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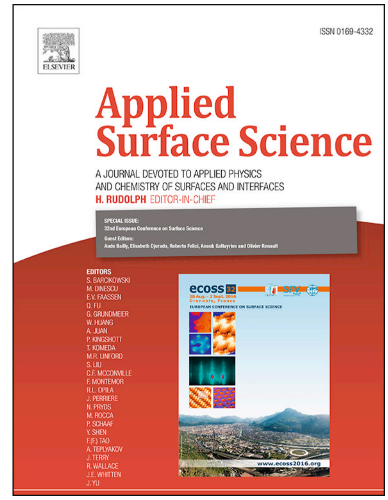

Full Length Article

Oxygen plasma etching of fused silica substrates for high power laser optics

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Oxygen plasma etching of fused silica substrates for high power laser optics

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Abstract

Laser damage resistance of a transparent optical component significantly depends on its substrate surface quality. In this work low energy oxygen plasma etching of fused silica (FS) substrates was investigated in terms of plasma ion energy and etching depth. Laser induced damage threshold (LIDT) and surface roughness of experimental samples were measured and compared. The LIDT of plasma treated uncoated FS substrate increased from 5.0±0.3 J/cm^2 up to 75±4 J/cm^2 for 355 nm laser ns pulses without any surface roughness deterioration. Anti-reflective (AR) optical interference coating for 355 nm wavelength was deposited on plasma etched and non-etched substrates. Measured LIDT of plasma etched and AR coated component was 3.4 times higher comparing to coated non-etched substrate case and reached 14±0.7 J/cm^2. These results demonstrate successful application of low energy oxygen plasma etching for improving laser induced damage performance of uncoated and AR coated fused silica substrate without deterioration of surface roughness. This application could be also successfully extended for production of other transparent high power UV laser optics like polarizers, beam splitters, etc.

Keywords: plasma etching; subsurface damage; fused silica etching; LIDT; AR coatings; high power UV coatings

1. Introduction

Necessary guidance of laser beam within the laser system is performed using optical components, which basically are polished substrates coated with thin layers of dielectric materials. They can reflect, transmit, polarize or split the incident light beam. Output power of emerging laser pulse is usually limited by optical resistance of installed optical elements within the laser. Low absorption, low scatter and high laser damage resistance are typical desirable properties of optical components which are also dependent on bulk and surface properties of used substrate. Fused silica is perhaps the most common material used in optical element fabrication for UV laser applications due to its low absorption and high thermal stability.

Grinding, lapping or polishing of a substrate results in scratches, digs which are considered as sub-surface defects (SSD) [1-3] and contamination layer of polishing residuals like cerium oxides, etc. [4]. These defects lead to increased optical absorption and local electric field amplification of laser pulse [5,6]. Therefore polishing residuals and SSD’s are responsible for