Specific tissue characteristics and laser parameters used contribute to different tissue effects. laser radiation parameters can be wavelength, exposure time, applied energy, focal spot size, energy density, and power density (pg 45)

Table 3.9. Wavelengths and photon energies of selected laser systems

Laser type Wavelength (nm) Photon energy (eV)

ArF 193 6.4

KrF 248 5.0

Nd:YLF (4ω) 263 4.7

XeCl 308 4.0

XeF 351 3.5

Argon ion 514 2.4

Nd:YLF (2ω) 526.5 2.4

He-Ne 633 2.0

Diode 800 1.6

Nd:YLF 1053 1.2

Nd:YAG 1064 1.2

Ho:YAG 2120 0.6

Er:YAG 2940 0.4

CO2 10600 0.1

Table 3.11. Sources of UV radiation

Light source Wavelength (nm)

ArF laser 193

KrF laser 248

Hg lamp 254

Nd:YLF laser (4ω) 263

Nd:YAG laser (4ω) 266

XeCl laser 308

XeF laser 351

The five categories of tissue-laser interaction types are classified today. These are photochem ical interactions, thermal interactions, photoablation, plasma-induced abla tion, and photodisruption. Thermal effects on tissue are vaporization, carbonization, coagulation, Hyperthermia.

Table 3.6. Thermal effects of laser radiation

Temperature Biological effect

37◦C Normal

45◦C Hyperthermia

50◦C Reduction in enzyme activity,

cell immobility

60◦C Denaturation of proteins and collagen, coagulation

80◦C Permeabilization of membranes

100◦C Vaporization, thermal decomposition (ablation)

> 100◦C Carbonization

> 300◦C Melting

3.2.5 Summary of Thermal Interaction:

• Achieving a certain temperature which leads to the desired thermal effect

• Observations can be either coagulation, vaporization, carbonization or melting

• Typical lasers: CO2, Nd:YAG, Er:YAG, Ho:YAG, argon ion and diode lasers

• Typical pulse durations: 1 µs . . . 1 min

• Typical power densities: 10 ... 106 W/cm2

• Special applications: coagulation, vaporization, melting, thermal decomposition, treatment of retinal detachment, laser-induced interstitial thermotherapy

Laser effect examples:

1) Human tooth vaporized with 20 pulses from an Er:YAG laser (pulse

duration: 90 µs, pulse energy: 100 mJ, repetition rate: 1 Hz). (b) Enlargement show ing the edge of ablation

2) Uterine tissue of a wistar rat coagulated with a CW Nd:YAG laser

(power: 10W, bar: 80 µm). Photograph kindly provided by Dr. Kurek (Heidelberg).

3) Human cornea coagulated with 120 pulses from an Er:YAG laser (pulse dura tion: 90 µs, pulse energy: 5 mJ, repetition rate: 1 Hz, bar: 100µm)

4) Tumor metastases on human skin carbonized with a CW CO2 laser

(power: 40W, bar: 1 mm). Photograph kindly provided by Dr. Kurek (Heidelberg).

5) Human tooth carbonized with a CW CO2 laser (power: 1W, bar: 1 mm)

6) Human tooth melted with 100 pulses from a Ho:YAG laser (pulse duration: 3.8 µs, pulse energy: 18 mJ, repetition rate: 1 Hz). (b) Enlargement show ing the edge of the melted zone ig. 3.20.

6) Hole in tooth created by focusing 1000 pulses from a Nd:YLF laser

on the same spot (pulse duration: 30 ps, pulse energy: 1 mJ, repetition rate: 1 kHz).

7) Enlargement showing cubic recrystallization in form of plasma sublimations.

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8) Photoablation of corneal tissue achieved with an ArF excimer laser

(pulse duration: 14 ns, energy density: 180 mJ/cm2, bar: 100 µm).

(Citation: Markolf H. Niemz Laser-Tissue Interactions Fundamentals and Applications Third, Enlarged Edition)

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In response to growing concerns over the production, deployment, and use of laser weapons that cause blinding, the international community in 1995 convened an international conference to restrict the use and transfer of blinding laser weapons. The result was the Fourth Additional Protocol to the 1980 United Nations Convention on Certain Conventional Weapons. In doing so, a significant step was taken towards restricting the intentional blinding of combatants in time of war.

(The Legal Status of Laser Weapons That Blind, Jeffrey S. Morton, Volume 35, Issue 6)