
L A S E R C O L L O Q U I U M

Scaling and Precision in Ultrashort Pulsed Laser Processing: From Glass to Semiconductor Materials

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ABSTRACT

Fraunhofer ILT addresses nearly the entire spectrum of laser research and development. Within the groups Micro- and Nanostructuring and In-Volume Structuring & Lithography, five teams translate ultrashort-pulse (USP) laser processes into applications for micrometre-precise processing of a broad range of materials. The developed processes include surface processing, thin-film ablation, drilling, involume structuring, and polishing.

This presentation focuses on two central objectives: reducing processing times through scalable process strategies and increasing precision by extending current process limits. Scaling approaches include the controlled application of higher average laser powers using burst-mode processing, faster beam deflection at increased repetition rates, and advanced beam shaping, such as multi-beam processing and optical stamping. Higher precision can be achieved through closed-loop process control based on in-line sensing, shorter wavelengths towards the UV and DUV spectral ranges, shorter pulse durations, and aberration correction.

A particular focus will be placed on laser radiation around 2 μm , which enables new processes for semiconductor materials at wavelengths for which they are transparent. Building on concepts established for the in-volume structuring of glass, the presentation discusses the transfer of these approaches to semiconductor materials. Current challenges in the in-volume structuring of transparent dielectrics and corresponding solution strategies will be presented.

ABOUT THE SPEAKER

(born 1990) studied Physics at RWTH Aachen University from 2011 to 2016, completing both his Bachelor's and Master's degrees with a specialization in experimental condensed matter physics. From 2017 to 2021, he worked as a doctoral researcher at the Chair of Laser Technology (LLT) at RWTH Aachen University. His research focused on energy deposition during in-volume laser structuring of glass, particularly using burst-mode ultrashort laser pulses. Further topics included spatially and temporally resolved measurements of excitation dynamics in glass by pump-probe microscopy, spatial beam shaping using spatial light modulators (SLMs) for multi-beam generation and aberration correction, as well as laser-based glass cutting.

From 2022 to 2023, Martin Kratz served as Team Leader for "Glass Processing" within the Micro- and Nanostructuring Group at the Fraunhofer Institute for Laser Technology ILT. His work concentrated on ultrashort-pulse laser processing of glass, including selective laser-induced etching (SLE), laser ablation, in-volume structuring, and advanced beam shaping. Since 2024, he has been heading the group "In-Volume Structuring & Lithography" at Fraunhofer ILT. In this role, he is responsible for research and development activities in laser-based in-volume structuring and lithography, covering both glass processing and the ultrashort-pulse laser processing of semiconductor materials.

Laser semiconductors processing at Fraunhofer ILT

Dr. Serhiy Danylyuk

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ABSTRACT

Laser processes are used across semiconductor manufacturing, from ingot slicing and wafer dicing down to through-silicon vias, direct-write lithography and DUV/EUV patterning, with the industry continuously demanding higher spatial resolution, tighter control of the interaction volume, and minimal debris and defect generation. This talk presents how Fraunhofer ILT addresses these requirements through wavelength scaling into the UV, DUV and EUV range, combined with ultrashort-pulse (USP) processing.

Selected results are discussed: EUV and UV lithography; USP grooving of silicon, where short wavelengths enable sub-100 nm ablation depth control and sub-1 μm burr heights; high-speed dicing of SiC; and laser lift-off of GaN transistors with a 266 nm USP laser, achieving the first full-wafer USP-DUV lift-off with laser-induced damage confined to the buffer layer.

Finally, a prototype system for dynamically switchable, high-throughput μLED assembly, based on multibeam SLM-driven laser-induced forward transfer (LIFT) of GaN μLEDs , will be presented.

ABOUT THE SPEAKER

(born 1978) received his diploma in physics from Volyn State University, Ukraine, in 1999 and his PhD

in semiconductor physics from RWTH Aachen University, Germany, in 2005. From 2011 to 2019 he led

the EUV technology group at the Chair for Technology of Optical Systems (TOS) at RWTH Aachen University, developing new applications of EUV radiation for nanopatterning, microscopy, and thin-film characterization. His group designed and realized a compact laboratory EUV exposure tool based

on a discharge-produced plasma source, demonstrating Talbot, interference, and proximity lithography with resolutions down to 28 nm half-pitch, and established EUV reflectometry and spectrometry as characterization techniques for nanoscale thin-film systems.

Since October 2019 he has been with the Fraunhofer Institute for Laser Technology ILT in Aachen, where he leads the semiconductor structuring team. His current work focuses on novel industrial applications of DUV and UV laser technologies for the semiconductor industry, including sub-micrometer and sub-200 nm surface structuring, wafer dicing, thin-film processing, and selective surface functionalization. He is an author or coauthor of more than 100 scientific publications in semiconductor physics and applications of short-wavelength radiation.