Selective Glass Surface Modification with Picosecond Laser Pulses for Spatially Resolved Gloss Reduction (M402)

Thomas Herrmann, Melissa Piontek, Johannes L'huillier, *Photonik-Zentrum Kaiserslautern e.V., Kaiserslautern, Germany*

Today, gloss and other properties describing the reflectance of a surface are important in a wide range of applications, e. g. displays of mobile phones and laptops. Influencing the visual appearance and therewith the quality of an object, an inadequate gloss can lead to rejection of an item. Hence, these properties have to be precisely adapted to each application. Especially gloss reduction of spatially selected parts is quite challenging using common techniques like chemicals etching: Etch masks are required to prohibit the modification of the surrounding surface. This is sophisticated, expensive and comparatively inflexible. Unlike with mask based processes laser micromachining results in a very flexible tool for the modification of optical properties of selected surface areas. Furthermore by using ultrashort pulses, the surface structuring is precise, it causes minimal thermal damage outside the micro-machined area and shows a maximum degree of flexibility in terms of geometry of the fabricated structures.

Our approach aims for the selective adjustment of the specular gloss level of soda-lime glass surfaces by applying picosecond laser pulses at 1064 nm. The size and the morphology as well as the density and the order of the structures have been tailored. A detailed investigation of the structures generated by picosecond pulses by means of an optical microscope and atomic force microscope (AFM) is presented. Based on the findings of the AFM measurements simplified surface structures were modeled in *SolidWorks* and the corresponding laser beam reflection was simulated in *Zemax*. Finally, a numerical model of the specular gloss of laser modified surfaces was implemented and it was compared with experimental results. As a result, the novel method of laser based gloss reduction provided a defined adjustment of the specular gloss between 30 GU and 150 GU. The paper will discuss advantages but also specific limitations concerning the laser based method.

Keywords: Surface Property Modification, Specular Gloss, Spatially resolved gloss reduction, Picosecond Laser Pulses

Ultrafast Laser Ablation of Silica Optical Fibers for Fabrication of Diaphragm/cantilever-based Photonic Microsensors (M410)

Lei Yuan, Jie Liu, Hai Xiao, *Clemson Univ., Clemson, SC, USA*, Yinan Zhang, *Lumentum, San Jose, CA, USA*

Recent process in ultrafast laser three-dimensional (3D) micro- and even nano-scale micromachining technique has been proven an effective and flexible way for high precision fabrication of micro devices and structures in various transparent materials, such as fused silica glass and single crystal sapphire materials. When used for ablation, ultrafast laser has many unique characteristics, including negligible cracks, minimal heat-affected-zone, low recast, and high precision. The merits of this advanced manufacturing technique enable the unique opportunity to fabricate novel photonic microsensors with enriched functionality, enhanced intelligence, and unprecedented performance.

Recently, all-optical fiber sensors have attracted increasing interest and emerged as a mainstream technology in industrial sensing applications due to their advantages of high sensitivity, compactness, immunity to electromagnetic interference (EMI), and resistance to corrosion. In addition, all-optical fiber sensor is a good candidate to address the monitoring needs within extreme environment conditions, such as high temperature, high pressure, corrosive/erosive atmosphere, and large strain/stress.

A series of high performance all-optical fiber Fabry-Perot (FP) sensing probes were fabricated using our home integrated femtosecond (fs) laser micromachining system. Both diaphragm- and cantilever-based structures that can form FP cavity using high precision fs laser ablation process are involved. The dimensions of diaphragm and cantilever beam located at the tip of the fiber can be well controlled via this powerful tool. A number of fs laser micro machined all-optical fiber sensor probes are summarized in this review paper, including diaphragm-based fiber optic pressure/acoustic sensors, a cantilever-based fiber optic acoustic sensor and a hybrid pressure/temperature sensor.

Keywords: Femtosecond laser micromachining, Fiber optic sensors

The Effect of Pulse Interval on Multi-burst Mode Ultra Short Pulsed Laser Ablation (M404)

Sanghoon Ahn, Jiyeon Choi, Sung Hak Cho, *Korea Institute of Machinery and Materials, Daejeon, Republic of Korea*, Lee SeungHwan, *Korea Aerospace Univ., KyungGiDo, Republic of Korea*

Since the ablation rate is directly related to production cost, a large number of studies have been conducted. Previous studies have been elucidated the key parameters which affects to the ablation rate, such as fluence, center wavelength, repetition rate, and duration of laser pulse. A recipe of each processes are established based on these parameters. However, aforementioned parameters are limited by characteristics of laser sources and it is very difficult to develop proper laser sources for each process applications. Therefore, the process method which can exceed the limitation of conventional ablation rate needs to be developed. Recently, manufacturers of lasers released multi burst mode ultrashort pulsed lasers and several laser system companies demonstrated the feasibility of fast and fine processing of display panel glasses with multi burst mode. However, it has not been carefully studied the effect of pulse interval on multi burst mode processing. Therefore, in this study, we manipulated pulse interval from femtosecond regime to nanosecond regime and investigated the ablation rate at each regimes. The multi burst mode of femtosecond laser was generated by splitting and merging of pulse with polarized beam splitter. And the manipulation of pulse interval was executed by changing of optical path length differences of each split pulses.

Keywords: Multi burst mode, Ultra short pulsed laser, Ablation rate, Femtosecond