Abstract

Modern optical laser beam guidance systems are necessary for many laser applications. These systems can consist of optical fibers as well as free space approaches using mirrors. Thus the transfer of the laser beam can be realised spatially flexible utilizing waveguide properties or rather quickly adaptable allowing other optical components to be implemented in the beam path. A typical application is for instance a galvo scanner consisting of two mirrors allowing the precise irradiation of the area of interest.

Optical components need to guarentee a safe and long-lasting operating time independent of the usage to prevent unscheduled process failure reducing accompanying cost and time expenses. With regards to this, the laser-induced damage threshold (LIDT) is one of the most important physical quantities to characterize the long-term process suitability of an optical component for given laser parameters. Consequently, detailed standards were developed in the past to create a unified measurement routine allowing a straight-forward comparison between multiple institutes. However, laser systems with increasing output power are developed each year, the optical systems are getting more compact, the components quality rises and different as well as novel materials are used. This leads to deviations in the damage behavior and the impact of single laser-induced damage sites on the components properties on which the measurement routines are based on.

For these reasons, this work presents suitable measurement routines to determine the LIDT of modern optical components which have relatively specific damage characteristics. The investigations are focused on the nanosecond pulse induced damages in polymer optical fibers, as well as the thermal-driven damage mechanism of optical mirrors by continuous wave lasers with powers of several kilowatts. These components are of high interest due to their damage behavior. Damages usually occur in polymer materials in the nanosecond pulse visible range in the bulk material which requires the consideration of the complex varying intensity distriution during the propagation within the fiber. In contrast, the damage behavior of mirrors in the continuous wave regime is governed by thermal mechanisms but previous appro-

ximations are not suitable regarding todays small optical components. The results regarding these scientific challenges and the development of suitable measurement routines are presented in detail in this work.
A reliable determination of the LIDT using an adapted measurement procedure and a corresponding evaluation of the data was demonstrated in the studies for two beam guiding components. The damage behavior of polymer optical fibers in dependence of the complex intensity distribution along the fiber was observed, and the cause is led back to damage mechanisms reported in the literature. The investigations of mirrors under continuous wave laser irradiation show a fundamentally thermal mechanism. Due to the high quality of the mirrors the pure instrinsic damage behavior is dominated in some cases by the absorption of defects. Application-driven studies using a galvo scanner under its most critical conditions proofed the generation of locally thermal-driven material modifications, which however did not limit the process.
Key words: Laser-induced damage threshold, polymer optical fiber, hybrid mirrors