LUMOS LASER

Ultrafast Lasers in Precision Processing of Intraocular Lenses

EPIC Online Technology Meeting on Photonics for Vision and Eye Research

Dr. Altan YILDIRIM

03.June.2024

Ultrafast Laser Applications: Micromachining and Beyond

Industry, Medical, Science

LUMOS LASER

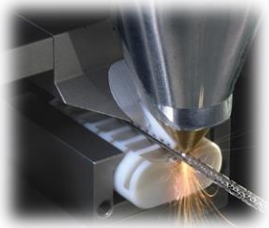
Already Industrialized

CONSUMER ELECTRONICS

Smart phones: chip dicing, microphone holes drilling, PCB drilling, glass cutting, etc., OLED Displays

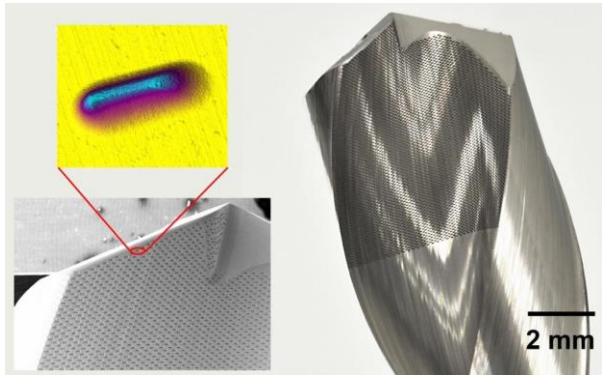
MECHANICAL COMPONENTS

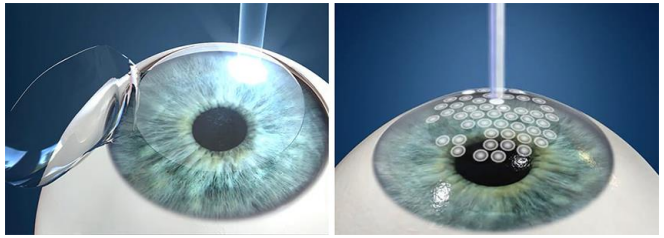
Medical Devices, Automotive Components, Watchmaking, Jewelry, Plastic Injection Tools.



MEDICAL APPLICATIONS

Surgery, LASIK, ophtalmology.



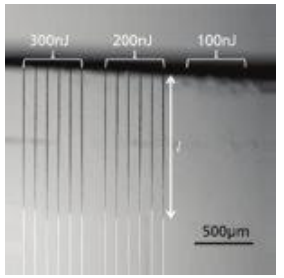


www.electrooptics.com www.oled-info.com www.laserfocusworld.com www.neec.com

Emerging Applications

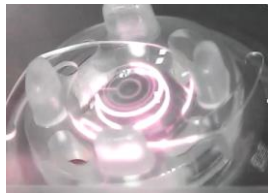
GLASS PROCESSING

Drilling, coating removal, selective etching, 3D processing, etc.



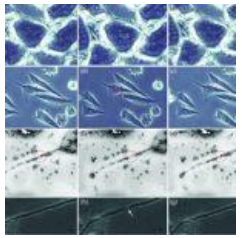
MEDICAL and MEDICAL DEVICES

Eye diseases treatment, Intraocular lenses, cochlear implants, biocompatible surfaces, dermatology, tissue processing, etc.



SCIENCE

Neuoscience, bio-imaging, spectroscopy, atto-science, etc.



ENERGY

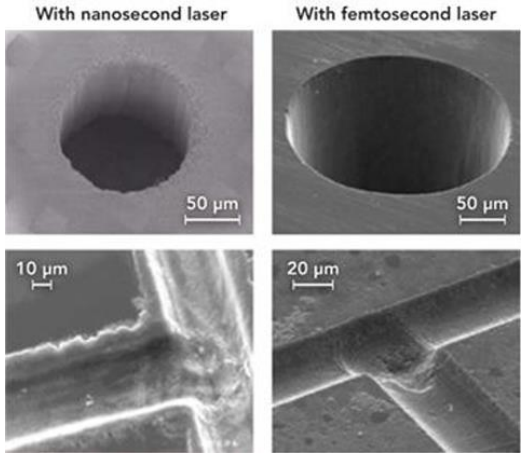
Photovoltaic, fuel cells, batterys.

www.lumoslaser.com

Why femtosecond laser?

Compared to other micromachining solutions, it offers:

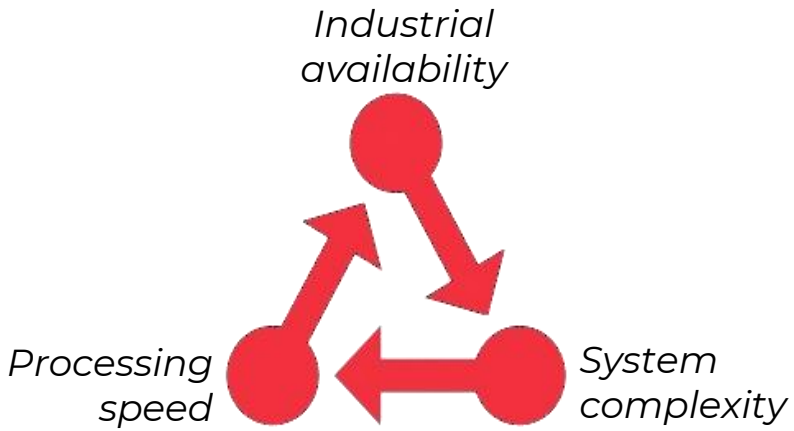
- unprecedented **precision and flexibility**,
- **no heat input** on the material,
- **no waste** of tool, material, water or chemicals,
- **safety** with minimized human contact,
- processing **any material**: metal, polymer, glass, diamond, etc.
- suitable for **industry 4.0**, focus already on 5.0.



Challenges: Speed, Costs and New Applications

Practical drawbacks:

- **speed**: has to speed up for volume production,
- **cost**: at least 3x more expensive than conventional tools,
- **service**: complex serviceability.



Our Solution: GHz-Burst fs-Laser Technology

Higher Machining Speed & Simple System Design

Lumos's **breakthrough innovation**

to improve **industrial availability**

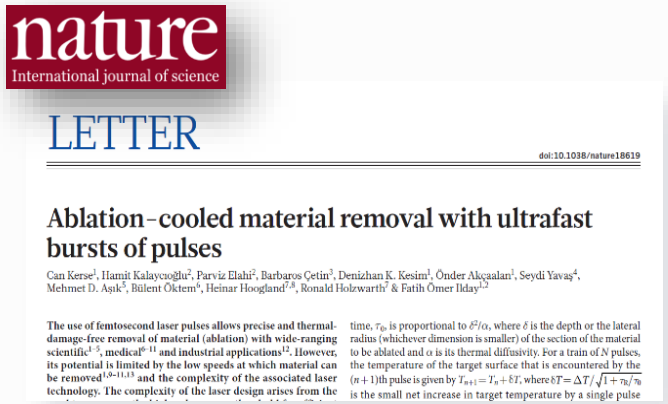
A completely new laser design, offering

- ✓ 5-10 times **higher processing speed***
- ✓ **Low-power laser architecture**
- ✓ Simplified laser modules available for industrial adaptation
- ✓ Easier serviceability
- ✓ **Lower initial cost**
- ✓ Up to 80% **energy saving**

over current femtosecond laser solutions.

*Depends on the material.

Our Articles on High Micromachining Speed


nature
International journal of science

LETTER

doi:10.1038/nature18619

Ablation-cooled material removal with ultrafast bursts of pulses

Can Kerse[1], Hamit Kalaycıoğlu[2], Parviz Elahi[2], Barbaros Çetin[3], Denizhan K. Kesim[1], Önder Akçaalan[1], Seydi Yavaş[4], Mehmet D. Aşık[5], Bülent Öktem[6], Heinar Hoogland[7,8], Ronald Holzwarth[7] & Fatih Ömer İlday[1,2]

The use of femtosecond laser pulses allows precise and thermal-damage-free removal of material (ablation) with wide-ranging scientific[1–5], medical[6–11] and industrial applications[12]. However, its potential is limited by the low speeds at which material can be removed[1,9–11,13] and the complexity of the associated laser technology. The complexity of the laser design arises from the

time, τ_0, is proportional to δ^2/α, where δ is the depth or the lateral radius (whichever dimension is smaller) of the section of the material to be ablated and α is its thermal diffusivity. For a train of N pulses, the temperature of the target surface that is encountered by the $(n+1)$th pulse is given by $T_{n+1} = T_n + \delta T$, where $\delta T = \Delta T / \sqrt{1+\tau_0/\tau_0}$ is the small net increase in target temperature by a single pulse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CONFERENCE PROCEEDINGS

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Poster + Presentation + Paper

7 March 2021

High throughput ablation with ultrafast GHz burst fiber laser

Seydi Yavas, F. Alp Ucak, İbrahim Ateşpare, M. Yusuf Kaya, Söhret G. Karamuk, Gizem Akpakut, Hamit Kalaycioğlu

Author Affiliations +

Proceedings Volume 11674, Laser-based Micro- and Nanoprocessing XV; 116741H (2021)

https://doi.org/10.1117/12.2578398

Event: SPIE LASE, 2021, Online Only

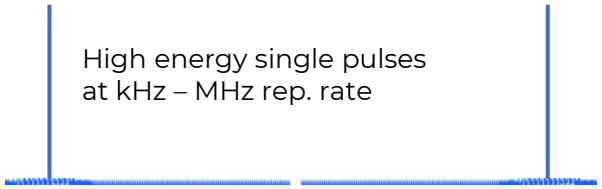
Increasing the Speed: A Comparative Description

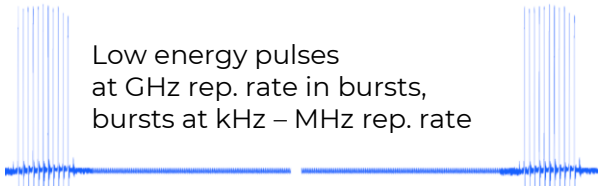
LUMOS LASER

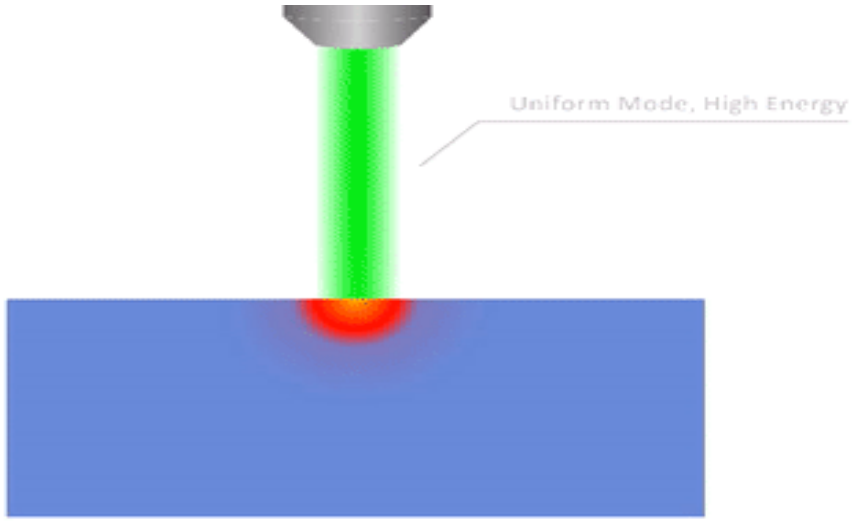
Uniform fs Repetition Rate

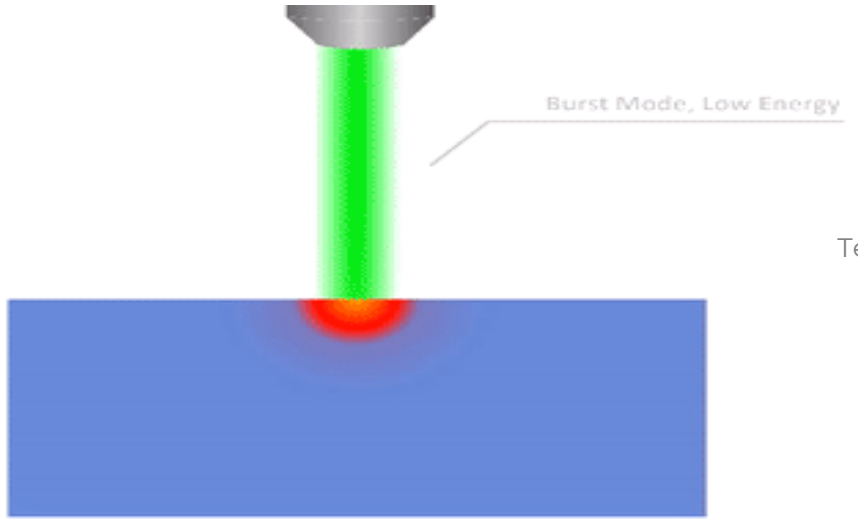
VS

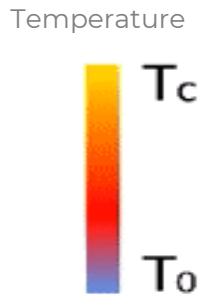
GHz Burst fs Pulses











F. Ö. Ilday et al., Ablation-cooled material removal with ultrafast bursts of pulses. *Nature*, vol. 537, pp. 84–88 (2016).

Material Processing Speed

Highest line scribing efficiency to date for stainless steel and Ti

Maximum Specific Ablation Rate [(mm^3/min)/W]			
Material / Laser type	Lumos Duro GHz	GHz-Burst Literature	Uniform fs/others
Aluminum	1.88	2.01 [1]	0.40 [2]*
Copper	0.52	0.73 [1]	0.18 [3]
Silicon	1.74	2.29 [1]	-
Stainless Steel	1.93	1.05 [1]	0.26 [4]
Titanium	2.07	-	0.68 [5]**

At least 3x improvement in all materials compared to ablation with uniform repetition rate

Further parameter optimization needed to reveal full potential

[1] G. Bonamis et al, Optics Express, 28, (2020).
[2] J. Lopez et al, Journal of Laser Applications, 27, (2015).
[3] H. Matsumoto et al, Proc. SPIE 10519, (2018).
[4] B. Jaeggi et al, (LAMOM) XXII. Vol. 10091, (2017).
[5] Sedao et al, Optics and Lasers in Engineering, 116, (2018).

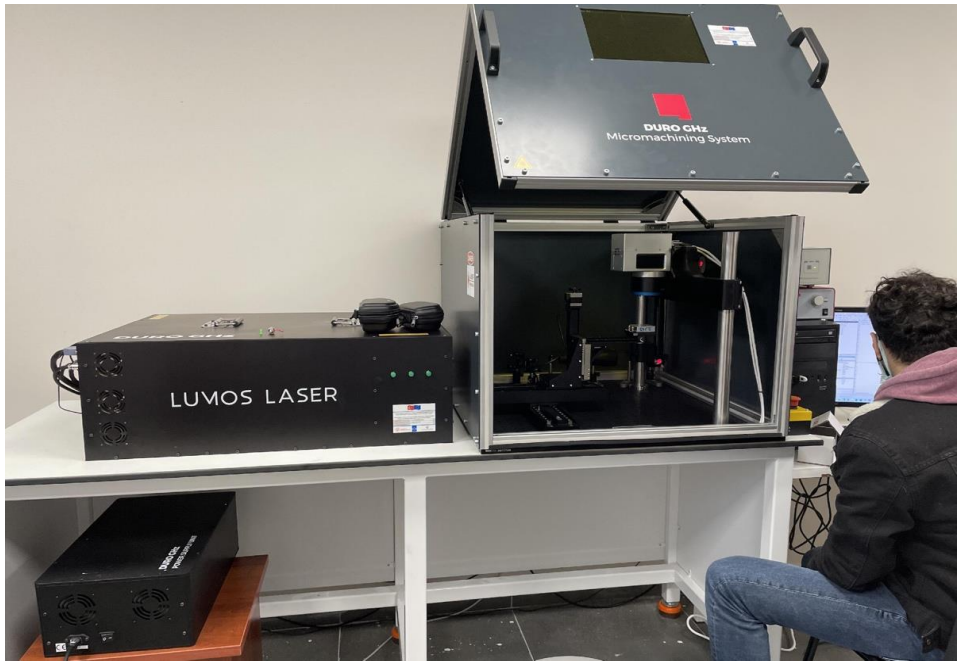
Lumos Laser

LUMOS LASER

- 7 years old start-up company
- Manufacturer of GHz Burst fs-lasers and micromachining stations
- Roots at the Bilkent University, Prof. Ilday's Ufolab
- Team with 2 usp laser experts and talented engineers, 3 PhD's.
- Founded by the inventors of the GHz Burst fs-laser technology
- Many R&D partnerships realized, collaborative mindset

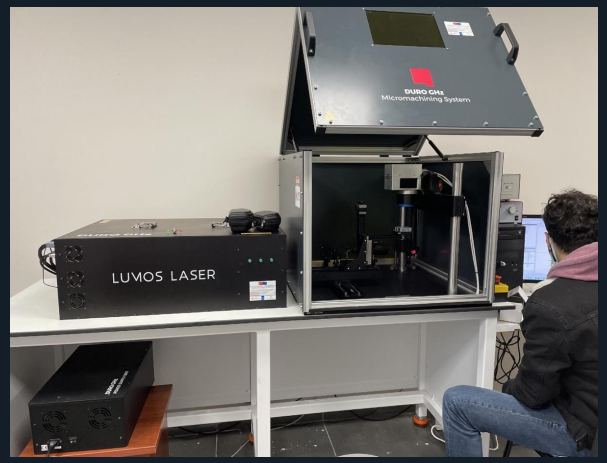
Istanbul - Bogazici University Teknopark

Istanbul - Bogazici Univ. & Özyeğin Univ. Photonics Laboratories



Product & Technology Development Roadmap

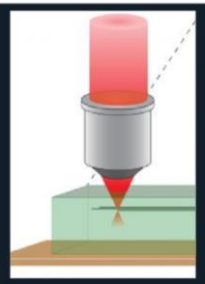
Applications developed on Metal Micromachining, Coating Removal on Glass, Glass, Polymers and Research



2021 – Our MVP DURO GHz LP20
High value Metals and Spinel Glass Processing

2022 – DURO GHz Versa Dual Mode Laser
Research & Metallic Materials Processing

2024 Duro GHz LP30
High avg. Power for Research & Coating Removal over Glass



2025 DURO GHz LP
for Polymer Processing

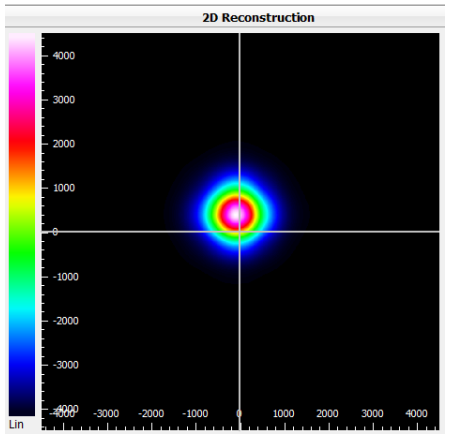
Product Duro GHz LP Series
Specifications and Features

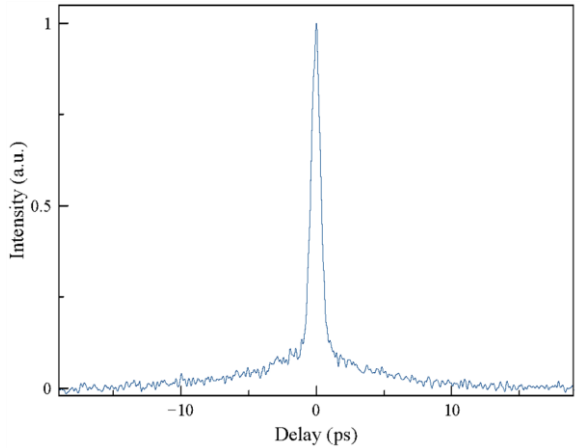
LUMOS LASER

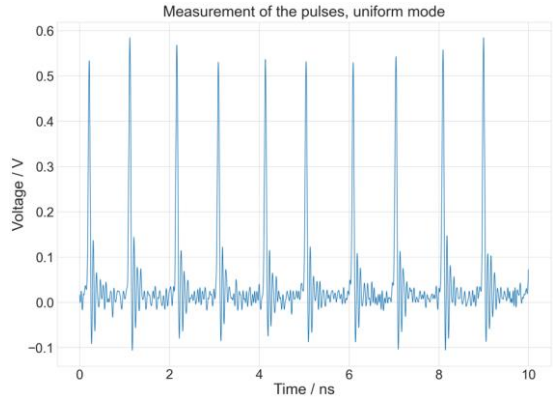
DURO GHz LP Series

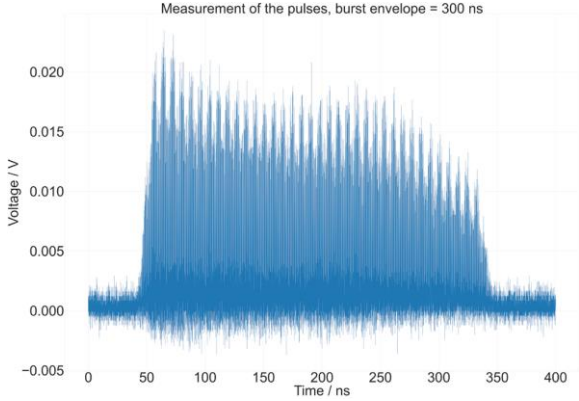
Up to 30W GHz-Burst Femtosecond Laser Module

- Up to 30W average power
- Up to 6000 pulses inside burst
- 4 GHz Repetition Rate
- Fiber laser design
- Adjustable burst shape
- Up to 150µJ burst energy @1030nm – Pulse energy 300nJ
- Adjustable pulse duration 500fs – 10ps









SAYEM Consortium Project & Pulsate Program

Intraocular Lens Processing

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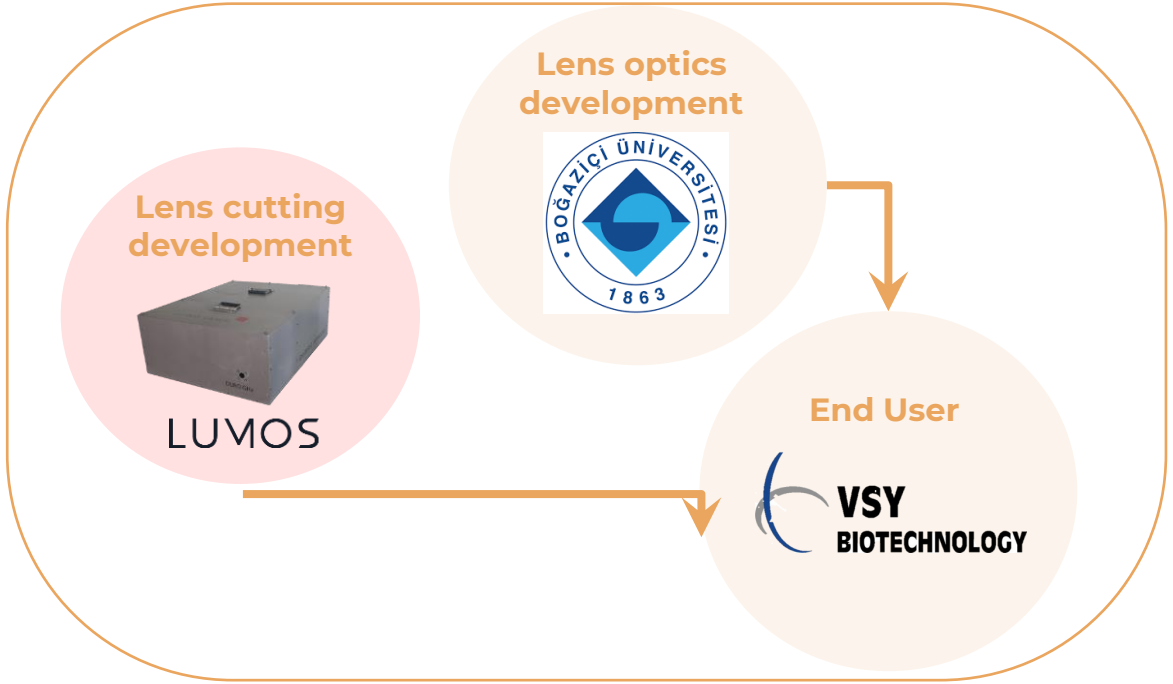

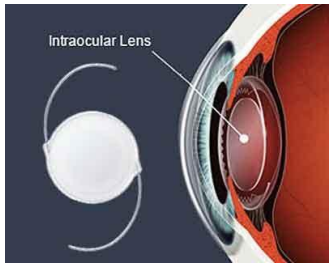

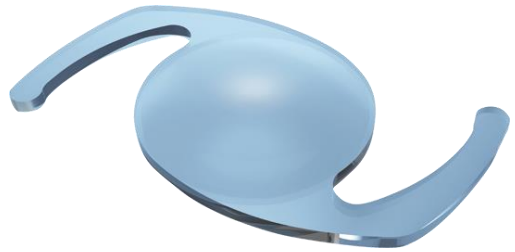

- Process development phase:
  Funded by European Commission (PULSATE programme), €150K.
- Manufacturing system development:
  Funded by TÜBİTAK, €700K.
- Full scale product performance demonstration

TÜBİTAK

Co-funded by the European Union

Pulsate

SAYEM Consortium Project & Pulsate Program

Intraocular Lenses are delicate medical devices

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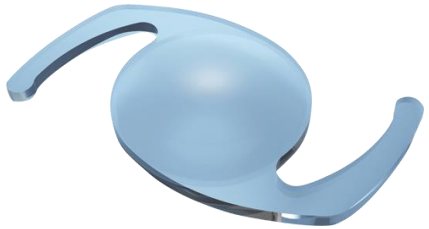
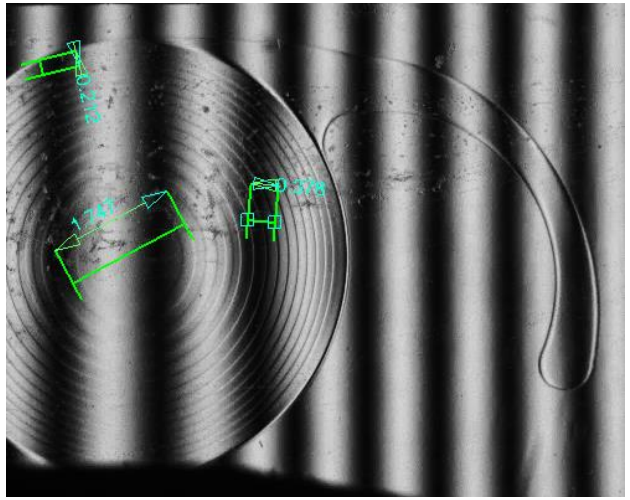
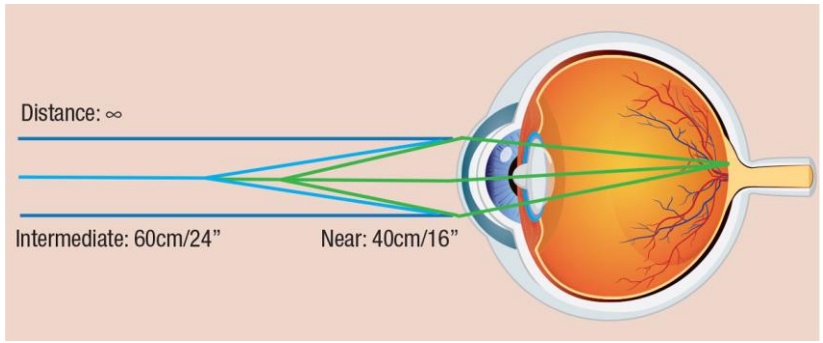
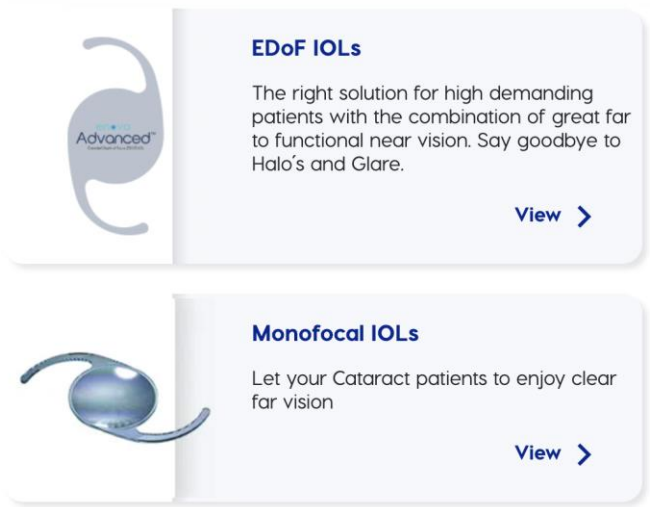






VSY BIOTECHNOLOGY



TÜBİTAK

Co-funded by the European Union

Pulsate

SAYEM Consortium Project & Pulsate Program

IOL Processing by Laser - Feasibility

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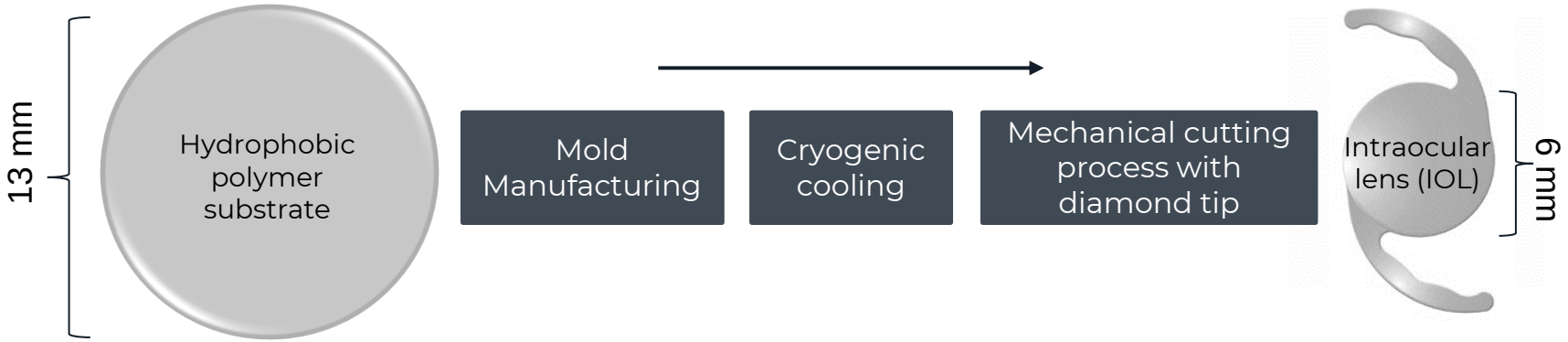


Processing speed → 40-55 sec/IOL

Scrap rate → 19-20%

Low productivity

High carbon & energy footprint

Processing speed → 30-40 sec/IOL

Scrap rate → 7-8%

Overall productivity increase → 30%

Reduced carbon & energy footprint

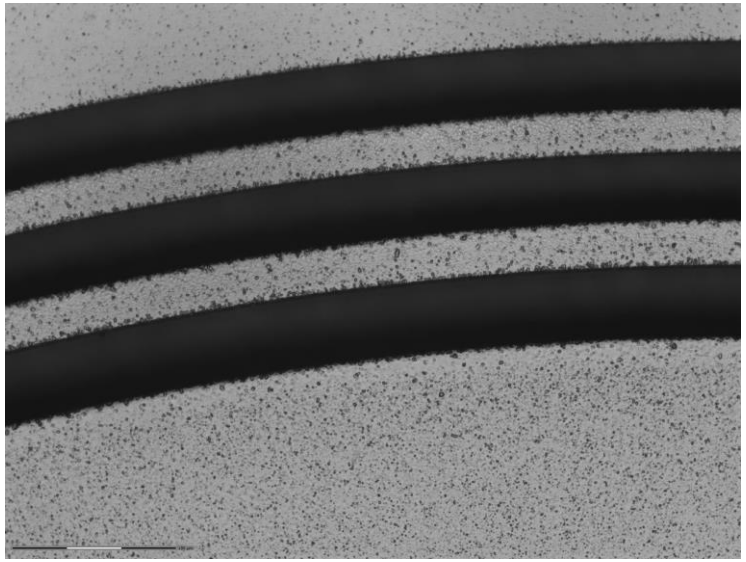
Promising ROI

SAYEM Consortium Project

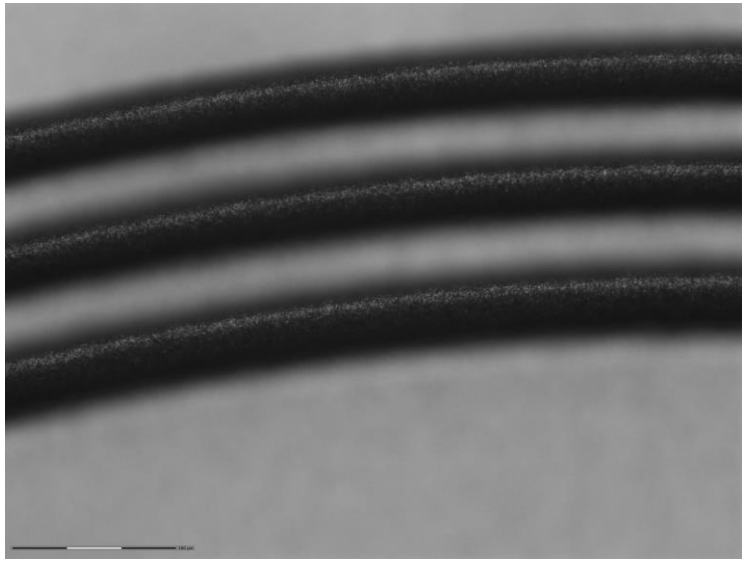
Studies on Processing Fresnel Rings onto the Polymer Surface

LUMOS LASER

Microscopy images of Fresnel rings engraved on polymer:



Focus of the image is on the unprocessed material surface



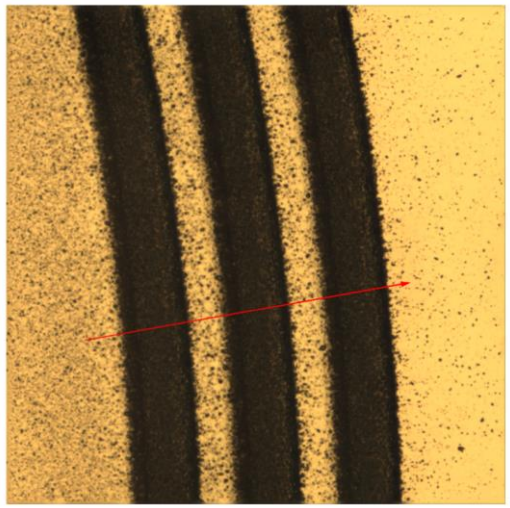
Focus of the image is on the processed material surface

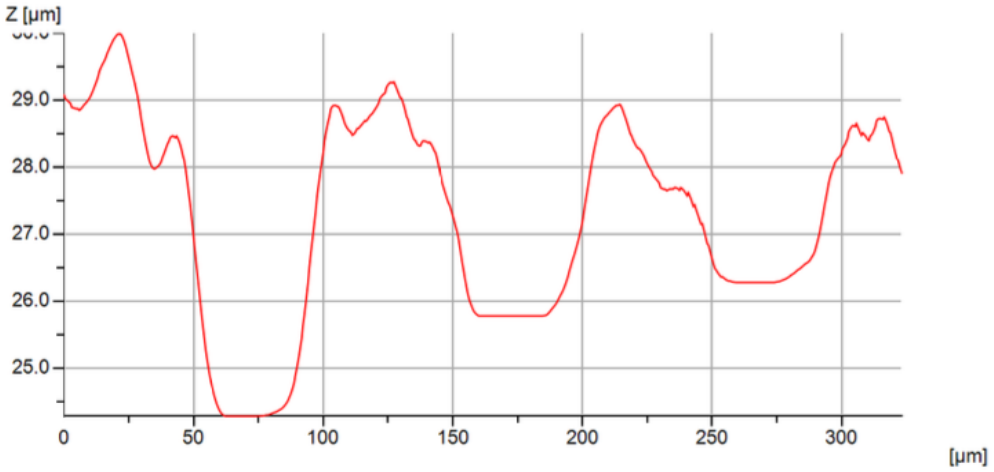
SAYEM Consortium Project

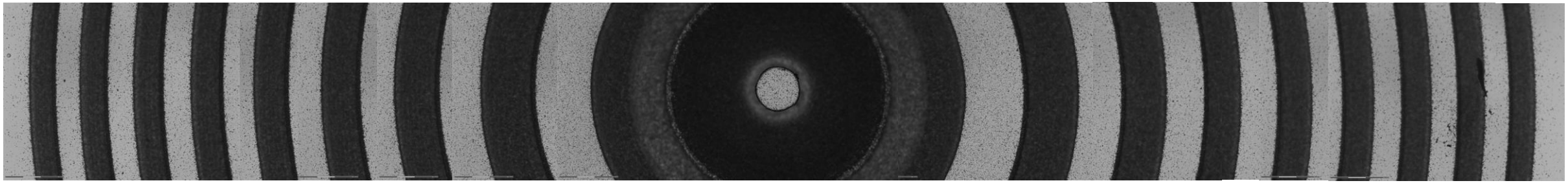
Studies on Processing Fresnel Rings onto the Polymer Surface

LUMOS LASER

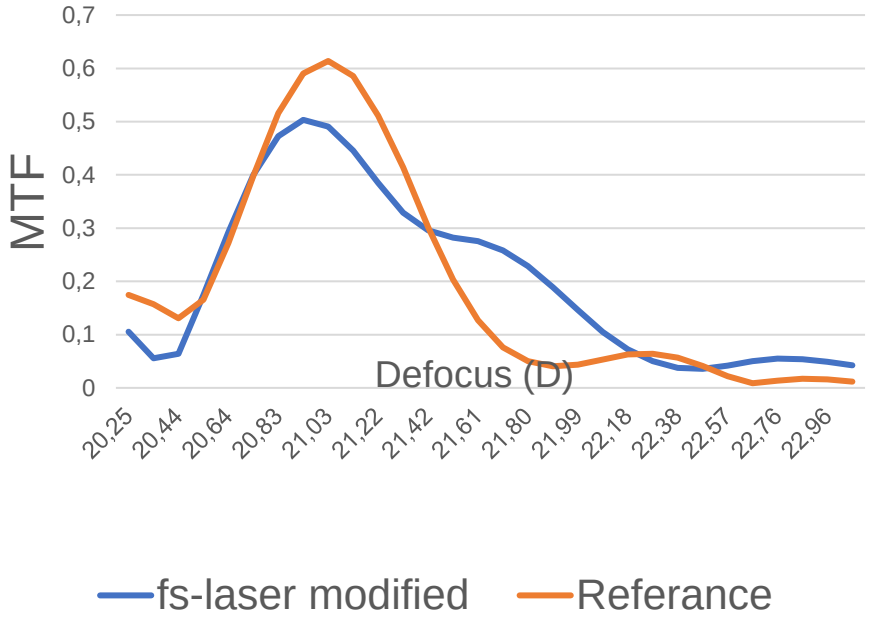
The profilometer image and depth profile of Fresnel rings engraved on polymer:

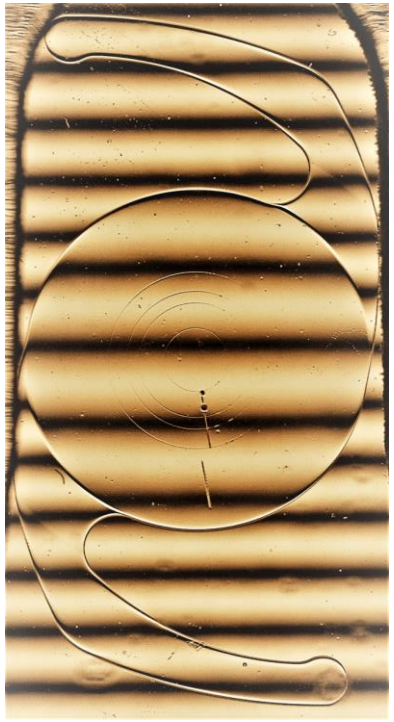






Monofocal to Enhanced Depth-of-Focus (EDOF) POC





SAYEM Consortium Project

Cutting Studies on Intraocular Lens

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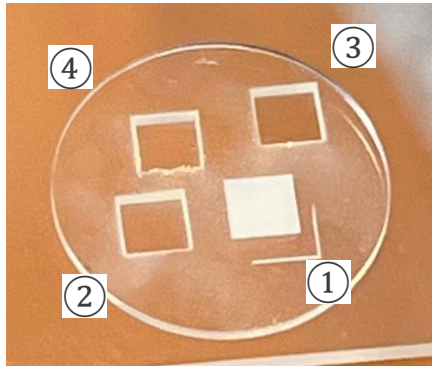
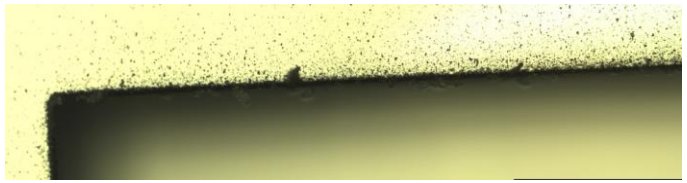


① Ablation with multipass

④ Cutting trial



2.6 x 2.6 mm square
600 µm depth
Volume = 4.056 mm^3

Micromachining with Galvo scanner

Collaboration Opportunities

LUMOS LASER

What we offer?

- Talented team of usp laser experts
- Custom GHz Burst laser development
- Collaborative value-focused mindset

Looking for:

- R&D partnerships (Consortium, cluster, project-based, applab) for new application development
- Technical collaboration especially on material processing
- Deep-tech investment oppotunities

LUMOS LASER

Thank you!

altan@lumoslaser.com

www.lumoslaser.com

2024