The Use of LASERs in Periodontics

Yota Stathopoulou, DDS, MS, PhD, DMD

Diplomate, American Board of Periodontology
Associate Professor and Director,
Advanced Education Program in Periodontics

stathopp@ohsu.edu


JUDGE ME BY MY SIZE, DO YOU?
SEE YOU IN THE
LASER TAG ARENA I WILL.

- Introduction – Basic laser physics
- Tissue – laser interaction
- Laser types and indications for use
- Clinical cases using a Diode, Nd:YAG or Er:YAG laser
- Laser safety

L ight

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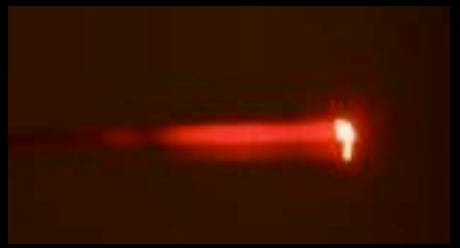
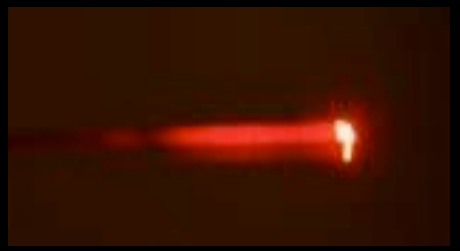
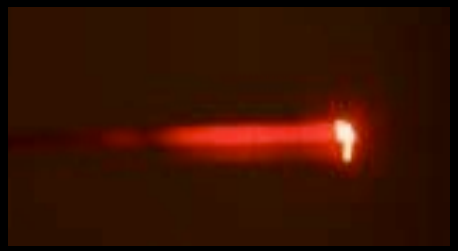


Basic LASER Terminology

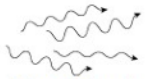
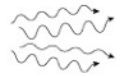
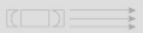
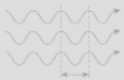


- Laser Type (Diode, YAG, CO_2)
- Wavelength (λ = 350 – 10600 nm)
- Energy (Watts)
- Frequency (Hz)
- Function Mode (CW, pulsed mode)
- Usage mode (contact, non – contact mode)

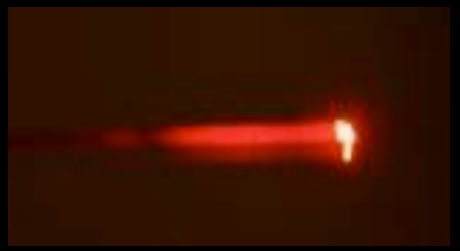
Understanding Ordinary Light



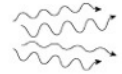
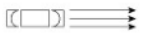
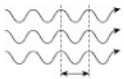
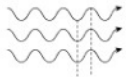
- Multiple colors or wave lengths
- Limited ability to focus
- Not very predictable

	Directivity (light waves travel in straight line)	Monochromaticity	Coherence
Ordinary light	 Light bulb	 Many different wavelengths	
Laser beam	 Laser	 Single wavelength	 Peaks and troughs align

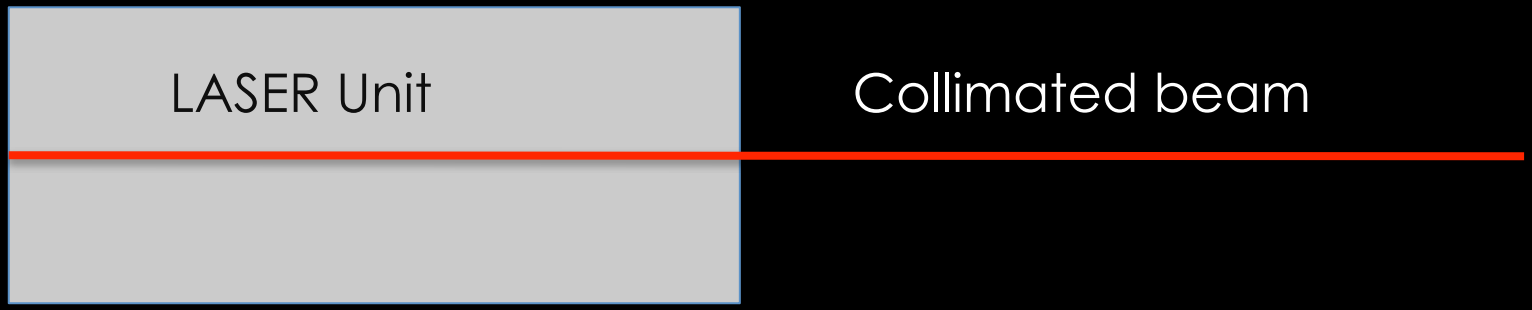
Understanding LASER Light



- One color
  - Monochromatic
  - Very specific wavelength generated
- Can be highly focused and directional
  - Coherent energy
  - Focus to a very small spot
- Very predictable
  - Collimated/ Focused/ Divergent

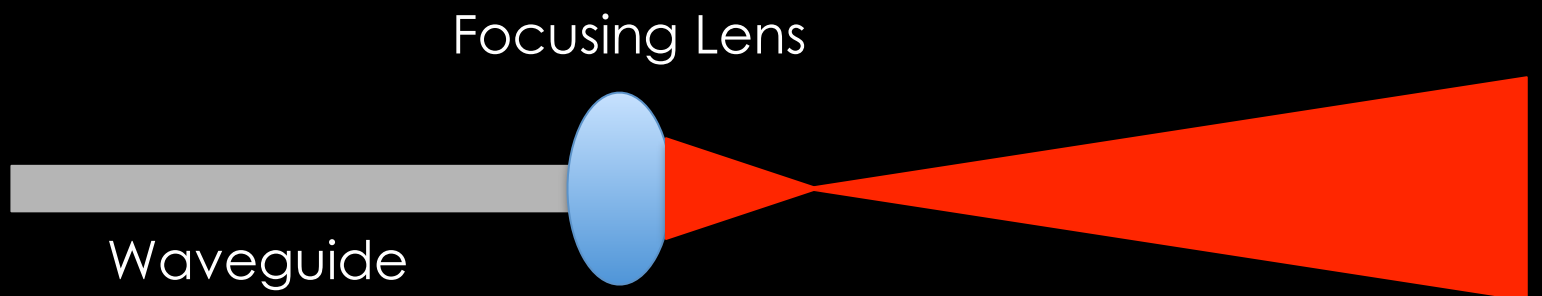
	Directivity (light waves travel in straight line)	Monochromaticity	Coherence
Ordinary light	 Light bulb	 Many different wavelengths	
Laser beam	 Laser	 Single wavelength	 Peaks and troughs align

Understanding LASER Light



- Very predictable
  - Collimated : along the delivery system
  - Focused : by means of lenses at the end of the delivery system
  - Divergent : at the exit of a fiber or tip

Understanding LASER Light



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Understanding LASER Light

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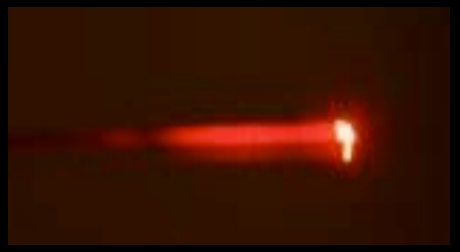
Understanding Light as Radiation



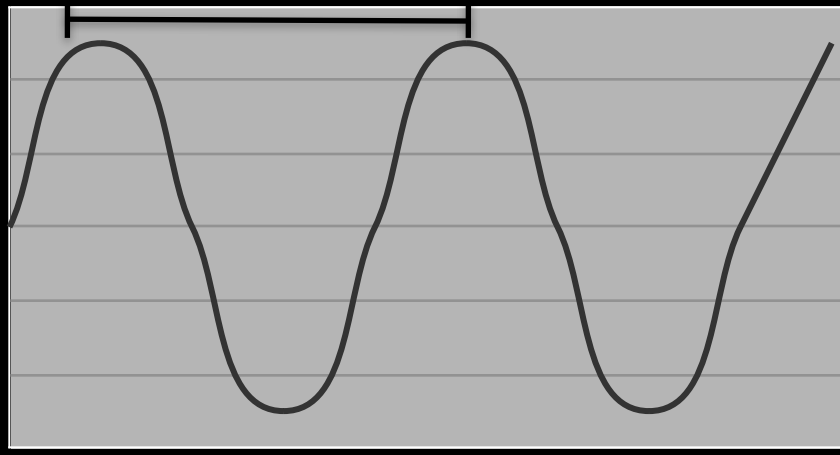
- Described by waves and discrete particles
  - Wavelength and Frequency
  - Electromagnetic Spectrum of Radiation
  - Photon Energy
  - Quantum Energy Levels

Wavelength and Frequency

- Wavelength: horizontal wave "measure"
- Frequency: number of oscillations of a wave per sec
- Inversely proportional measures

↑ Wavelength → ↓ Frequency

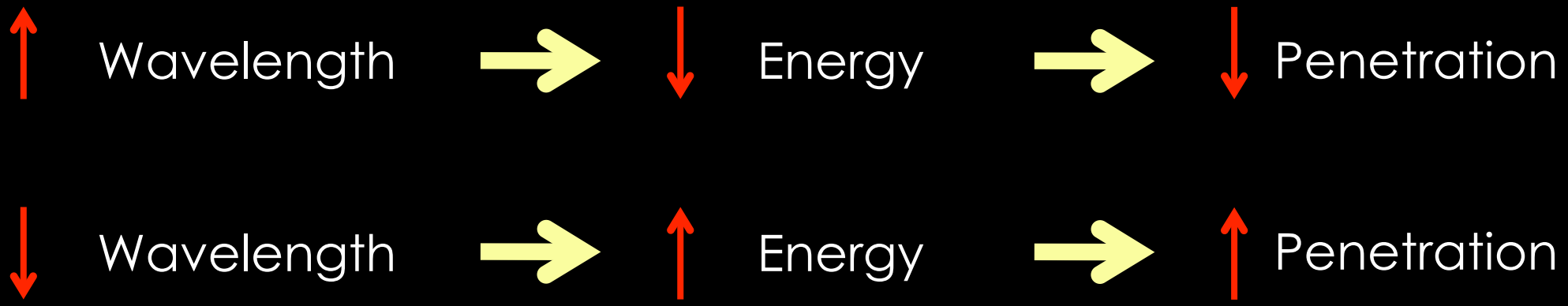
↓ Wavelength → ↑ Frequency



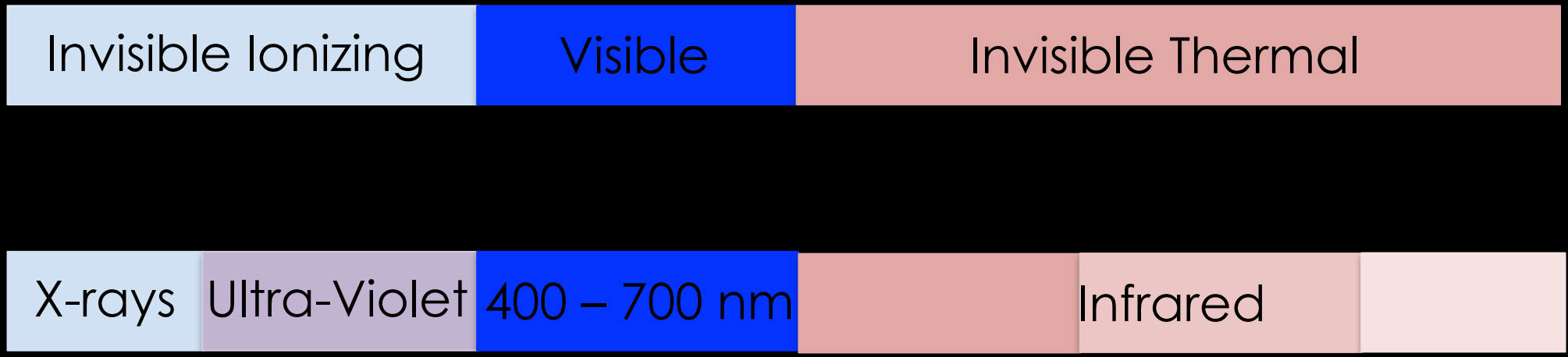
Photons and Energy

- All photons have energy
- Energy is inversely proportional to wavelength

$$E = \frac{h\,c}{\lambda}$$



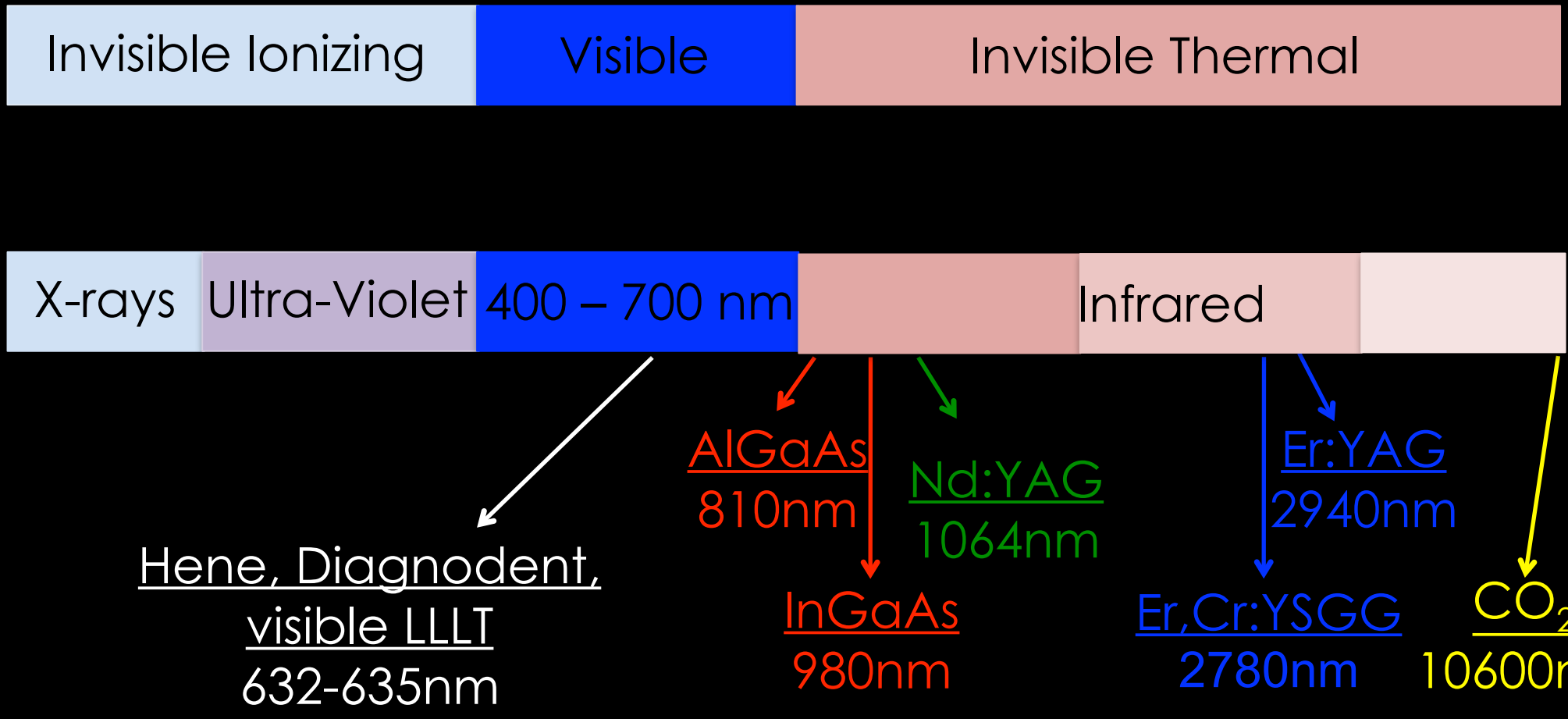
Electromagnetic Spectrum



↑ Wavelength → ↓ Energy → ↓ Penetration

↓ Wavelength → ↑ Energy → ↑ Penetration

Dental LASER Wavelengths on the Electromagnetic Spectrum



What does a LASER comprise of

- Active Medium
  - Liquid, Gas, or Solid (Crystal) to emit the specific wavelength
- External Energy Source
  - Pumping mechanism to excite the atoms
- Optical Resonator
  - Mirrors to reflect specific wavelengths

What does a LASER comprise of

- Active Medium
  - Liquid, Gas, or Solid (Crystal) to emit the specific wavelength
- Determines the LASER type
  - Diode : solid (semiconductor wafer)
  - Er:YAG : solid (rod of Yttrium, Aluminum, Garnet "doped" with Erbium)
  - Argon, CO_2 : gas

What does a LASER comprise of

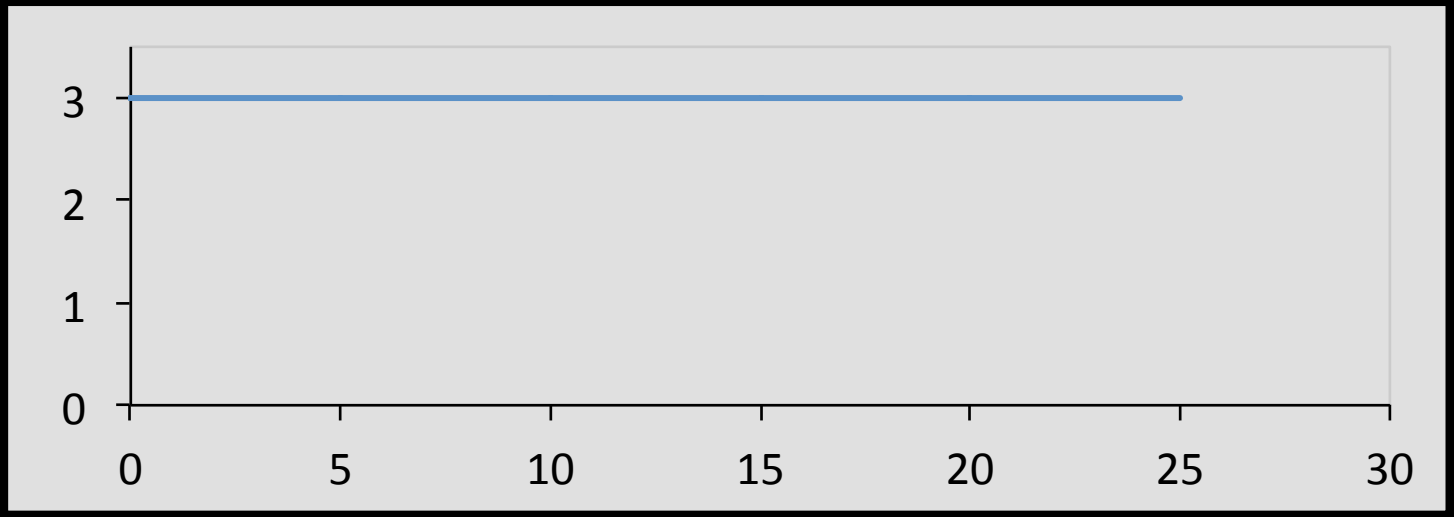
- External Energy Source
  - Pumping mechanism to excite the atoms
- Electrical current for continuous wave (CW) LASERs
  - Diode, CO_2
- Rapidly flashing lamp for free running pulsed LASERs
  - Nd:YAG, Erbium lasers

Modes of Operation

- Continuous Wave (CW)
  - Diode, CO_2
- Gated - pulsed mode
  - Mechanically shuttering CW
- Free – running pulsed mode
  - Nd:YAG, Erbium lasers

Continuous Wave (CW)

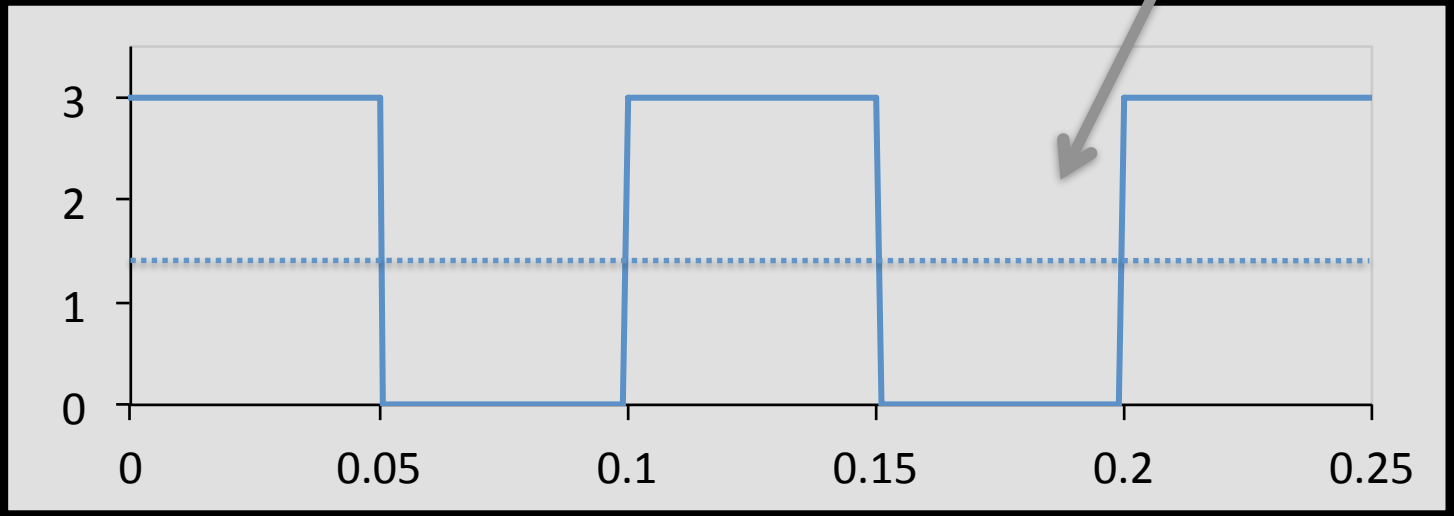
- Output Setting: 3.0 W
- Frequency: CW
- Pulse duration: CW
- Peak Power: 3.0 W, Average Power: 3.0 W



Gated – Pulsed Mode

- Output Setting: 3.0 W
- Frequency: 10 Hz
- Pulse duration: 0.05 sec (50msec)
- Peak Power: 3.0 W, Average Power: 1.5 W

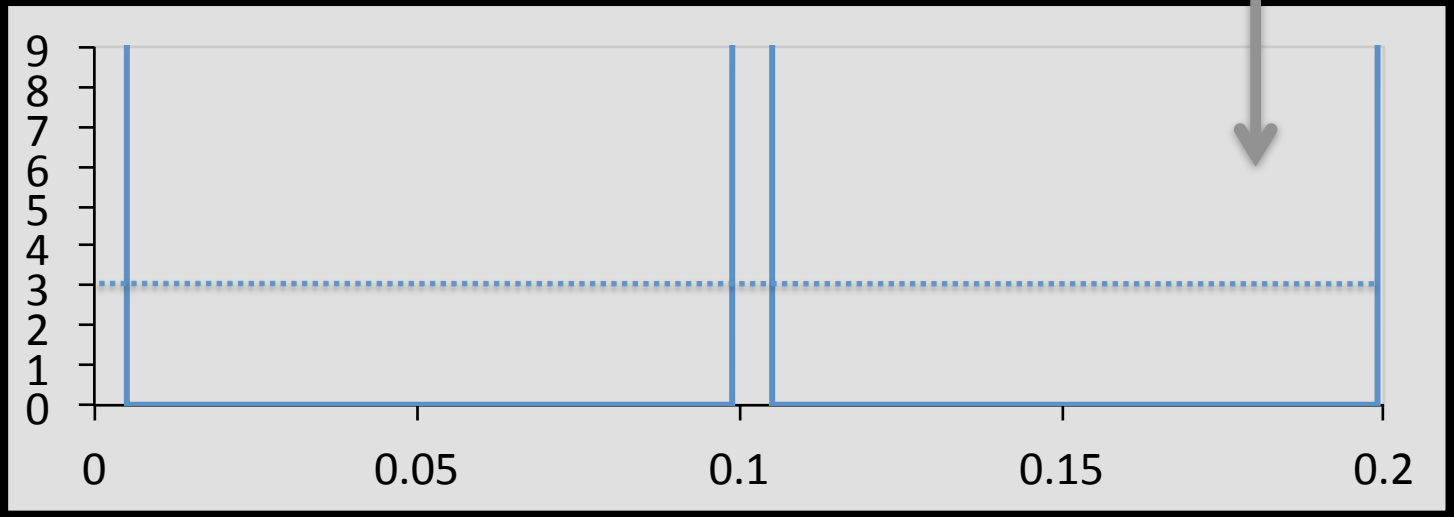
Thermal Relaxation Time



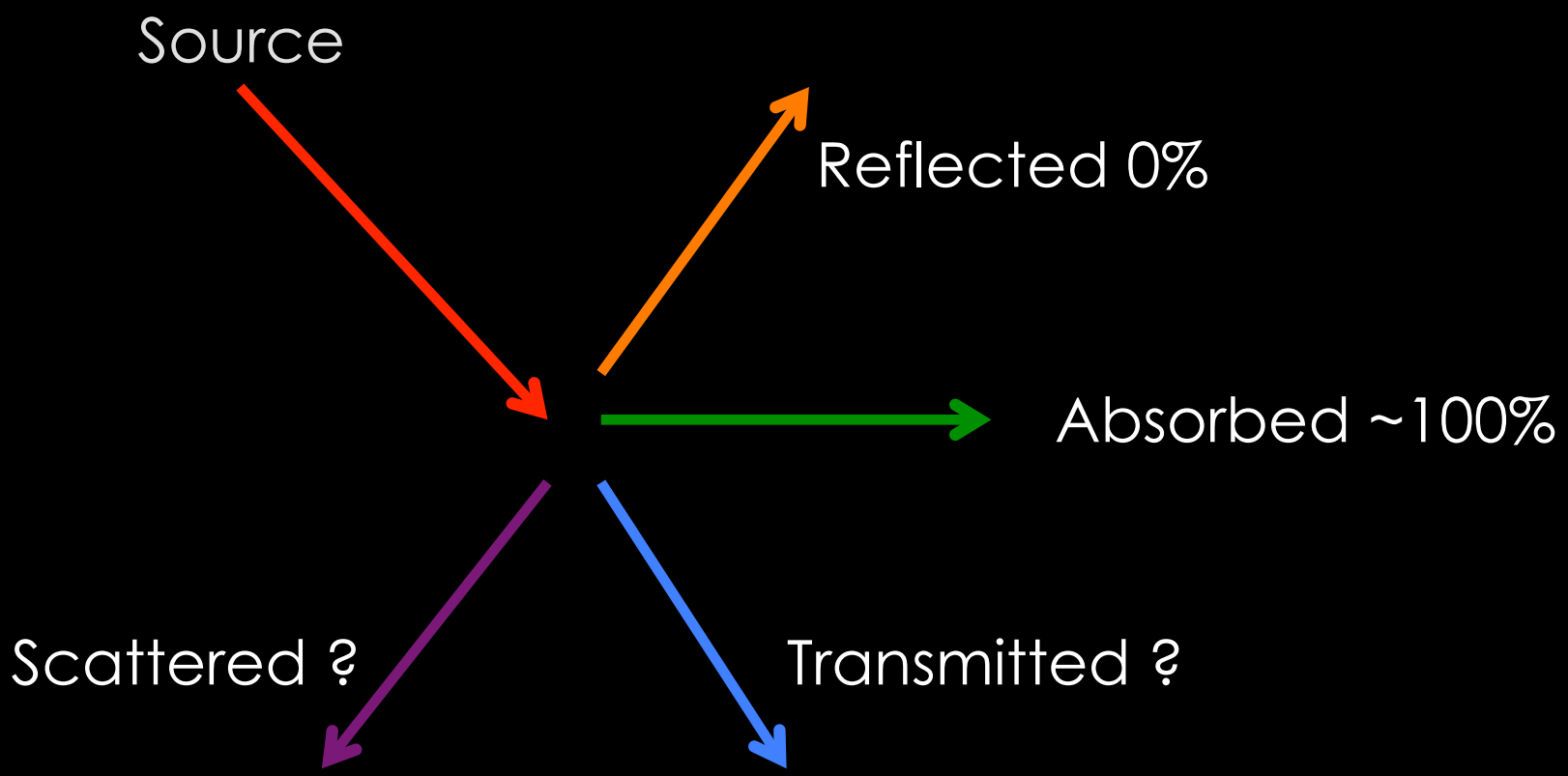
Free – Running Pulsed Mode

- Output Setting: 3.0 W
- Frequency: 10 Hz
- Pulse duration: 0.0002 sec (200µsec)
- Average Power: 3.0 W, Peak Power: 1500 W

Thermal Relaxation Time



LASER – Tissue Interaction



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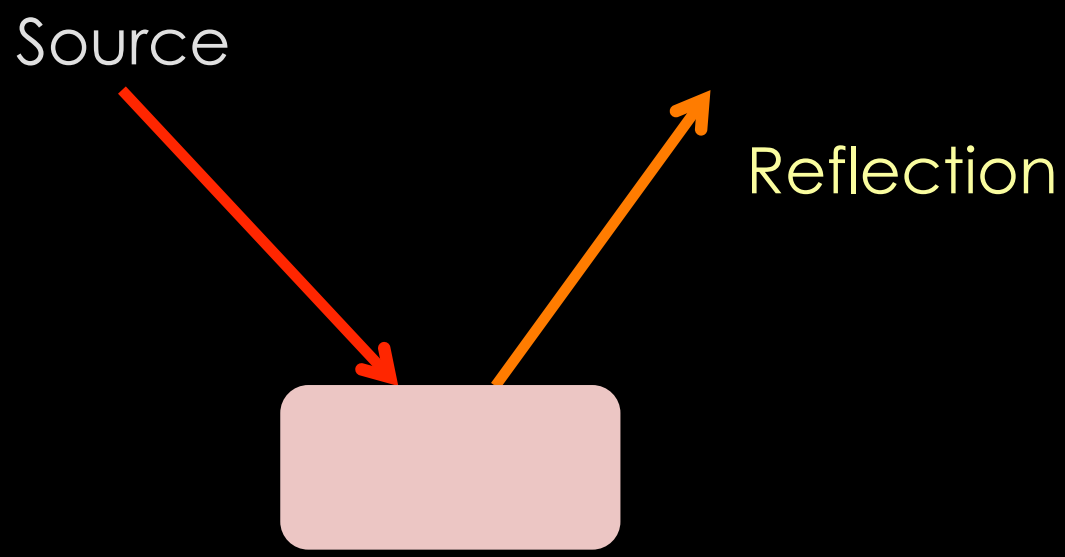
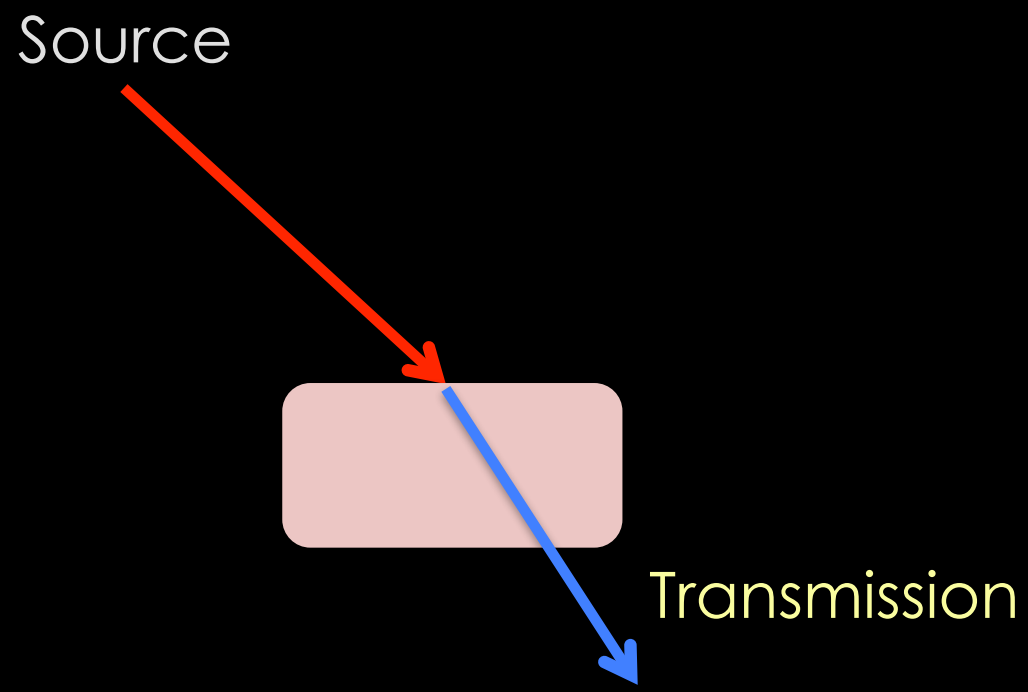


Laser energy has no effect on tissue

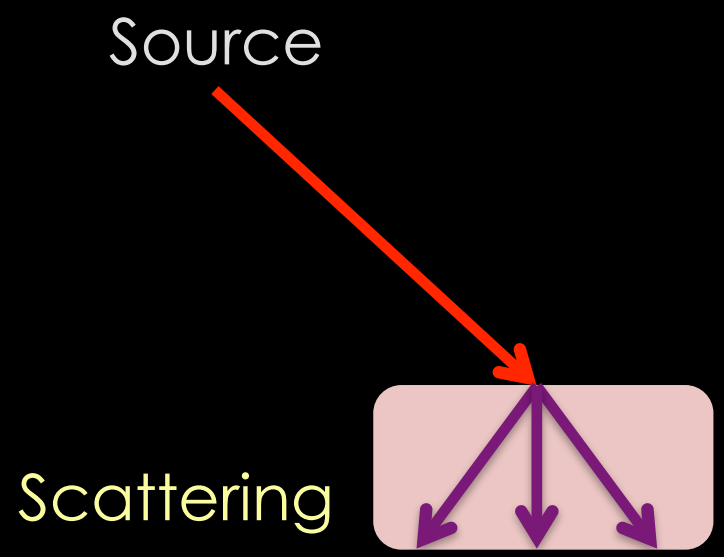
LASER – Tissue Interaction



Energy passes through the tissue

Dependent upon tissue type and wavelength

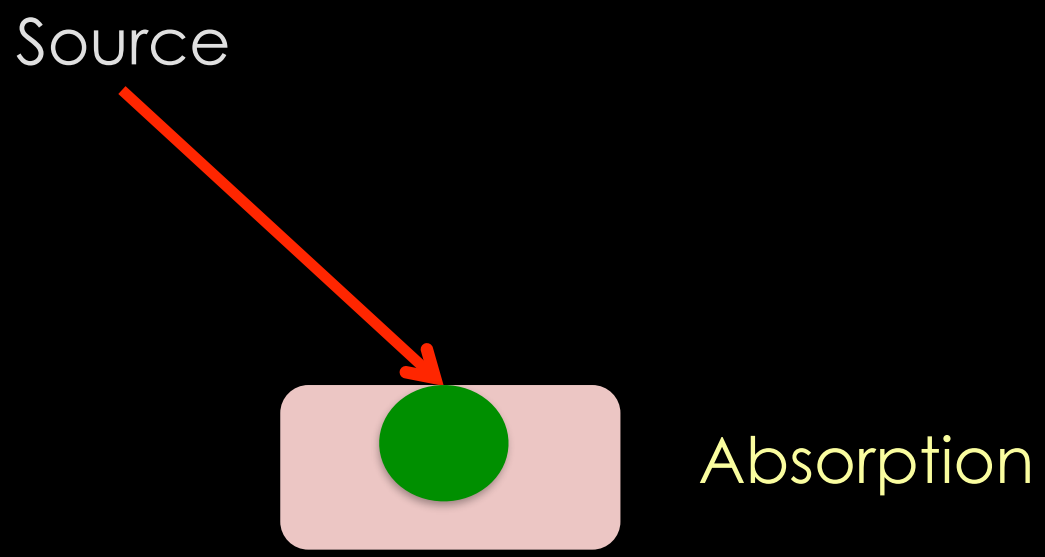
LASER – Tissue Interaction



Energy enters the tissue, spreads out, and dissipates

Dependent upon tissue type and wavelength

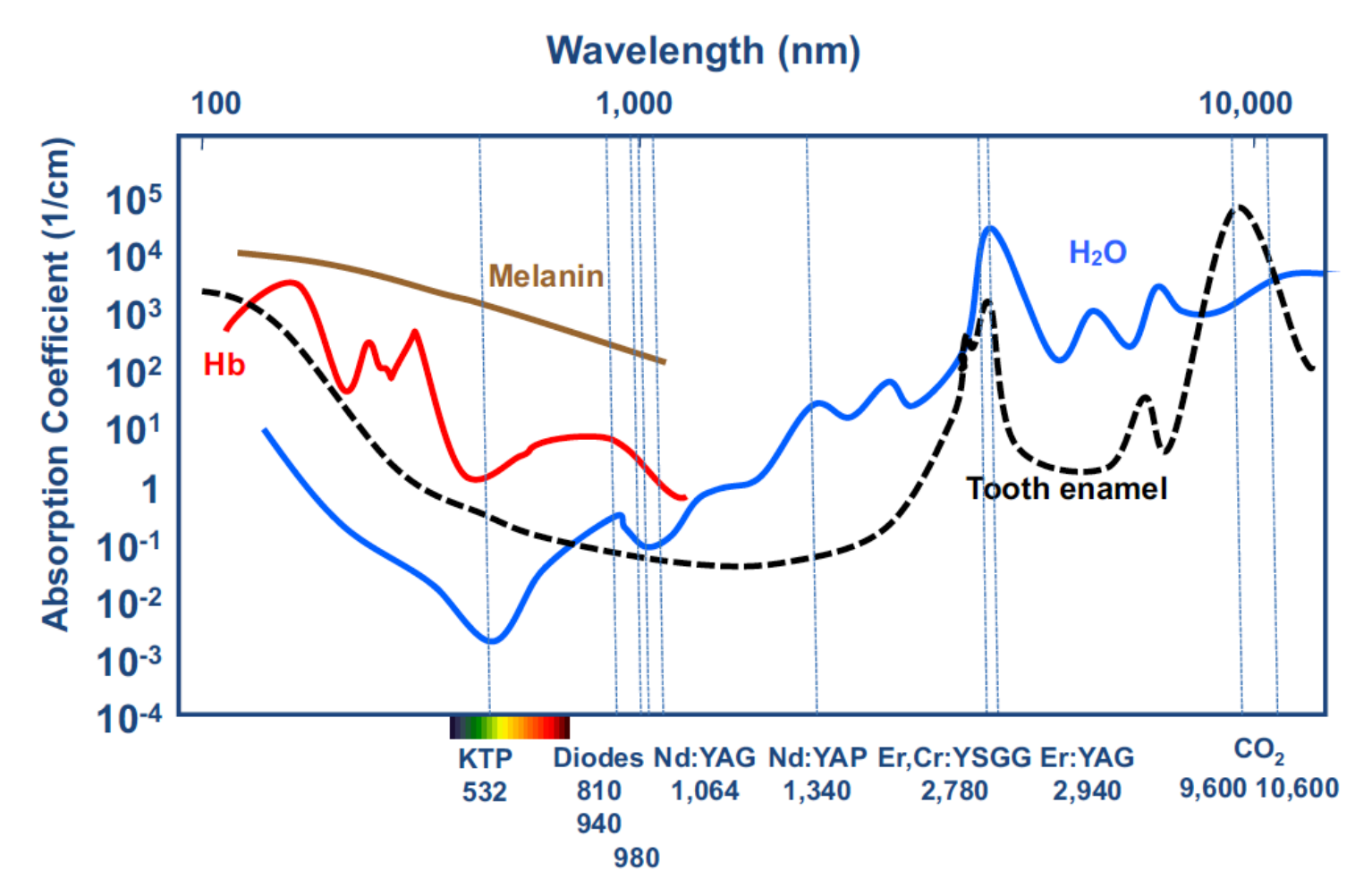
LASER – Tissue Interaction



Energy enters the tissue and does work!!!

Dependent upon wavelength, tissue composition and tissue pigmentation

Absorption Curves of Biologic Tissue Components



Aoki et al. Periodontal and peri-implant wound healing following laser therapy. Periodontol 2000 2015; 68: 217-269

Types of LASER – Tissue Interactions

- Photochemical
  - Stimulate chemical reactions
  - Break chemical bonds
- Photothermal
  - Coagulation
  - Vaporization
- Photodynamic Therapy
- Biostimulation
  - Pain relief
  - Wound healing
  - Collagen growth

All dental LASERs exhibit tissue interaction that is primarily photo-thermal

Light energy is changed into heat during absorption by the target tissue

Thermal Effect of LASERs on Tissues

Tissue temperature (°C)	Observed Effect
37 – 50	Hyperthermia
> 60	Coagulation/Protein Denaturation
70 – 90	Welding
100 – 150	Vaporization
> 200	Carbonization

Modes of Use

- Contact mode
  - Diode, YAG
- Non - contact mode
  - Diode, YAG, CO_2

Contact Mode

Advantages

- Accuracy
- Lower energy levels required
- Controlled power density
- High speed/action ratio

Disadvantages

- Only applicable to fiber delivery system
- Risk of “hot-tip” effect from debris build-up
- Risk of deep tissue harm

Non – contact Mode

Advantages

- Lower power density
- Greater area of tissue exposed
- Greater control of effects
- Low risk of deep tissue penetration
- Applicable to all delivery systems

Disadvantages

- Lower power density
- Greater area of tissue exposed
- Greater risk of collateral damage

Types of Dental LASERs

- Diode - 810 nm, 980 nm
- Nd:YAG - 1064 nm
- Er:YAG - 2940 nm
- Er,Cr:YSGG - 2780 nm
- CO_2 - 10600 nm

Dental Practitioners' Expectations

- Latest technology
- High quality of service
- One device to-do-everything (all-tissue laser)
- Low cost

Diode - 810 nm, 980 nm

AlGaAs (Aluminium, Gallium, Arsenate) 810 nm

InGaAs (Indium, Gallium, Arsenate) 980 nm

- Invisible semiconductor laser
- Fiber delivery
- CW, Gated pulsed
- Medium to high power
- High absorption by melanin
- Minimum absorption by dental hard tissue
- Excellent for soft tissue surgery and hemostasis
- Can be used for tooth whitening with proper catalyst
- Small and lightweight

Nd:YAG - 1064 nm

Nd:YAG (Neodymium:Yttrium Aluminum Garnet) 1064nm

- Invisible solid – state
- Fiber delivery
- Free-running pulsed (CW possible but uncommon)
- High peak power
- High absorption by melanin
- Minimum absorption by water and dental hard tissue
- Excellent for soft tissue surgery and hemostasis
- FDA approved for specific protocol for periodontal treatment (Millenium)
- Can be used for tooth whitening
- Can be used for laboratory welding
- Larger than Diode

CO_2 - 10600 nm

- Invisible gas
- Hollow waveguide delivery, never fiber
- Dental lasers are currently CW only
- Non-contact mode only
- High absorption by water
- Low absorption by dental hard tissue
- Excellent for soft tissue surgery and hemostasis
- Risk for collateral thermal damage (must be managed)
- Use of special anodized non-reflecting instruments is necessary
- Large size

Indications for Soft Tissue LASERs

- Aphthous ulcers and herpetic lesions treatment
- Dental hypersensitivity
- Biopsy

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- Dental hypersensitivity
- Biopsy
- Frenectomy
- Gingivectomy, gingivoplasty

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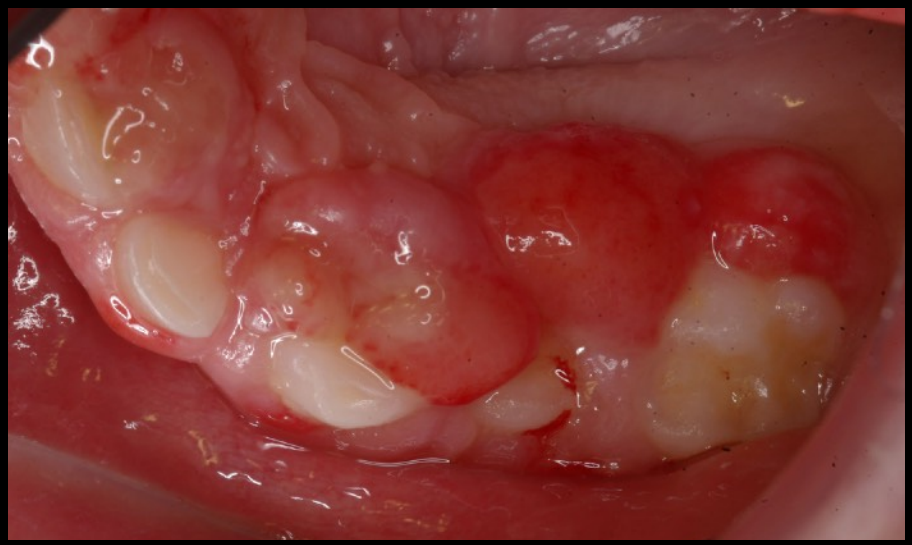
Indications for Soft Tissue LASERs

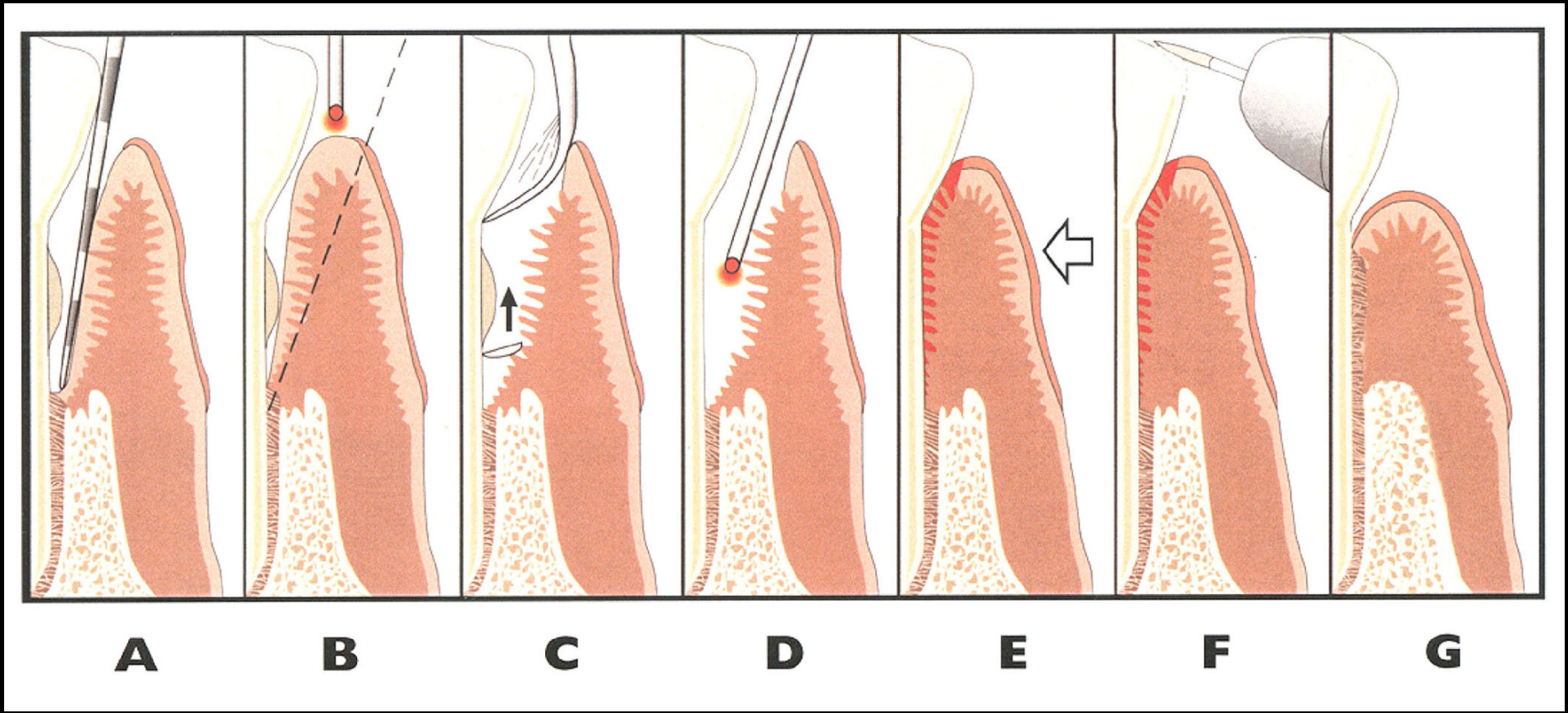
- sior
- Removal of pigmentation or tissue tattoos
- Hemostasis and coagulation



Indications for Soft Tissue LASERs

- Aphthous ulcers and herpetic lesions treatment
- Dental hypersensitivity
- Biopsy
- Frenectomy
- Gingivectomy, gingivoplasty
- Removal of pigmentation or tissue tattoos
- Hemostasis and coagulation
- Implant uncovering
- LANAP (Laser Assisted New Attachment Procedure) for Nd:YAG
- LAPIP (Laser Assisted Peri-Implantitis Procedure) for Nd:YAG
- Bacterial load decrease in pocket and root canals
- Biostimulation

Laser-Assisted New Attachment Procedure (LANAP)



Periodontal Disease Treatment

2018 AAP Best Evidence Consensus Statement on the Efficacy of Laser Therapy in the Non-surgical and Surgical Treatment of Periodontitis and Peri-implant Diseases

<u>Non-surgical Periodontal Treatment</u>

"Current evidence fails to demonstrate a beneficial long-term (>48 months) effect of laser treatment as an adjunctive therapy"

Periodontal Disease Treatment

2018 AAP Best Evidence Consensus Statement on the Efficacy of Laser Therapy in the Non-surgical and Surgical Treatment of Periodontitis and Peri-implant Diseases

<u>Surgical Periodontal Treatment</u>

"Current evidence suggests no additional benefit beyond that seen with surgery alone"

Periodontal Disease Treatment

2018 AAP Best Evidence Consensus Statement on the Efficacy of Laser Therapy in the Non-surgical and Surgical Treatment of Periodontitis and Peri-implant Diseases

<u>Surgical Peri-implant Treatment</u>

"Most studies show reduction in BOP; short-term data demonstrate inconsistency in PD, CAL gain, and bone fill"

Periodontal Disease Treatment

2018 AAP Best Evidence Consensus Statement on the Efficacy of Laser Therapy in the Non-surgical and Surgical Treatment of Periodontitis and Peri-implant Diseases

<u>Antimicrobial Photodynamic Therapy</u>

"Current evidence demonstrates that appropriate aPT as an adjunct may provide modest (<1mm) improvements in PD and CAL gain"

Erbium - 2940 nm, 2780 nm

Er:YAG (Erbium:Yttrium Aluminum Garnet) 2940 nm

Er,Cr:YSGG (Erbium,Chromium:Yttrium Scandium Gallium Garnet) 2940 nm

- Invisible solid – state
- Waveguide and articulated arms delivery, rarely fiber
- Free-running pulsed
- High peak power
- High absorption by water and dental hard tissue
- Hard tissue applications
- Soft tissue applications
- Limited hemostasis
- Large size

Indications for Hard Tissue LASERs

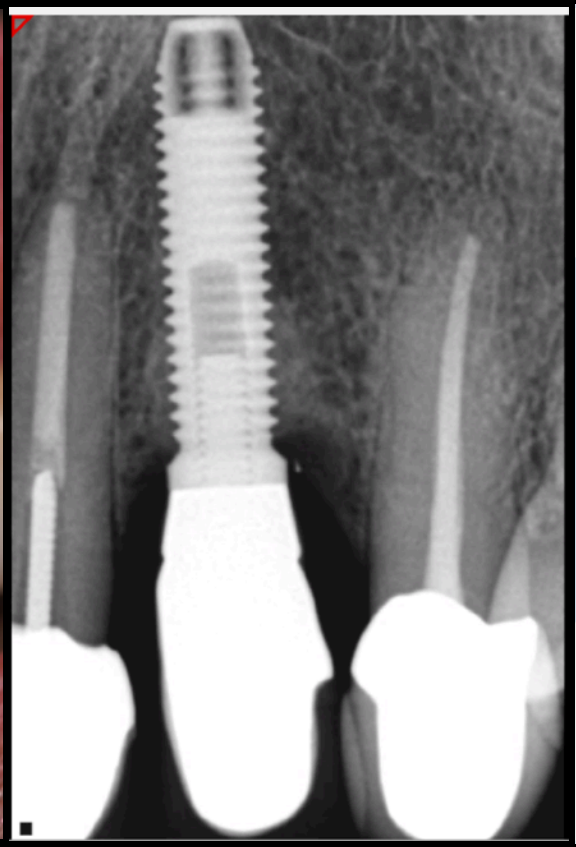
- Caries detection
- Caries removal, cavity preparation
- Enamel roughening
- Composites curing
- Ostectomy, osteoplasty

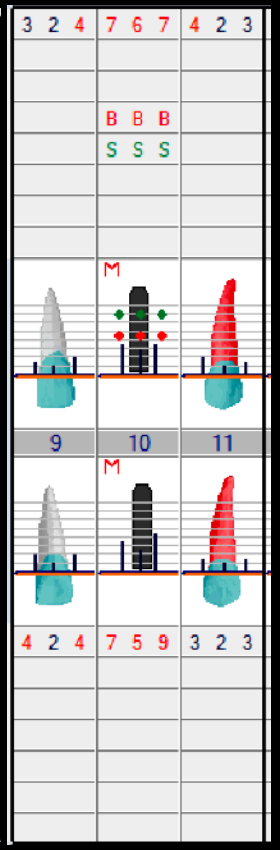
Indications for Hard Tissue LASERs

- Caries detection
- Caries removal, cavity preparation
- Enamel roughening
- Composites curing
- Ostectomy, osteoplasty
- Root canal preparation
- Apicoectomy
- Tooth whitening
- Biostimulation
- Peri-implantitis treatment

Indications for Hard Tissue LASERs

- Caries detection





- Biostimulation
- Peri-implantitis treatment

Indications for Hard Tissue LASERs

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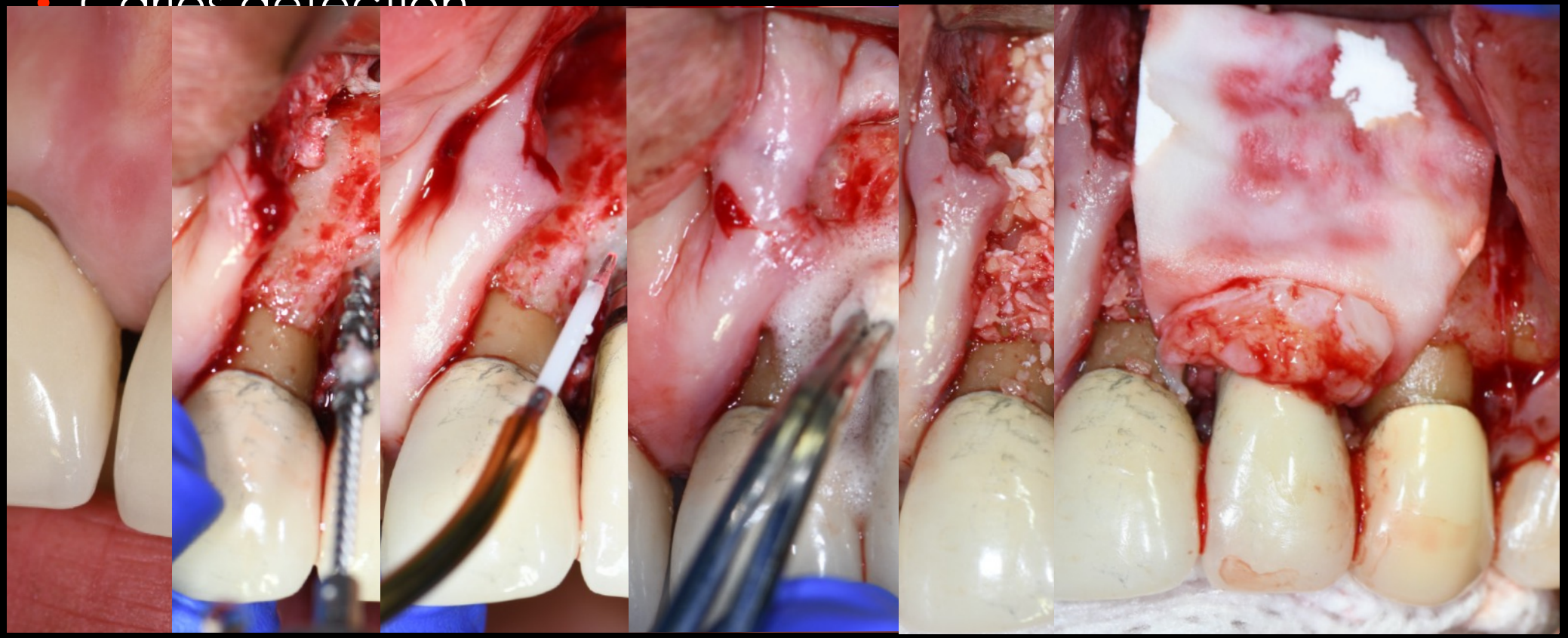


- Biostimulation
- Peri-implantitis treatment

Low Level Lasers - 630 – 900 nm

- Visible and invisible infrared
- Rigid tip delivery
- CW, Gated pulsed
- Local blood flow stimulation
- Possible fibroblast stimulation by visible red
- Possible osteoblast stimulation by near-infrared
- Caries detection (Diagnodent)

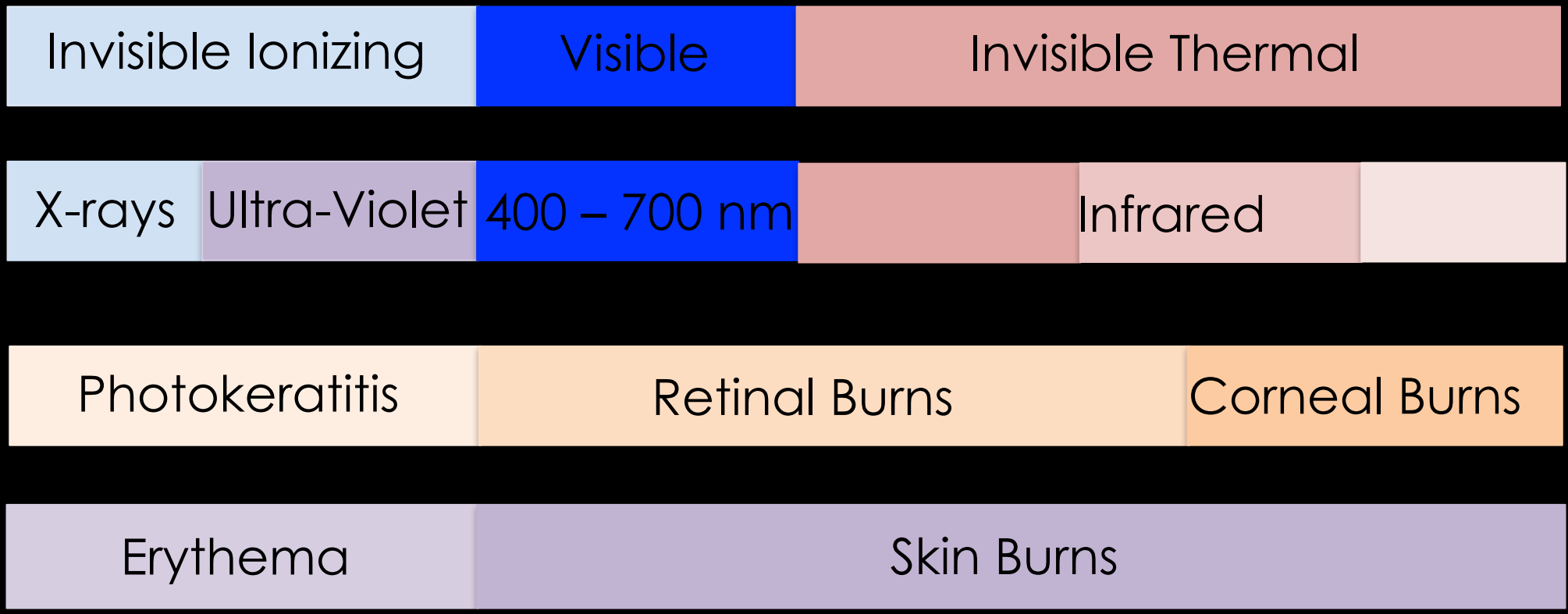
Aiming Beam Laser

- Visible
- Produced by low power diode laser, or conventional source
- Delivered co-axially with surgical laser
- Enables precise placement of the invisible laser beam on the target tissue

LASER Classification

- Class I
  - CD-ROM players, laser printers
  - Eye damage risk
- Class II
  - Low Power Visible Light, laser pointers, UPC scanners
  - Eye damage risk
- Class III
  - Low Level Lasers
  - Requires special training and eye protection
- Class IV
  - Medical and Dental Lasers
  - Requires special training and eye protection
  - Skin burn risk

Damaging Effects of LASER on Eye and Skin



LASER Safety

- On/off switch with a key
- Emergency stop button
- Protective eyewear for specific wavelength
  - OD 4+ to be acceptable
  - Regardless of color!!!
  - Use with loupes!!!
- Masks 0.1 μm pore
- Powerful suction
- Sterilization and disinfection
- New tips or cut fiber

stathopp@ohsu.edu