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Broadband grating waveguide mirror for high efficiency pulse compression and high-power high efficiency green laser

Background

Processing highly reflective materials such as copper poses a particular challenge in laser processing, especially in terms of reproducibility and avoiding undesired spattering. On the other hand, this type of processing offers many advantages, particularly when it comes to joints that are difficult to access.

Problem

Green wavelength laser light is ideal for processing copper because the radiation is very well absorbed by the material – six times better than infrared radiation (at room T°). Green laser systems are already available, but usually their power is limited due to undesired effects (e.g. thermal lensing) occurring with polarization and wavelength selective optical components (e.g. Brewster windows, etalons, etc.) that are required and used for the second harmonic process. Often, several of these components are required in the cavity which leads to a cumbersome system and additional losses.

Solution

The principle of polarization and wavelength selective "grating waveguide mirrors" developed at the Institut für Strahlwerkzeuge (University of Stuttgart) allows an efficient and stable frequency conversion with simultaneous polarization and wavelength selection. Using a single highly efficient optical element can yield a very high output power. The new configuration allows to almost double the total efficiency having a diffraction efficiency higher than 99.8%. Such a mirror can be used as cavity end-mirror or output coupler. The developed components were demonstrated to sustain more than 125 kW/cm² (at an incident power of 40 KW) making them exceptionally robust and efficient at the same time.

The grating waveguides can also be used for pulse compression, having a diffraction efficiency of over 99 % for a spectral bandwidth of several nanometers. The device also has a high laser induced damage threshold of more than 3 J/cm2 for a nanosecond regime.

Contact
Dipl.-Ing. Julia Mündel
TLB GmbH
Ettlinger Straße 25
76137 Karlsruhe | Germany
Phone +49 721-79004-0
muendel@tlb.de | www.tlb.de

Development Status
Validation / TRL4

Patent Situation
EP 3111259 A1 pending

Reference ID
13/027TLB

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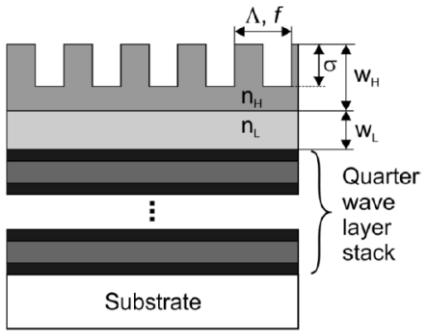

Schematic example of a grating waveguide mirror [Source: University of Stuttgart].

Advantages

- minimum reflection loss at high damage threshold
- multi-kW power with green laser and thus automated processing of copper
- high efficiency with good beam quality thanks to a highly efficient optical element
- robust component
- easy to implement and cost-effective

Application

The configuration of a grating mirror presented here enables a previously unattainable increase in power for green-wavelength lasers. Other applications of this technology are pulse compressors or "dense wavelength multiplexing" of high-power lasers (diodes, fibers or solid-state lasers).