



Academy of Laser Dentistry

Glossary of Laser Terms

Foundations in Laser Dentistry Digital Course

Provided by the ALD as a downloadable handout for the Foundations in Laser Dentistry Self-Paced Digital Learning Course

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Foundations in Laser Dentistry - Self-paced Digital Learning
(6 CEU) covers 5 chapters

- Chapter: 1 Fundamentals of Light
- Chapter: 2 Production of Light
- Chapter: 3 Laser-Tissue and Laser-Material Interactions
- Chapter: 4 Clinical Applications in Laser Dentistry
- Chapter: 5 Laser Safety in Dentistry

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Glossary of Laser Terms

- **Ablation:** using thermal energy to remove a segment of tissue.
- **Absorption:** the transfer of energy into the target tissue resulting in change in that tissue. All wavelengths are absorbed by some media. Examples: CO₂ lasers, which are in the far infrared spectrum, are absorbed by water, and Nd:YAG lasers, in the near-infrared, are absorbed by melanin. Absorption is the number one determinant in predicting the tissue effect of any laser wavelength. Absorption is a function of wavelength, tissue composition, pigmentation, and water content. High absorption results in shallow penetration in tissue. Low absorption results in deeper penetration.
- **Absorption Coefficient:** a measure of the amount of absorption of energy in unit area. The absorption coefficient determines how far into a material light of a particular wavelength can penetrate before it is absorbed. In a material with a low absorption coefficient, light is only poorly absorbed. The absorption coefficient depends on the material and also on the wavelength of light which is being absorbed.
- **Accessible Emission Limits (AEL):** the classification of a laser is based on the concept of accessible emission limits (AEL) that are defined for each laser class. This is usually a maximum power (in W) or energy (in J) that can be emitted in a specific wavelength range and exposure time. For infrared wavelengths above 4 μm , it is specified as a maximum power density (in W/m²).
- **Active Medium:** the material within the optical cavity that, when stimulated and amplified into a population inversion, will emit laser energy. The active medium is positioned within the laser cavity between the optical resonator and is also surrounded by the pumping mechanism or energy source.
- **Alexandrite Laser:** was originally designed to be a fixed wavelength laser, but later was developed into a tunable solid-state laser. Alexandrite rods are usually 0.3 to 0.7 cm in diameter and 7.6 to 10 cm long. Alexandrite lasers can be pulsed or continuous, depending on the requirements of the operation. A frequency-doubled Alexandrite laser, emitting at 377 nm, has been used experimentally in dentistry to selectively remove calculus from teeth.
- **American National Standards Institute (ANSI):** a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States. The organization also coordinates U.S. standards with international standards so that American products can be used worldwide.
- **American Society for Laser Medicine and Surgery (ASLMS):** the world's largest professional organization dedicated to promoting excellence in patient care by advancing laser applications and related technologies.
- **Amplification:** a process that occurs in the optical resonator whereby stimulated emission produces a population inversion.
- **Amplitude:** the height of a wave from the top of one peak to the bottom of the next.
- **ANSI Z-136.1: American National Standard for Safe Use of Lasers.** Defines hazard evaluation, personal protective equipment, training, and criteria for exposures of eye and skin.
- **ANSI Z-136.3: American National Standard for Safe Use of Lasers in Health Care.** Defines laser safety officer, hazard classification, control measures, laser safety programs.
- **Argon Laser:** invented in 1964 by William Bridges at Hughes Research Laboratories and is one of a family of ion lasers that uses a noble gas as the active medium. Argon lasers are used for retinal phototherapy (for diabetes), lithography, and pumping other lasers. Dental applications include

intraoral soft tissue surgery and curing of composite materials. Argon lasers emit at 13 wavelengths through the visible, ultraviolet, and near-visible spectrum. Wavelengths pertinent to dentistry include 488.0 and 514.5 nm.

- **Articulating Arm:** a type of delivery system that directs the laser beam; usually a series of hollow tubes with right-angle mirrors. In this system, laser energy is reflected off each mirror until it emits from the arm.
- **Atom:** the smallest particle of an element that can exist, either alone or in combination.
- **Attenuation:** the observed decline in energy as a laser beam passes through an absorbing or scattering medium.
- **Average Power:** the average of the peak power and the laser off time. Calculated in Watts. This is the amount of energy delivered over a period of time. Average Power = Energy x Frequency.
- **Beam:** any collection of electromagnetic rays that may be divergent, convergent, or collimated
- **Beam Diameter:** diameter along any specified line that is perpendicular to the beam axis and intersects it.
- **Beam Divergence:** of an electromagnetic beam is an angular measure of the increase in beam diameter or radius with distance from the optical aperture or antenna aperture from which the electromagnetic beam emerges.
- **Beam Spot Size:** the diameter of the beam at any distance. It varies with the focal distance.
- **Blink Reflex:** the eye's self-defense mechanism, also called the blink or aversion response. When a bright light hits the eye, the eye tends to blink or turn away from the light source (aversion) within a quarter of a second. Infrared lasers are particularly hazardous, since the body's protective 'blink reflex' response is triggered only by visible light. For example, some people exposed to high power Nd:YAG laser emitting invisible 1064 nm radiation may not feel pain or notice immediate damage to their eyesight. A pop or click noise emanating from the eyeball may be the only indication that retinal damage has occurred (i.e., the retina was heated to over 100°C resulting in localized explosive boiling accompanied by the immediate creation of a permanent blind spot).
- **Carbon Dioxide (CO2) Laser:** a specialized laser that is filled with carbon dioxide gas and uses an infrared emission for cutting tissue through heat absorption. It is one of the most common lasers used in surgery and is good for precise cutting and vaporization of tissue, such as that needed in the treatment of superficial lesions or removing small volumes of tissue. Uses an articulated arm or hollow waveguide delivery system. It emits in the range of 9300-10600 nm in the far-infrared thermal portion of the electromagnetic spectrum. Used in dentistry for intraoral soft tissue surgical procedures.
- **Cavity End Mirrors:** one mirror is partially reflective (transmissive) and the other is totally reflective, placed at opposite ends of the optical cavity. These mirrors reflect the photons back and forth through the active medium, stimulating the atoms to release additional photons. A small but finite amount of energy is transmitted out of the cavity through the partially transmissive mirror and constitutes the laser output of the device.
- **Center for Devices and Radiological Health (CDRH):** a bureau of the U.S. Food and Drug Administration that regulates the manufacture of radiation-emitting electronic products.
- **Chromophore:** a light-absorbing compound or molecule normally occurring in tissues that absorbs specific wavelengths of laser light.
- **Cladding of a Fiber:** a thin coating that surrounds the core of glass in a fiber-optic delivery system. It maintains the propagation of the laser beam along the glass.
- **Coagulation:** denaturation of soft tissue proteins that begins to occur at 60°C.
- **Coherent:** every wave is of the same wavelength and in phase with one another. The photons are

well ordered and travel parallel to each other.

- **Collimated:** all the waves are parallel with no divergence.
- **Concave:** curving inward. A concave surface is shaped like the inside of a bowl.
- **Contact Mode:** direct touching of the laser delivery system to the target tissue.
- **Continuous Wave:** a laser that continuously emits energy at the level that is selected on the control panel. Maximum (peak) power is identical to average power. Continuous-wave lasers emit a steady beam for as long as the laser medium is excited. If this beam is held on tissue longer than the thermal relaxation time, excessive heat will be conducted into tissue, delaying healing and increasing scarring. All continuous-wave lasers may be pulsed, either mechanically or by electronic or photonic means.
- **Control Panel:** usually a microprocessor that allows for variation in operating parameters so that the desired laser emission is produced. The control panel allows the operator to adjust operating parameters: emission modes, energy output, pulse rate, and pulse duration. Air and water coolant adjustments and ready mode vs. standby activations are made from the control panel.
- **Converging Lens:** (positive lens) a lens that brings light waves together to a specific point. An example is a convex lens.
- **Convex Lens:** Curving outward. A convex surface is shaped like the outside of a circle.
- **Cooling system:** laser subsystem that removes built-up heat from the active medium in order to keep it below maximum operating temperature. Cooling systems can utilize air or water and can be the largest component in the more powerful lasers.
- **Delivery System:** a device or mechanism that carries the amplified light as it escapes the laser cavity through the partially transmissive mirror to the "work site" and directs it at a specific tissue area so that tissue interaction can take place. Delivery systems used in dental lasers include optical fibers, hollow waveguides, and articulated arms.
- **Denaturation:** a process in which proteins or nucleic acids lose their tertiary structure and secondary structure by application of some external stress or compound, such as a strong acid or base, a concentration inorganic salt, an organic solvent (e.g., alcohol or chloroform), or heat. If proteins in a living cell are denatured, this results in disruption of cell activity and possibly cell death. Denatured proteins can exhibit a wide range of characteristics, from loss of solubility to communal aggregation.
- **Diffraction:** the bending of a light ray as the light passes through a medium; also known as refraction. Diffraction is the slight bending of light as it passes around the edge of an object
- **Diffuse reflection:** the reflection of light from a surface such that an incident ray is reflected at many angles rather than at just one angle as in the case of specular reflection.
- **Diode Laser:** a laser whose active medium is a semiconductor similar to that found in a light-emitting diode. The most common type of laser diode is formed from a p-n junction and powered by injected electric current. The former devices are sometimes referred to as injection laser diodes to distinguish them from optically pumped laser diodes. In dentistry, diode lasers may be used as intraoral soft tissue surgical and endodontic lasers, aiming beams, a way to induce fluorescence in caries-detection devices, or low-level laser therapeutic devices.
- **Divergence:** as light exits the distal end of a delivery system fiber, it spreads out over a larger area.
- **Diverging Lens:** (negative lens) a lens that causes parallel light rays to diverge or spread out.
- **Doping:** the addition of an element to the laser crystal, resulting in a specific wavelength emission.
- **Duty Cycle:** the duty cycle of a machine or system is the time that it spends in an active state as a fraction of the total time under consideration. In a periodic event, duty cycle is the ratio of the duration of the event to the total period. The term is often used pertaining to electrical devices,

e.g., switching power supplies. 60% duty cycle means the power is on 60% of the time and off 40% of the time. The duty cycle is the ratio of the laser on time to the time between successive pulses

- **Electromagnetic Radiation:** energy in the form of electromagnetic waves.
- **Electromagnetic Spectrum:** an entire range of wavelengths or frequencies of electromagnetic radiation, extending from gamma to the very long radio waves.
- **Electromagnetic Wave:** time-varying electric and magnetic wave fields propagating through space
- **Emission:** the release of radiant energy.
- **Emission Mode:** the manner and timing in which generated light leaves the laser device.
- **Energy Density:** the amount of laser energy delivered to a given tissue surface, measured in Joules per centimeter squared.
- **Energy Source:** that which will deliver exactly the right amount of energy to excite an atom of the active medium enabling photon generation.
- **Erbium:** a rare earth element that is used to dope a crystal of yttrium aluminum garnet or yttrium scandium gallium garnet.
- **Erbium, Chromium:Yttrium Scandium Gallium Garnet (Er,Cr:YSGG):** a laser emitting at 2780 nm, used in dentistry for intraoral hard and soft tissue surgical procedures and endodontics
- **Erbium:Yttrium Aluminum Garnet (Er:YAG):** a laser emitting at 2940 nm, used in dentistry for intraoral hard and soft tissue surgical procedures and endodontics.
- **Eukaryote:** an organism whose cells contain complex structures enclosed within membranes.
- **External Optical Train:** the optical components external to the resonator cavity consisting of a combination of lenses and or mirrors and constitute the external train. These components direct the laser beam as it exits the optical cavity and focus it into the optical delivery system.
- **Extinction Length:** the thickness of a substance in which 98% of the incident laser energy is fully absorbed. The extinction length defines the depth of tissue up to which 90% of the incident laser beam is absorbed and converted into heat.
- **Fluence:** energy density in Joules per centimeter squared.
- **Fluorescence:** the property of emitting light while being exposed to light; the wavelength of the emitted light is usually longer than that of the light absorbed. This principle is the basis of operation of caries detection optical devices.
- **Focal Length:** distance between the lens and the focal point.
- **Focal Point:** the point at which a laser beam has converged and is most intense.
- **Free-Running Pulsed (FRP) Emission:** a laser operating mode in which an extremely high peak power burst of energy strikes the target tissue for a very short period of time, followed by a relatively long thermal relaxation time. The average power is equal to the power selected on the control panel.
- **Frequency:** the number of complete oscillations of a wave; inversely proportional to wavelength.
- **Gas Lasers:** use a gas or mixture of gases within a tube. The most common gas laser uses a mixture of helium and neon (HeNe), with primary output of 632 nm which is a visible red color. Other examples of gas lasers are CO₂ and Argon.
- **Gated Pulsed Emission:** a laser operating mode in which the emission is pulsed by “chopping” the continuous-wave beam by means of a mechanical shutter or electronic controls. On some laser devices, control panel settings allow regulation of pulse duration and time between pulses. A duty cycle can be calculated, and the average power is equal to the product of the duty cycle multiplied by the peak power selected.
- **Helium-Neon (HeNe):** Gas-type laser, excited by a DC electrical discharge, and operating at 632.8 nm (red) or 543.5 nm (green). Used as an aiming beam or a low-level laser device.

- **Hertz:** a unit of frequency measured as one cycle per second.
- **Hollow Waveguide:** a laser delivery system consisting of a flexible hollow tube with a mirrored inner surface that guides the beam along its length.
- **Joule:** a unit of energy, the amount of energy delivered by one Watt of power in one second.
- **Laser:** acronym for Light Amplification by Stimulated Emission of Radiation; a device that uses the natural oscillations of atoms between energy levels for generating coherent electromagnetic radiation in the ultraviolet, visible, or infrared regions of the electromagnetic spectrum.
- **Laser Biostimulation:** treatment using irradiation with light at low power intensities and with wavelengths generally in the range of 540 nm to 830 nm. The effects are thought to be mediated by a photochemical reaction that alters cell membrane permeability, leading to increased mRNA synthesis and cell proliferation. The effects are not due to heat, as in laser surgery. Low-level laser therapy has been used in general medicine, veterinary medicine, and dentistry for a wide variety of conditions, but most frequently for wound healing and pain control. Also called photobiomodulation.
- **Laser Safety Officer (LSO):** the LSO is responsible for ensuring that safety regulations are followed by staff. Responsibilities include securing the laser in a safe place (serves as the keeper of the key or passcode), training of staff, reporting laser mishaps, and making sure the unit and accessories are properly maintained.
- **Light:** a form of electromagnetic radiation. Generally refers to wavelengths that are visible to the human eye (approximately 400 to 700 nm).
- **Light-Emitting Diode (LED):** semiconductor device (not a laser) which emits incoherent light when voltage is applied to it.
- **MASER:** microwave amplification by stimulated emission of radiation. A device that emits coherent microwave radiation, first developed by Charles Townes in 1954. Its principles of using the natural oscillations of atoms or molecules between energy levels were later extended to the infrared and visible portion of the electromagnetic spectrum, producing the laser.
- **Maximum Permissible Exposure (MPE):** level of laser radiation exposure above which adverse biological changes to the unprotected eye or skin may occur.
- **Medium:** one or more gases, liquids, or solids used to produce amplified stimulated emission in a laser.
- **Meter:** a unit of measurement, subdivisions of which are used to describe a laser's wavelength (e.g., micron and nanometer).
- **Micron:** one millionth of a meter, used as a measure of wavelength. Its value is 10^{-6} meter.
- **Molecule:** the smallest particle of a substance that retains the property of the substance, composed of one or more atoms.
- **Monochromatic:** a single wavelength or frequency (one "color").
- **Nanometer:** one billionth of a meter, used as a measure of wavelength. Its value is 10^{-9} meter.
- **Nd:YAG (Neodymium:Yttrium Aluminum Garnet):** a laser emitting at 1064 nm, used in dentistry primarily for intraoral soft tissue surgical and endodontic procedures.
- **Nd:YAP (Neodymium:Yttrium Aluminum Perovskite):** a laser emitting at 1340 nm, used in dentistry primarily for intraoral soft tissue surgical and endodontic procedures.
- **Neodymium (Nd):** a rare earth element that is used to dope a crystal of yttrium aluminum garnet or yttrium aluminum perovskite.
- **Nominal Hazard Zone (NHZ):** the space within which the maximum permissible exposure of laser radiation is being exceeded. Anyone within the NHZ must be wearing laser protection.
- **Nominal Ocular Hazard Distance (NOHD):** the distance from the port of an operating laser to

the human eye beyond which exposure is not expected to exceed the maximum permissible exposure. Anyone within the NOHD must be wearing laser-specific protective eyewear.

- **Occupational Safety and Health Administration (OSHA):** part of the U.S. Department of Labor that oversees worker safety. Laser installations are subject to OSHA review.
- **Optical Cavity:** or resonator, houses the laser medium and the cavity end mirrors.
- **Optical Density:** measure of transmittance through an optical medium.
- **Output Power:** the power of a laser, expressed in Watts.
- **Peak Power:** the maximum power level achieved within a laser pulse.
- **Photon:** a quantum of radiant energy, the basic particle of light.
- **Photoablation:** decomposition of tissue when exposed to intense laser irradiation without thermal damage to the adjacent tissue. When matter is exposed to focused light, energy is absorbed in a thin layer of materials, typically less than 0.1 um thick, due to the short wavelength of deep UV light. The high peak power of an excimer light pulse, when absorbed into this tiny volume, results in strong electronic bond breaking in the material. The resultant molecular fragments expand in a plasma plume that carries thermal energy away from the site. As a result, there is little or no damage to the material surrounding the produced feature. It is volatilization of tissue by ultraviolet rays emitted by a laser.
- **Photoacoustic Effects:** beam exposure may cause acoustical effects or localized vaporization of tissue or fluids. The rapid increase in pressure produced by this vaporization creates mechanical shock waves that propagate through tissue, causing disruption and damage.
- **Photobiomodulation:** also known as Low Level Laser therapy, Cold laser, soft laser. It is a laser or LED that produces a biological response at the cellular level producing either Biostimulation or Bioinhibition.
- **Photochemical Effects:** effects caused by light either stimulating chemical reactions or breaking molecular chemical bonds. The curing of composite material by argon laser light is one form of photochemical effect, as is photodynamic therapy.
- **Photodynamic Therapy (PDT):** Treatment is based on a photo-sensitive liquid that is injected to the body that selectively accumulates within unhealthy cells. When exposed to light of a particular wavelength, the resulting reaction destroys unhealthy cells.
- **Photokeratitis:** or ultraviolet keratitis is a painful eye condition caused by exposure of insufficiently protected eyes to the ultraviolet (UV) rays from either natural or artificial sources. This condition is similar to a sunburn to the cornea and conjunctiva.
- **Photopyrolysis:** decomposition of material by the action of light energy transformed into heat.
- **Photothermal Effects:** a phenomenon associated with electromagnetic radiation, produced by photo-excitation of material, resulting in the production of thermal energy (heat). Thermal effects are caused by a rise in temperature following absorption of laser energy, potentially denaturing proteins and inactivating enzyme.
- **Plume:** the vapor, smoke, and particulate debris produced during laser ablation procedures. Laser plumes may contain carcinogens, mutagens, irritants, fine dusts, blood fragments, bacterial spores, polycyclic aromatic hydrocarbons, and various toxic gases. The human papilloma virus (HPV) has also been found within plume.
- **Population Inversion:** a state in the laser cavity in which more electrons are in a higher energy state than in a lower one. The concept is of fundamental importance in laser science because the production of population inversion is a necessary step in laser operation.
- **Potassium Titanyl Phosphate (KTP):** also called frequency-doubled Nd:YAG, a laser emitting at 532 nm, used in dentistry for intraoral soft tissue surgical procedures.

- **Power Density:** average power divided by the spot area, typically calculated in Watts per centimeter squared.
- **Prism:** a transmitting optical component used to spatially separate light into wavelengths. It can also change the direction of the light beam.
- **Pulse Width:** the amount of time that the pulsed laser energy is emitted in each pulse.
- **Pulsed Laser:** a laser that emits energy at timed intervals.
- **Pumping:** the process of exciting electrons to higher energy levels. The goal is to produce a population inversion that can generate laser emission.
- **Q-switching:** also known as giant pulse formation, allows a laser to produce a pulsed beam of light. The technique produces light pulses with very high power – much higher than would be produced by the same laser operating in a constant output (CW). Q-switched lasers are used in dermatology to remove tattoos.
- **Quantum:** a measurement of quantity of energy; can be referred to as a photon
- **Radiant Energy:** quantity of energy traveling through space in the form of light waves, measured in Joules.
- **Radiant Exposure:** total energy per unit area delivered to a given surface in a given time, measured in Joules per centimeter squared per second.
- **Radiation:** the process of emitting energy in the form of waves or particles.
- **Reflection:** return of radiation from a surface without a change in wavelength. When light is reflected from tissue there is virtually no therapeutic effect upon tissue.
- **Ruby Laser:** a laser emitting at 694.3 nm, used in dermatology to lighten port wine stains, remove hair, and reduce wrinkles. Takes its place in history as the first working laser to be demonstrated in 1960 by Theodore Maiman of Hughes Research Laboratories. Was the first laser type used to examine laser effects on dental tissue.
- **Scattering:** process in which laser energy strikes tissue or a surface and is deflected in many directions with no change in wavelength. Scattering is the result of random deflection from the beam's original angle and is wavelength dependent.
- **Selective Photothermolysis:** the precise targeting of a structure or tissue using a specific wavelength of light with the intention of absorbing light into that target area alone. The energy directed into the target area produces sufficient heat to damage the target while allowing the surrounding area to remain relatively untouched.
- **Soliton Wave:** is a non-linear wave that maintains its shape and increase amplitude after colliding with a similar wave. The increased amplitude of the combined wavelengths allows the soliton wave to penetrate deeper into the body tissue. The soliton wave makes it possible for subtle energy to penetrate deep into body tissue and resonate cells.
- **Spontaneous Emission:** emission of a photon by an electron when it spontaneously drops from a higher energy level to a lower one.
- **Spot Size:** the diameter of a laser beam, which can vary with the focal distance.
- **Stimulated Emission:** the process that occurs when an electron drops to a lower energy level and is stimulated by another photon to emit an additional photon. Typically, the photon doing the stimulating was just emitted from an electron that had just made the same transition.
- **Super-Pulsed or Ultra-Pulsed:** digitally controlling the pulse of a continuous-wave (CW) laser, in which peak power levels are several times higher than the maximum CW level. A technique employed by some CO2 lasers to improve surgical precision and reduce charring.
- **Thermal Contact:** occurs when two substances of different temperatures can affect each other's temperature.

- **Thermal Equilibrium:** occurs when two substances in thermal contact no longer transfer heat.
- **Thermal Expansion:** takes place when a substance expands in volume as it gains heat.
- **Thermal Relaxation:** the time during which the target tissue is allowed to cool between exposures to laser energy.
- **Thermodynamics:** the field of physics that deals with the relationship between heat and other properties (such as pressure, density, temperature, etc.) in a substance. Thermodynamics focuses largely on how a heat transfer is related to various energy changes within a physical system.
- **Transmitted:** the passage of electromagnetic radiation through any medium. When laser energy is transmitted directly through tissue it will have little or no thermal effect. Dependent on tissue type and wavelength.
- **Vaporization:** the transition from a solid or liquid phase into a gaseous (or vapor) phase. The physical process of converting a solid or liquid into a gas; for dental procedures, it describes conversion of liquid water into steam.
- **Velocity:** the rate of speed at which a wave travels.
- **Visible Light:** Wavelengths discernible by the human eye, between approximately 400 and 700 nm.
- **Watt:** a unit of power; one Watt equals one Joule per second.
- **Wavelength:** the distance between two corresponding points in a periodic wave, usually measured in microns or nanometers.
- **White Light:** the combination of all visible wavelengths (400 to 700 nm).