Corneal Tissue Ablation Using 6.1 µm QCL

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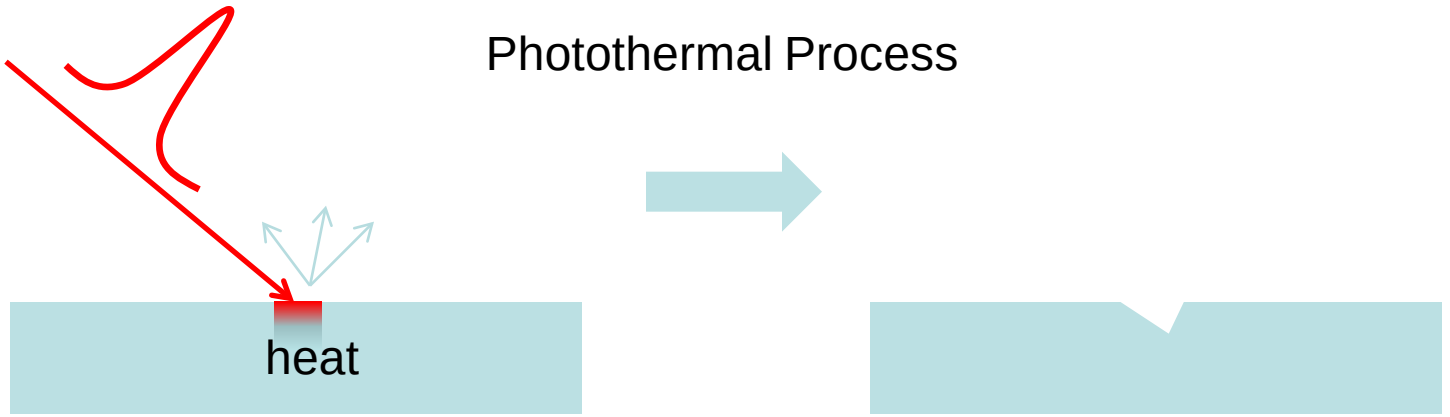
Outline

- Introduction
- Methods
- Results and Discussion
- Conclusion and Future work

Introduction

1. Laser-Tissue Interaction: Ablation
2. Unique property of 6.1 μm wavelength
3. Advantages of QCL

Laser -Tissue Interaction: Ablation



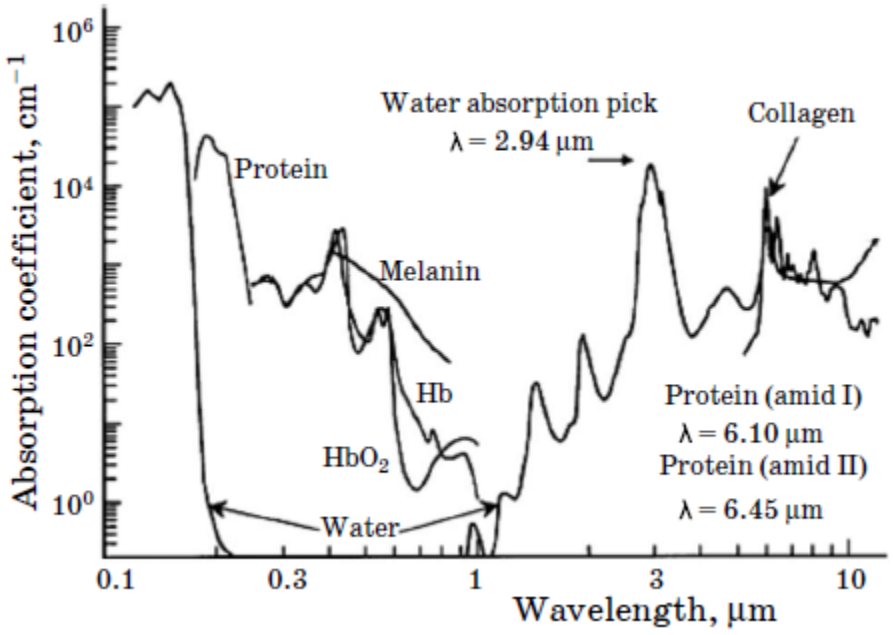
- Trains of pulses focused onto the bio-tissue
  - → Laser radiation absorption (α)
  - →Photon energy into vibrational energy of molecules
  - →Chemical transformation or dissociation of the molecules

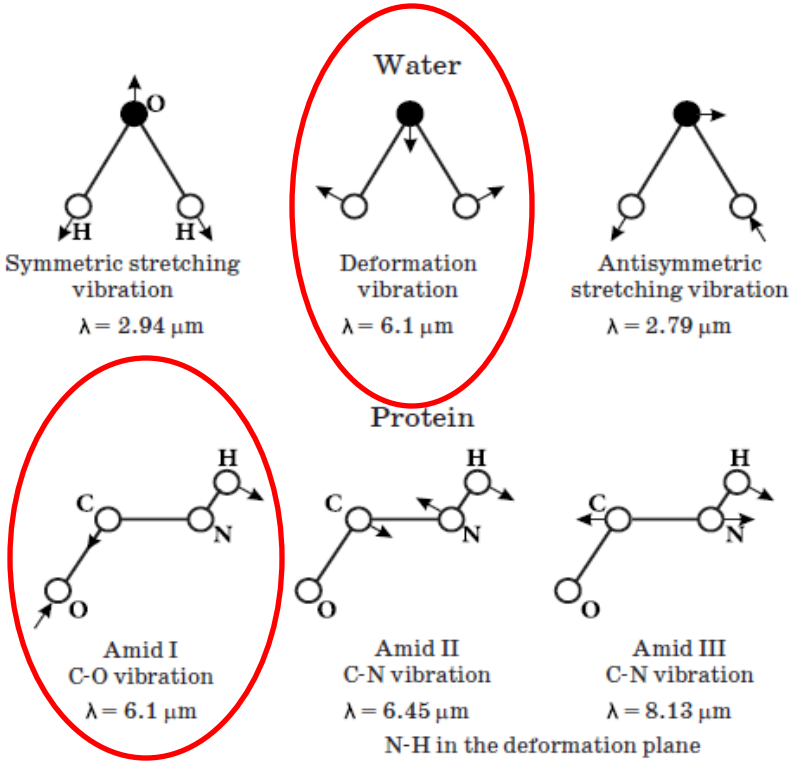
- Radiation Power threshold: Rate of rupture of molecular bonds >Recombination rate
- Interaction time

- Molecular fragments: pressure inside tissue and ejection of dissociated material.

Unique property of 6.1 μm wavelength

Spectral absorption of the principal chromophores in tissue





Configuration of IR excited water molecules and protein

In practically every type of soft tissue the chromophores are water (up to approximately 65% in soft tissue) and protein strands (35%).

V.A. Serebryakov et al. “Medical applications of mid-IR lasers. Problems and prospects”, J. Opt. Technol. 77(1), January 2010.

Unique property of 6.1 μm wavelength

Allows effective removal of tissues with minimal collateral damage.

1) absorbing properties of the deformation mode of OH (λ=6.1 μm) are essentially independent of the changes of the surrounding temperature and pressure as compared with the symmetric stretching mode of OH (λ=3 μm)

2) λ=6.1 μm corresponds to the peak of a protein band the absorbing properties of soft tissue remain practically unchanged during laser irradiation even with the concomitant evaporation of water.

Advantages of QCL

1. Compact
2. Cost effective
3. Relative high power
4. Stability
5. Wavelength tunable

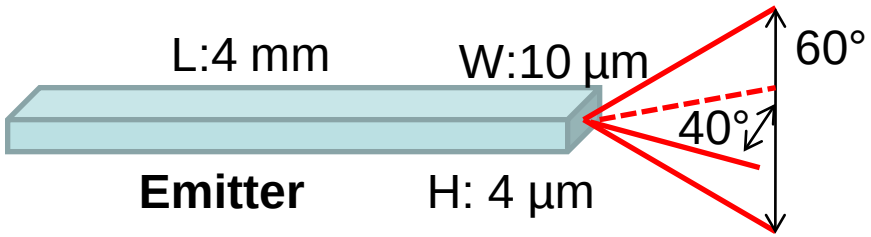
Contemporary MIR sources:

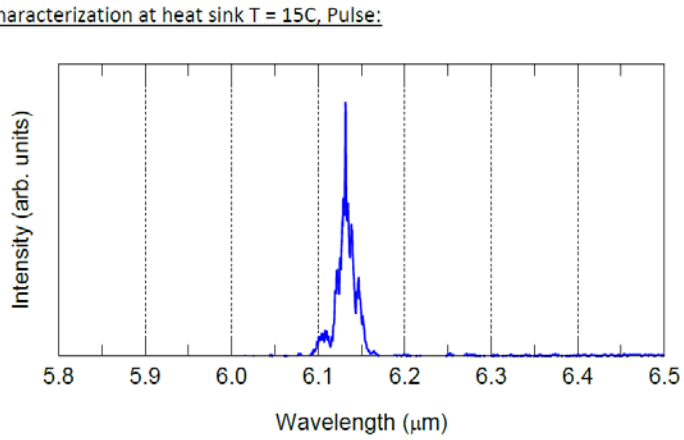
Free-electron Laser (FEL)

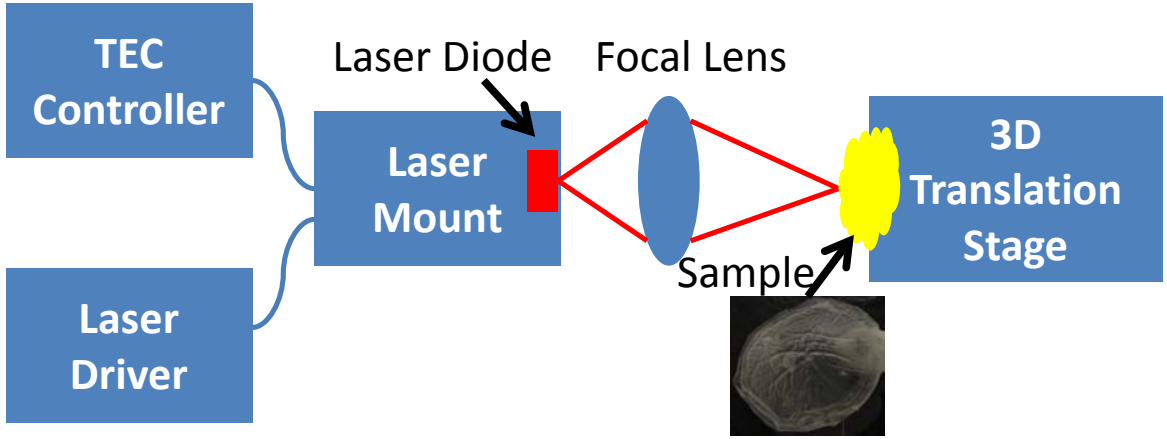
Optical Parameter Oscillator (OPO)

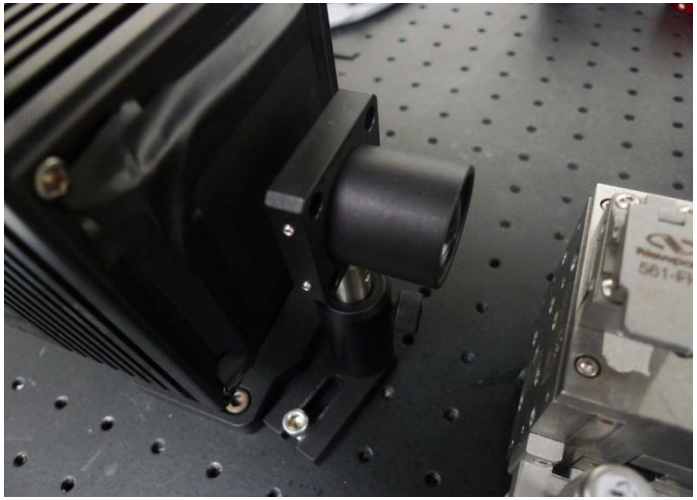
FEL Center: Vanderbilt University
first human surgery

Experimental Set-Up



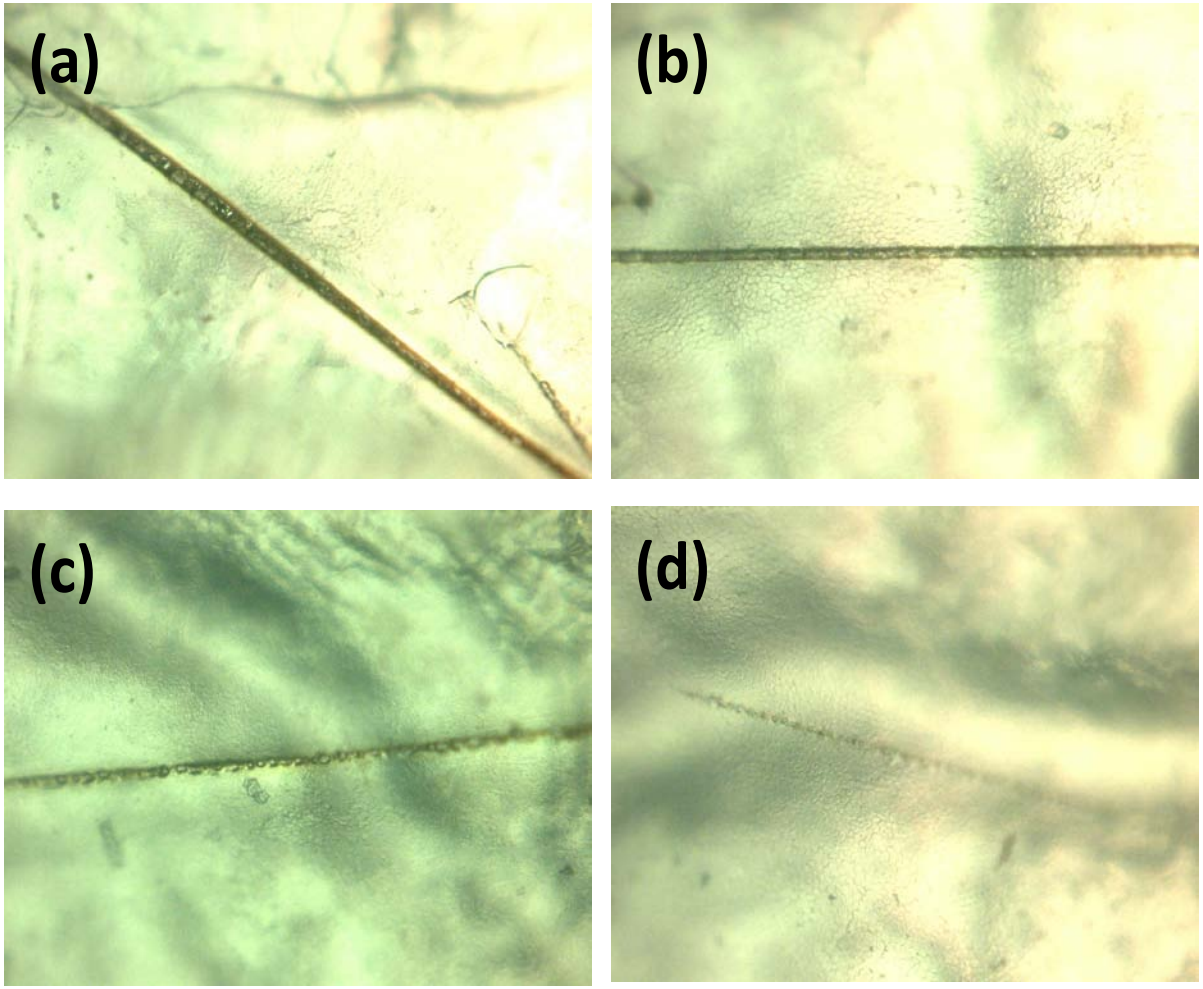






Results and Discussion

×250

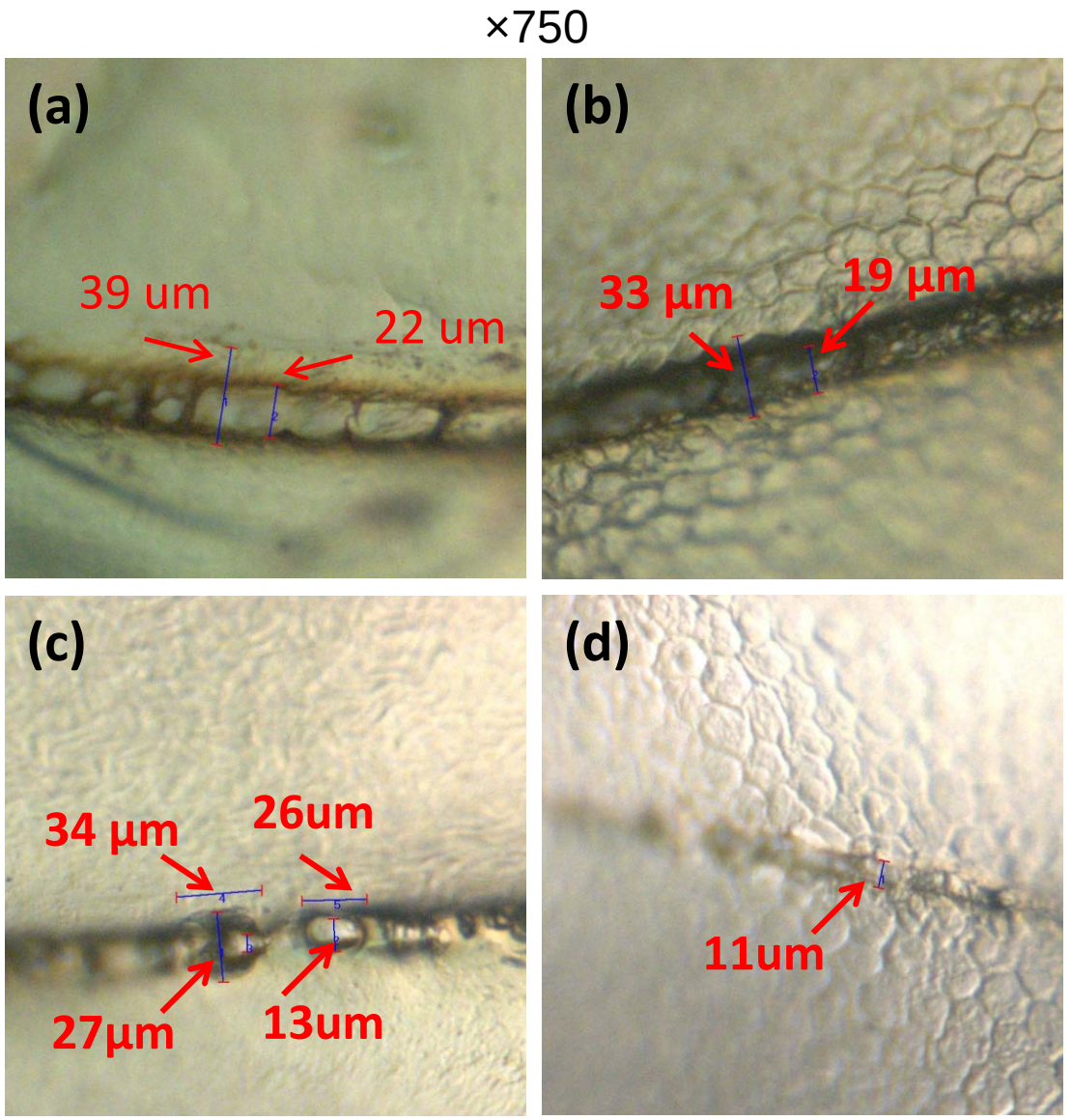


(a) 8mJ/pulse_20ms_ 25 Hz
(b) 4mJ/pulse_10ms_25 Hz
(c) 2 mJ/pulse_5ms_100 Hz
(d) 2 mJ/pulse_5ms_10 Hz

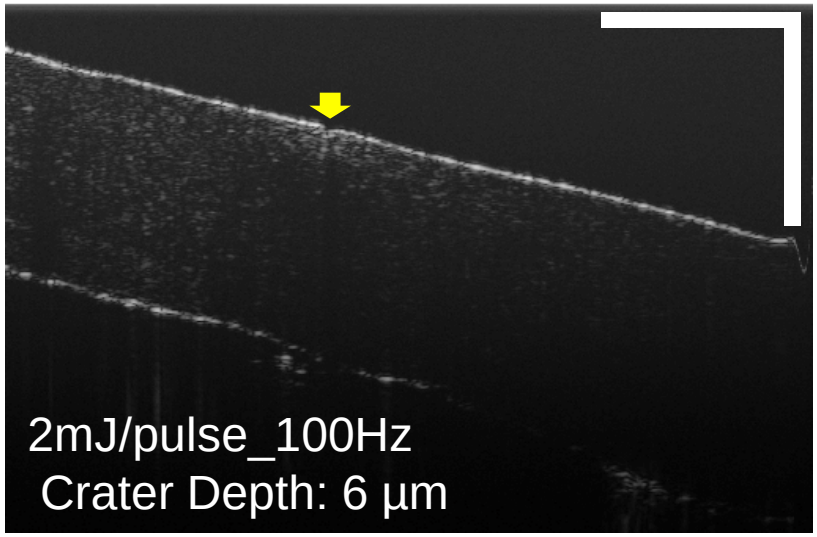
Clinical applications of mid-IR lasers require energy levels of radiation with λ=6.1–6.45 μm equal to 1–10 mJ/pulse at repetition frequency to 100 Hz

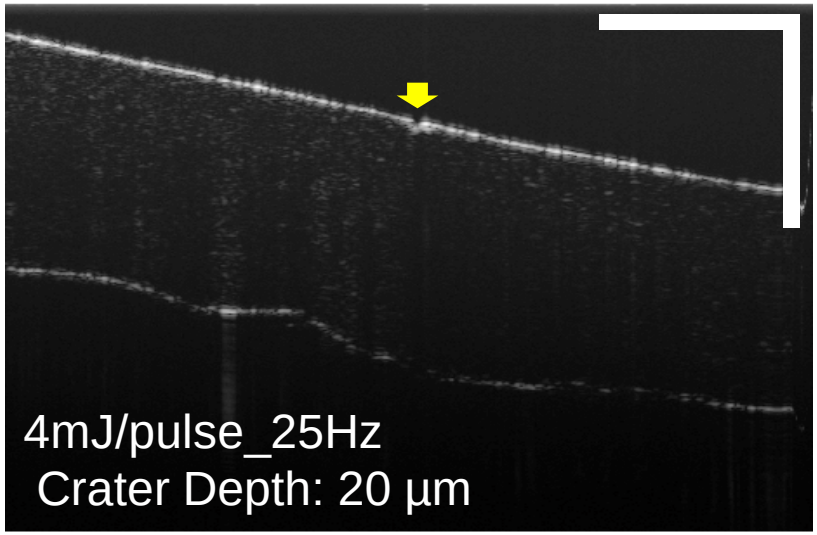
Results and Discussion

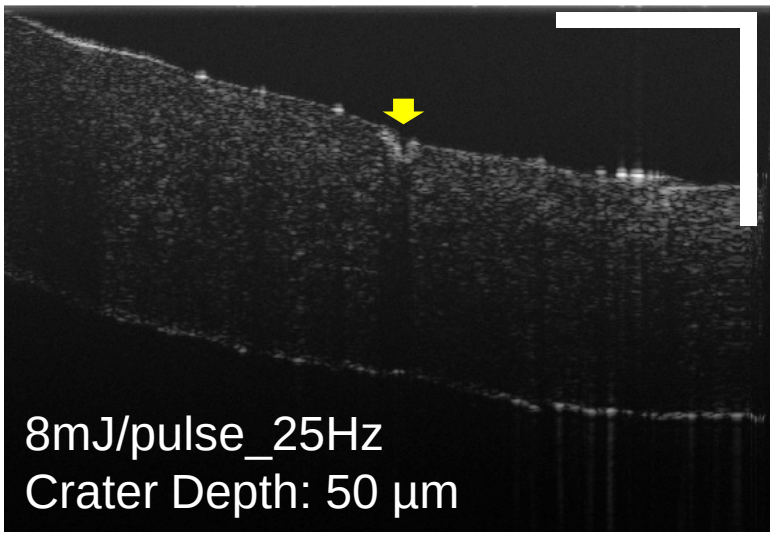
(a) 8mJ/pulse: 25 Hz
(b) 4mJ/pulse: 25 Hz
(c) 2 mJ/pulse: 100 Hz
(d) 2 mJ/pulse: 10 Hz



Results and Discussion







Scale bar: 0.5 mm

Results and Discussion

8mJ/pulse_20ms_25Hz

4mJ/pulse_10ms_25Hz

Videos show the depth profile of the ablation site over a lateral range.

Conclusion and Future work

- Precise Corneal Tissue ablation using 6.1 μm QCL was achieved.
- More study on the effect of different ablation parameters: pulse length, laser current, repetition rate, beam geometry etc.
- Experiments with AgI coated MIR light pipe is on-going.

Acknowledgement

Thanks to MIRTHE!
Thanks to AdTech Optics for providing us the QCL!
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Thank you all!

Questions???