2 Power Output – Pulsed and CW

Solid state lasers can be pulsed, CW (Continuous Wave), or quasi-CW.

- Pulsed SS lasers generally use various versions of xenon flashlamps like the original ruby laser. Q-switching is used to stabilize and boost peak power output by preventing the laser cavity from resonating (e.g., one of the mirrors is blocked or forced to be misaligned) until the population inversion has built up fully.

  Energy output is measured in joules (Watt-seconds) per pulse. Multiply this by the number of pulses/second to calculate average power output. To determine the peak power in each pulse requires a knowledge of the pulse shape.

  Flashlamp pumped SS lasers are used where high peak power is required as most other pumping methods can't even come close. However, the average power and efficiency may be quite low compared to approaches using high power laser diode pumping (see below).

- CW SS lasers may use xenon or krypton arc lamps or other sources of intense broad spectrum light. However, the trend today is toward the use of arrays of high power laser diodes to do the pumping. These can be designed to have a wavelength that matches an absorption band in neodymium (around 800 nm) making for very efficient excitation. The diode pumped approaches are rapidly taking over due to their efficiency, resulting lower power consumption and heat dissipation, much more compact size, as well as much higher reliability and lower (virtually no) maintenance. In fact, the relatively common, but still expensive green laser pointers currently available (prior to the introduction of direct injection green laser diodes) are diode pumped SS lasers with a frequency doubler as part of the laser cavity. More on that later.

  Power output is measured the same way as for other CW lasers.

- Quasi-CW SS lasers are actually pulsed lasers but operating with a Pulse Repetition Rate (PRR) high enough to appear (for the intended application) to be continuous. Generally, this means a PRR of at least 50 pps but may be 10s or 100s of kHz if electro-optically Q-switched.

  Depending on the application, the average power output or peak pulse energy or power may be the relevant measurement of performance.

  Note that while this output if frequency doubled to 532 nm (green) would appear CW to the human eye, it would NOT be suitable for laser TV or light show scanning since it really isn't continuous.

Note that while the *peak* power of the output pulses for a Q-switched laser may be many orders of magnitude greater than with the Q-switch disabled or bypassed, for the fundamental output wavelength (e.g., 1,064 nm for a Nd:YAG laser), the *total* energy (pulsed) or *average* power (quasi-CW) is generally lower. However, when frequency multiplication is used (e.g., 532 nm green from a Nd:YAG laser), total energy or average power may actually be greater with the Q-switch because frequency multiplication is a non-linear process and is much more efficient as the peak power increases. Depending on the application, the high peak power may more than offset the lower total energy or average power or vice-versa.

Efficiency of Solid State Lasers

Wall plug efficiency can vary from well under 1 percent for flashlamp and arc lamp pumped SS lasers to 25 percent or more for those pumped with laser diode pumped.

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A (laser) diode pumped Nd:YAG may have a 40% efficiency (operating multimode with good thermal control of the diodes), and the pump diodes themselves have about a 45% efficiency, resulting in a net 18% of efficiency from electrical power to the diodes to output beam power. However, at increased pump powers, thermal issues may cause the efficiency to decrease after a certain point. This decrease is power dependent, as well as resonator and pump assembly design dependent.