UNIVERSITÀ DEGLI STUDI
DELL'INSUBRIA

"Laser Micromachining"

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Keywords: Microfabrication with pulsed lasers, beam shaping and its application to microfabrication, micromachining of transparent materials, drilling, cutting, surface machining.

Objectives: Micromachining of transparent materials, such as glass, polymers, quartz, sapphire, semiconductors, and diamond, using femtosecond and picosecond pulsed lasers, for the generation of micro- and nanostructures localized within the bulk of the material, or surface microstructures. Examples of applications: microfluidics, photonics, microelectronics, and quantum sensing.

Location: c/o Department of Science and Advanced Technology (DISAT), Via Valleggio 11, Como.

Organization: The facility brings together research groups with expertise in laser physics, nonlinear and quantum optics, and utilizes the ultrafast laser sources (Amplitude's Trident titanium-sapphire laser and Light Conversion's Pharos ytterbium laser) available at the UNO (Ultrafast Nonlinear Optics) laboratories and the Quantum Optics laboratory. The micromachining setup consists of lenses, mirrors, telescopes, a spatial light modulator (SLM), and microscope objectives for beam shaping, beam steering, and beam focusing onto the sample, as well as the Altechna Ltd. platform equipped with a motorized, software-controlled 3D sample support and movement structure. In addition, there is a sample imaging system to observe the effects of laser interaction in real time.

Sample characterization immediately following micromachining is performed using high-resolution optical microscopy (Nikon optical microscope).

Linkage with CRIETT's Technology Platforms and the University's Scientific Platforms:

The facility's activities are integrated within the University's Scientific Platform "Technologies for Energy, Health, and the Environment." Among the resources available to the facility are the Pharos fs-pulsed source, listed in the CRIETT inventory (Matter Characterization Platform, MAC27 instrument), and the Trident fs-pulsed source (Matter Characterization Platform, MAC25).

Publications:

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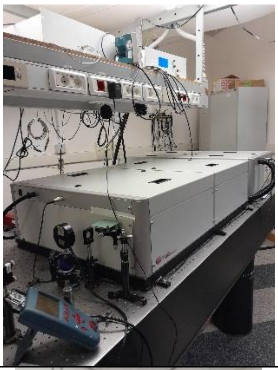
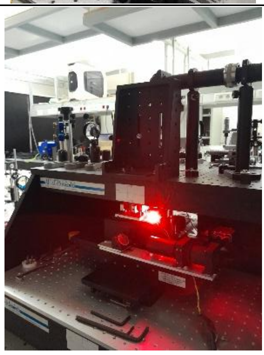
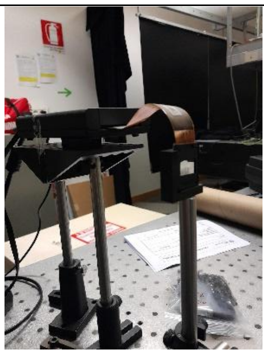
2. Britel, A. Kuriakose, E. Nieto Hernández, E. Corte, S. Ditalia Tchernij, P. Aprà, S. Sturari, N.-H. Amine, V. Pugliese, E. Redolfi, J. Forneris, P. Olivero, O. Jedrkiewicz, and F. Picollo, "*Comparative analysis of diamond graphitization approaches for 3D electrode fabrication",* J. Mater Sci: Mater Electron **36**, 1150 (2025).
3. Kuriakose, F. P. Mezzapesa, C. Gaudiuso, A. Chiappini, F. Picollo, A. Ancona, O. Jedrkiewicz, "*Bessel beam fabrication of graphitic micro electrodes in diamond using laser bursts*", Diamond and Related Materials **147**, 111316 (2024).
4. Kuriakose, A. Chiappini, P. Aprà, O. Jedrkiewicz, "*Effect of crystallographic orientation on the potential barrier and conductivity of Bessel written graphitic electrodes in diamond*", Diamond & Related Materials, **142**, 110760 (2024).
5. C. Ianhez-Pereira, A. Kuriakose, A. De Giovanni Rodrigues, A. L. Costa silva, O. Jedrkiewicz, M. Bollani, and M. Peron Franco de Godoy, "*Evaluation of microscale cristallinity modification induced by laser writing on Mn_3O_4 thin films",* Optical Materials **147**, 114609 (2024).
6. Kuriakose, A. Chiappini, B. Sotillo, A. Britel, P. Aprà, F. Picollo, and O. Jedrkiewicz, "*Fabrication of conductive micro electrodes in diamond bulk using pulsed Bessel beams"*, Diamond and related materials, **136**, 110034 (2023).
7. Kuriakose, M. Bollani, P. Di Trapani and O. Jedrkiewicz, "*Study of Through-Hole Micro-Drilling in Sapphire by Means of Pulsed Bessel Beams",* Micromachines **13**, 624 (2022).
8. N. Giakoumaki, G. Coccia, V. Bharadwaj, J. P. Hadden, A. J. Bennett, B. Sotillo, R. Yoshizaki, P. Olivero, O. Jedrkiewicz, R. Ramponi, S. M. Pietralunga, M. Bollani, A. Bifone, P. E. Barclay, A. Kubanek, and S. M. Eaton, "*Quantum Technologies in Diamond enabled by Laser Processing",* Appl. Phys. Lett. **120**, 020502 (2022);
9. V. V. Belloni, M. Bollani, S. M. Eaton, P. Di Trapani and O. Jedrkiewicz, "*Micro-Hole Generation by High-Energy Pulsed Bessel Beams in Different Transparent Materials*", Micromachines **12**, 455 (2021).
10. V. V. Belloni, V. Sabonis, P. Di Trapani, O. Jedrkiewicz, "*Burst mode versus single-pulse machining for Bessel beam micro-drilling of thin glass: study and comparison*", SN Applied Sciences **2**, 1589 (2020).

A) Facility di Microlavorazione laser	
	**Ultrafast amplified laser** (Trident, Amplitude) Titanium-sapphire laser source, ultrashort pulses, repetition rate 20 Hz, 800 nm, 38 fs, stretchable up to 15 ps, energy 12 mJ per pulse
	**Ultrafast amplified laser** (Pharos, Light Conversion) Ytterbium laser source, ultrashort pulses, 1030 nm, 190 fs, repetition rate 200 kHz–1 MHz, average power of the fundamental beam ≥6 W in the 3–200 kHz range. Single-pulse energy ≥2 mJ at any repetition rate ≤3 kHz
	**Motorized 3D handling platform for micromachining** Enables 3D positioning and translation of the sample with a resolution of 1 micrometer during laser micromachining
	**Spatial Light Modulator (SLM, Holoeye)** Spatial phase and amplitude modulator for laser beam shaping
	**Optical microscope (Nikon)** High-resolution optical microscope with phase contrast capability for the optical characterization of materials following laser micromachining