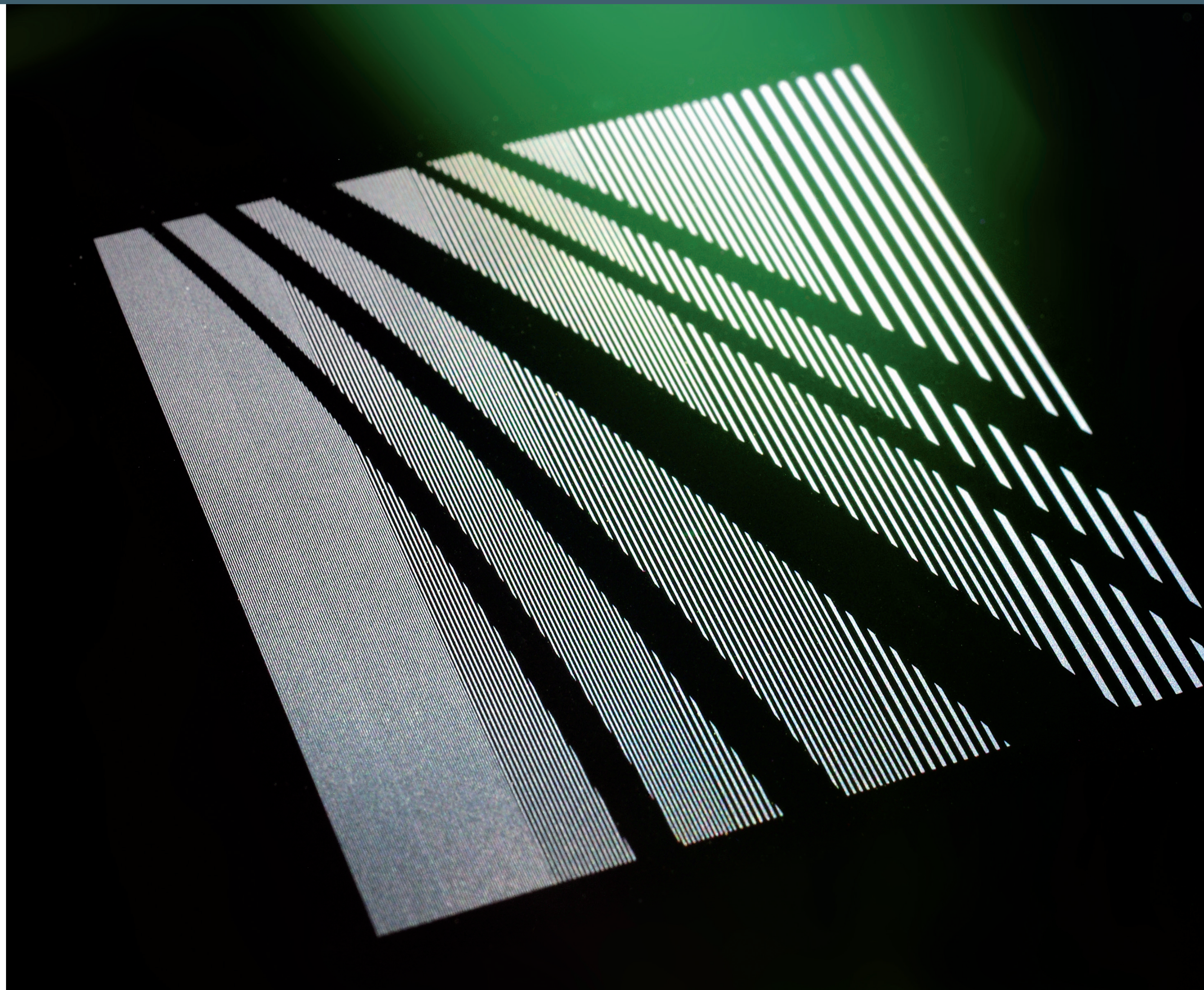
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

LASER ABLATION FOR THIN FILM STRUCTURING



DQS certified by
DIN EN ISO 9001:2015
Reg.-No. 069572 QM15

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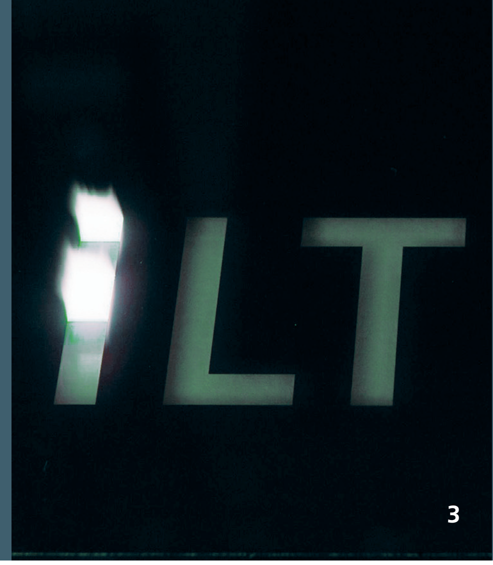
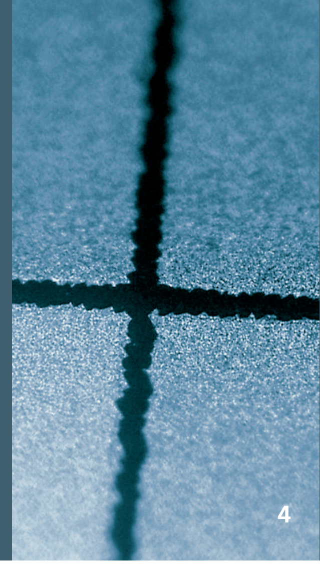
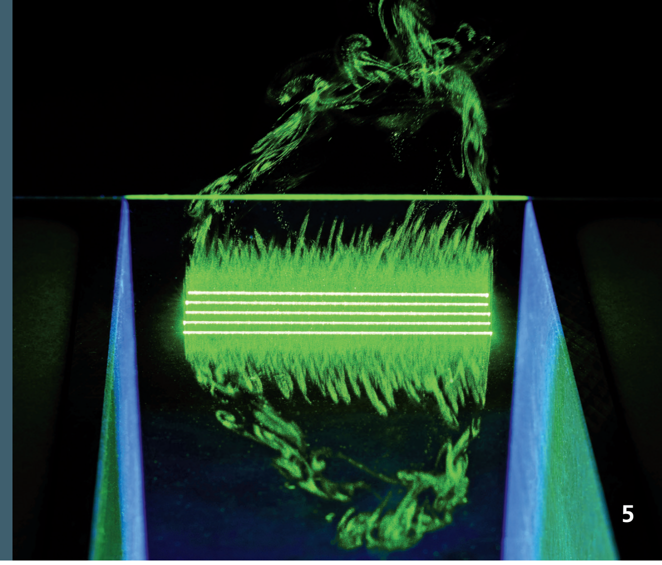
Fraunhofer Institute for Laser Technology ILT

The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing technology and industrial laser processes. This includes laser cutting, ablation, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, Fraunhofer ILT develops photonic components and beam sources for quantum technology.

Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing lines. The institute focuses on research and development for industrial and societal challenges in the areas of health, safety, communication, production, mobility, energy and environment. Fraunhofer ILT is integrated into the Fraunhofer-Gesellschaft.







LASER ABLATION FOR THIN FILM STRUCTURING

Many innovative products are based on thin films made out of conductive, semi-conductive or insulating materials. These materials are deposited on glass or foils and exhibit thicknesses in the nano and micrometer range. For example, screens for smart phones, flat lighting elements or flexible solar modules are produced from multiple layers of such films. The functionality of these components is determined by two-dimensional structures inside the film itself, which can be generated flexibly and economically by means of laser radiation. The Fraunhofer ILT is currently developing industry-ready processes to generate high-resolution structuring of thin films and the required process engineering for high throughput.

Monolithic Series Interconnection for Rigid and Flexible Solar Modules

Thin films in semi-conductor electronics have to fulfill, in essence, both electrical and optical functions. Many components manufactured using thin films consist of two electrically conductive layers with a semi-conducting layer in between them. In a solar cell the semi-conductor enables solar light to be transformed into electrical current, while the electrical conductors convey the current to an electrical circuit. For this to function, however, one of the electrodes has to be transparent. In comparison to metals, the transparent conductive oxide used here exhibits lower conductivity. To reduce the current flow and the ohmic losses resulting from this, Fraunhofer ILT has structured the layers, thus generating a series interconnection of narrow cell strips. This requires laser ablation processes that can be adapted to every layer and every material. The use of ultra-short pulsed lasers enables physical processes which are not possible when longer pulse durations are used. Through these innovations, new process windows are opened and industry-ready processes become viable.

Structuring Transparent Conductive Layers for Organic Electronics

Layers with thicknesses fewer than one hundred nanometers are extremely sensitive and can easily degrade or lose their functionality. The reasons for this can be particle debris or delamination of irradiated layers, thermal damage of neighboring areas and other layers, as well as the generation of bulges in the outer areas of the ablations. In order to achieve a sufficiently high quality, parameters – such as gas atmosphere, spatial and temporal pulse shape, and subsequent cleaning – have to be taken into account while the process is developed. Alternatively, one can fall back on hybrid processes such as thermochemical ablation. In particular, during structuring of the transparent conductive Indium tin oxide (ITO) – commonly used in organic electronics – bulges can form, which are problematic for subsequent layering. The Fraunhofer ILT is developing processes which can significantly reduce these sources of defects according to the requirements of the application, for example by using adapted wavelengths, pulse durations and ablation strategies.

OLEDs as Next Generation Light Sources

Organic Light-Emitting Diodes (OLEDs) have great potential to become an illumination technology of the future on account of their excellent properties: low energy consumption, excellent color brilliance, low weight and low thickness.
For this technology to make it to mass production, however, the current short lifetime of the components needs to be improved. For example, when these organic materials contact air, they begin to degrade. Therefore, a technically mature encapsulation by using barrier layers is required. For electrical contacts, however, these barrier layers have to be removed locally and selectively. The properties of the transparent electrodes, which exhibit similar optical characteristics as the barrier layer, may not, however, be changed by the ablation. Homogenously distributing the luminance poses a further difficulty for a large-scale implementation of OLEDs. Since the thin transparent layers used exhibit comparatively low conductivity, the luminosity decreases as the distance to the contact increases. Therefore, a fine grid made of metal conducting paths is applied to the conductive, transparent layer, in order to increase conductivity. Another possibility of reaching homogenous luminance is the monolithic series interconnection of the OLEDs.

Production Engineering for Large Formats and High Resolutions

Competitive process engineering for producing organic electronics requires high speeds with ablation rates of several mm^2/min, structure sizes < 10 µm and applicability to several m^2. Structured printing at high speeds enables structure sizes of down to approx. 10 µm. When laser structuring is also used, the resolution and the productivity can be increased significantly. To generate complex structures – e.g. for manufacturing electronic circuits – at high surface rates, innovative approaches to beam guiding and shaping are required. At the Fraunhofer ILT, various approaches are being pursued to improve process efficiency, e.g. the development of a polygon scanner, which enables the two-dimensional structuring of thin films with extremely high speeds of several hundred meters per second, and multiple beam splitting by using diffractive optical elements.

Relevant Beam Sources

- 10 ps, power up to 100 W, wavelengths 1064/532/355 nm
- 200 fs, power up to 10 W, wavelengths 1028/514/343 nm
- 100 ns, power up to 1.5 kW, wavelength 1064 nm, 600 µm fiber
- 10 - 500 ns, power up to 70 W, wavelength 1064 nm
- Excimer laser, wavelengths 193/248 nm

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1 Laboratory setup for the development of structuring processes.
2 Free form ablation of thin films.
3 Ultra-short pulse structuring of silicon-based thin films.
4 Micrograph of isolation grooves in Molybdenum.
5 Ablation of ITO and PET.