Photodisruption in tubid tissues with ultrashort laser pulses

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Outline

- Introduction
  - General method
  - Dynamics of photodisruption
- Results and discussion
  - Precise incision
  - Subsurface Microstructure
  - Microfilaments
- Summary
- Applications
Photodisruption: removal of tissue by ablation or vaporization

- Focus ultrashort pulse on tissue
- High laser intensity at focus
- Ionization by nonlinear mechanisms (MPI, tunneling, avalanche)
- Microscopic damage
Introduction

Nonlinear Absorption

Plasma formation

Plasma expansion

Mechanical effects

Permanent damage
Subsurface microstructure
Subsurface microstructure
Subsurface microstructure

100fs, 20μJ, single pulse
Subsurface microstructure

100fs, 30µJ

100fs, 4µJ
Surface microstructure

100fs, 10μJ
100fs, 5μJ
100fs, 3μJ

200ps, 10μJ
200ps, 5μJ
200ps, 3μJ
Subsurface microstructure

Surface damage at 40 \( \mu \text{J} \)

Subsurface damage at 20 \( \mu \text{J} \)

fs pulse     ps pulse
100fs, 3μJ, 0.6NA
100fs, 30\(\mu\)J, 100 pulses

100fs, 20\(\mu\)J, 100 pulses

100fs, 3\(\mu\)J, 3000 pulses

100fs, 3\(\mu\)J, 3000 pulses
high intensity laser pulses

Self-focusing leads to ionization of the medium

Plasma defocusing balances self-focusing

Trapped propagation
The moving focus model

$P > P_{\text{crit}}$
Precise incision
Precise incision
Precise incision

100fs, 20μJ

3 passes
at 0, 100μm, and 200μm
Applications

Dermitology: tattoo removal

Biology: cell manipulation

High precision scalpel

Transdermal drug delivery
advantages of fs pulses versus ps pulses

- reduced collateral damage
- smaller spot size in bulk

- demonstrated subsurface cavity formation in animal skin tissue
- demonstrated precise m-wide incision in bulk skin using fs pulses
- advantages of fs pulses versus ps pulses
  - reduced collateral damage
  - smaller spot size in bulk
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