

Encyclopedia of Laser Physics and Technology

Slope efficiency

Definition: differential power efficiency of a laser

Ask [RP Photonics](#) for advice on why the slope efficiency of your laser is lower than expected, or why the slope is not linear.

An important property of an optically pumped [laser](#) is its slope efficiency (or *differential efficiency*), defined as the slope of the curve obtained by plotting the laser output versus the pump power. Usually, this curve is close to linear, so that the specification of the slope efficiency as a single number makes sense. However, quite nonlinear curves can occur under certain circumstances, e.g. as a consequence of [three-level characteristics](#) of the gain medium or thermal effects.

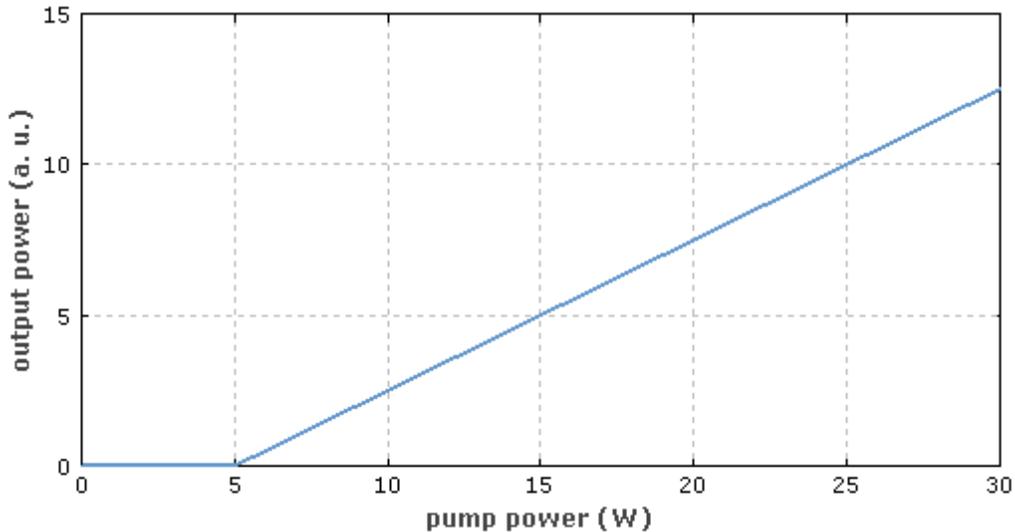


Fig. 1: Output vs. input power for an optically pumped laser. The threshold pump power is 5 W, and the slope efficiency is 50%.

Note that the slope efficiency may be defined with respect to incident or absorbed pump power. For comparisons of power efficiency, it is usually fair to compare slope efficiencies with respect to incident powers, so that the [pump absorption](#) efficiency is taken into account. However, there are cases where values based on absorbed pump power are useful – e.g. for judging the intrinsic efficiency of the gain medium.

In simple situations, the slope efficiency is essentially determined by the product of the pump absorption efficiency, the ratio of laser and pump photon energy (\rightarrow [quantum defect](#)), the [quantum efficiency](#) of the [gain medium](#), and the output coupling efficiency of the [laser resonator](#). It can be elucidating to compare the slope efficiency with the differential quantum efficiency in order to judge the potential for further device improvement.

The optimization of the laser output power for a given pump power usually involves a compromise between high slope efficiency and low [threshold pump power](#). Usually this leads one to a situation where the used pump power is a few times the threshold pump power, and the slope efficiency is somewhat reduced below the value attainable with a stronger degree of output coupling.

The slope efficiency can also be defined for other laser-like devices such as [Raman lasers](#) and [optical parametric oscillators](#). In the latter case, the differential slope efficiency with respect to incident pump power can even well exceed 100% under certain circumstances.