

激光材料和光学元件

重复激光脉冲作用下薄膜损伤演化规律研究

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摘要: 为了深入研究重复激光脉冲的能量效应对光学薄膜的烧蚀机理, 采用实验观测与热力学分析相结合的方法进行了研究。通过观察光学薄膜烧蚀形貌随入射激光脉冲数量增加发生改变的典型形貌特征, 分析了激光与等离子体相互作用的热力学过程, 得到了在激光重复脉冲作用下光学薄膜的损伤特性及其演化规律。结果表明, 薄膜在重复脉冲作用下, 其表面会变得粗糙, 这会大大增加对激光的吸收效应, 从而加速了薄膜的破坏, 最终被完全去除而露出基底; 同时, 烧蚀物会在热膨胀作用下向激光作用区域外扩散, 在激光烧蚀中心区域外进行沉积, 而形成更大范围的污染。由于激光光强为高斯分布, 重复脉冲作用的效应主要是对在光束中心区域的薄膜进行集中烧蚀, 会不断增加烧蚀的损伤程度, 而对烧蚀面积的增加效应极为有限。这一研究结果为重复激光脉冲对薄膜烧蚀机理的建立提供了参考。

关键词: 激光技术 重复激光脉冲 薄膜损伤 高斯光束 X射线衍射光谱

Accumulation effect of film damage under repetitive laser pulses

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Abstract: In order to study the accumulation effect of film damage under repetitive laser pulses, experimental observations and thermodynamic analysis were carried out. The morphologies damaged by single and multiple laser pulses were observed under a $5000\times$ microscope, then the thermodynamic process between the interaction of laser and plasma was analyzed. Finally the evolution rule of the film damage was found. Both of these two damaged morphologies can be explained by the thermodynamic interactions between laser and laser plasmas. The research results show that: the rough surface of thin film is induced by the laser pulses, which will absorb more laser energy than the beginning. The melt will be removed by the stronger ablation and will be accumulated outside of the laser working area. Since the laser energy is Gaussian distributed, the damaged of multiple laser pulses is centralized and the ablation is limited at the center of laser beam only. This result is a preference for study about film ablation under repetitive laser pulses.

Keywords: laser technique repetitive laser pulse thin film damage Gaussian beam X-ray diffraction spectra

收稿日期 2013-05-08 修回日期 2013-06-06 网络版发布日期 2014-01-06

DOI: 10.7510/jgjs.issn.1001-3806.2014.02.014

基金项目:

国家重大专项课题资助项目 (GFZX0205010803.220)

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