101, 2017
3. Huapan Xiao, Hairong Wang, Guanglong Fu, et al, Surface roughness and morphology evolution of optical glass with micro-cracks during chemical etching, *Applied Optics*, 56(3) 702-711, 2017
4. Hairong Wang, Hongfeng Chen, Guanglong Fu, et al, Relationship between grinding process and the parameters of subsurface damage based on the image processing, *International Journal of Advanced Manufacturing Technology*, 83(9-12) 1707-1715, 2016
5. Wang Hairong, Chen Hongfeng, Xiao Lihui, et al, Fast Predicting Statistical Subsurface Damage Parameters of the K9 Sample, *International Journal of Optomechatronics*, 9(3), 248-259, 2015
6. Hairong Wang, Guanglong Fu, Lihui Xiao, et al, Accuracy of the subsurface damage parameters calculated by the FD algorithm, *Journal of the European Optical Society*, 10(15056) 2015
7. Wang Hairong, Guan Cheng, Zhang Bike, et al, 3D topography evolution of micro cracks of subsurface damages during etching process, *Int. J. Nanomanufacturing*, 9(5/6) 446-456, 2013

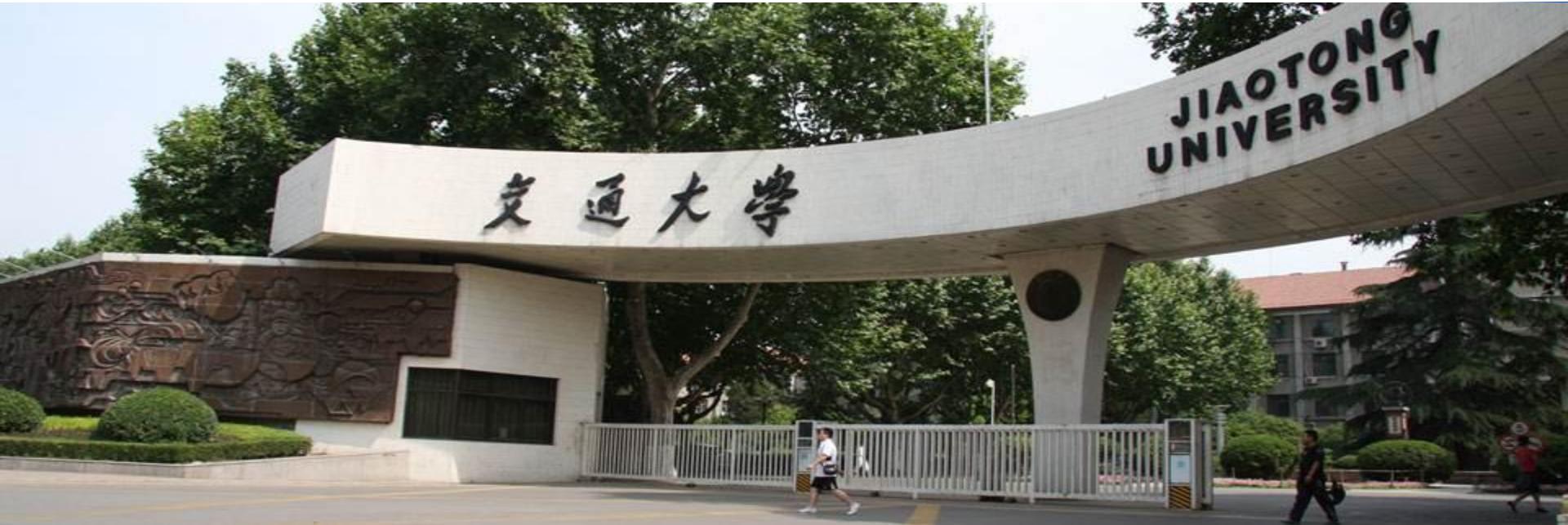
亚表面损伤的研究成果

8. Huapan Xiao, Zhi Chen, Hairong Wang, et al, Effect of micro-crack and reaction product on laser damage performance of optical glass during chemical etching, Proceedings of SPIE, 10713, 1071309, 2018
9. Hairong Wang, Zhi Chen, Huapan Xiao, et al, Combined modulation to incident laser by subsurface crack and contaminant on fused silica, Proceedings of SPIE, 10713, 1071312, 2018
10. Huapan Xiao, Hongfeng Chen, Hairong Wang, et al, The influence of subsurface damage's micro crack on the optical properties of the optical components, Proceedings of SPIE, 10255, 1025510, 2017
11. Hairong Wang, Hongfeng Chen, Guanglong Fu, et al, The Influence of Grinding Process Parameters on Transmittance and Absorbance of the Optical Components, 3M-NANO, 31-34, 2015
12. Hairong Wang, Hongfeng Chen, Lihui Xiao, et al, Fast predicting statistical subsurface damage parameters of the K9 sample, 3M-NANO, 197-201, 2014
13. Hairong Wang, Lihui Xiao, Hongfeng Chen, et al, Application of finite difference to study morphology evolution during etching the optical surface with subsurface damage, Proceedings of SPIE, 9449, 94493L (1-6), 2014
14. Hairong Wang, Bike Zhang, Lihui Xiao, et al, Investigation on HF based etching of the polished K9 glasses and its application in the subsurface damage, 3M-NANO, 229-233, 2013
15. Wang Hairong, Guan Cheng, Zhang Bike, et al, 3D topography of the micro cracks of subsurface damages by etching process, 3M-NANO, 355-359, 2012

亚表面损伤的研究成果

16. 王海容等，光学元件亚表面损伤的化学刻蚀测量方法、辅助实验装置及试验方法，申请号：201711132418.8
17. 王海容等，一种硬脆性高精元件亚表面损伤程度的表征方法，授权号：201310044339.7
18. 王海容等，一种光学玻璃的高深宽比微结构加工方法，授权号：201210014024.3
19. 王海容等，脆性材料亚表面损伤层微裂纹全息反演检测方法，授权号：201110270926.9
20. 王海容等，基于温度场有限元分析仿真的亚表面损伤检测方法，授权号：201010270268.9
21. 王海容等，一种检测球面光学元件亚表面损伤程度表征参数的方法，授权号：201410330795.2





谢谢大家

