Lasers in Medicine

Presented by

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Third year students

1. Single pulsed lasers

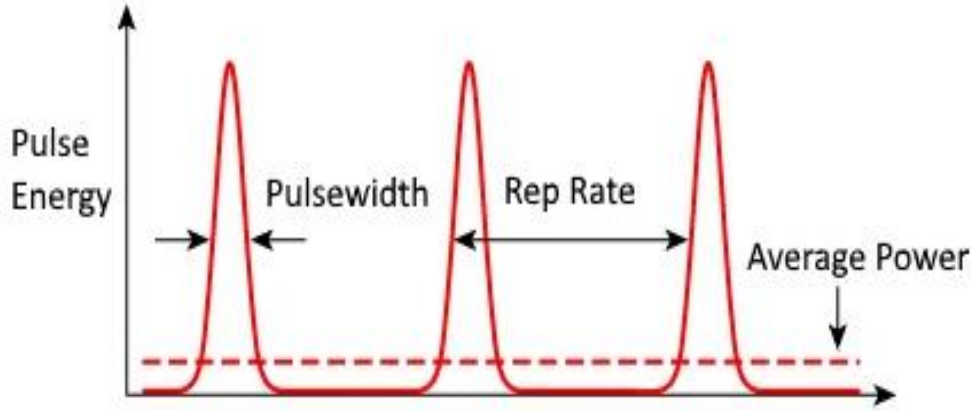
Pulsed operation of lasers refers to any laser not classified as continuous wave, so that the optical power appears in pulses of some duration at some repetition rate. This encompasses a wide range of technologies addressing a number of different motivations. Some lasers are pulsed simply because they cannot be run in continuous mode.

In other cases, the application requires the production of pulses having as large an energy as possible. Since the pulse energy is equal to the average power divided by the repetition rate, this goal can sometimes be satisfied by lowering the rate of pulses so that more energy can be built up in between pulses. In laser ablation for example, a small volume of material at the surface of a work piece can be evaporated if it is heated in a very short time, whereas supplying the energy gradually would allow for the heat to be absorbed into the bulk of the piece, never attaining a sufficiently high temperature at a particular point.

Other applications rely on the peak pulse power (rather than the energy in the pulse), especially in order to obtain nonlinear optical effects. For a given pulse energy, this requires creating pulses of the shortest possible duration utilizing techniques such as Q-switching.

The optical bandwidth of a pulse cannot be narrower than the reciprocal of the pulse width. In the case of extremely short pulses, that implies lasing over a considerable bandwidth, quite contrary to the very narrow bandwidths typical of continuous wave (CW) lasers.

The lasing medium in some dye lasers and vibronic solid-state lasers produces optical gain over a wide bandwidth, making a laser possible which can thus generate pulses of light as short as a few femtoseconds.



Laser Pulses

Pulsed lasers emit bursts of light spaced in time

• Between pulses, the laser emits no light.

• The period is the time from the start of one pulse to the next.

• The pulse duration (pulse width) is the time measured across a pulse, often at its full width half maximum (FWHM)

2. Single-pulse, Repetitive

2.1 Single-pulse Mode

Some pulsed lasers are operated in a single-pulse mode where each pulse can be freely triggered when the application demands it. In that regime, one often achieves rather high pulse energies, but only quite limited pulse repetition rates.

It is suitable, for example for lamp-pumped solid-state lasers.

2.2. Repetitive Pulsing

Some lasers emit pulses with a constant pulse repetition rate. In case of Q-switched lasers, this is often between 10 Hz and 100 kHz, while mode-locked lasers emit with very high repetition rates, typically tens or hundreds of megahertz, sometimes even many gigahertz. The energy per pulse is correspondingly low. The pulse repetition rate may be reduced by some possibly large factor by using a pulse picker.

3. Applications of pulsed laser

Pulsed Nd:YAG and Er:YAG lasers are used in laser tattoo removal and laser range finders among other applications.

Pulsed lasers are also used in soft-tissue surgery. When a laser beam comes into contact with soft-tissue, one important factor is to not overheat surrounding tissue, so necrosis can be prevented. Laser pulses must be spaced out to allow for efficient tissue cooling (thermal relaxation time) between pulses.