Laser Diodes

The most efficient pump source for solid-state lasers is the diode laser. Although the advantage of pumping solid-state lasers with monochromatic pump sources has been recognized very early, the low power output, low packaging density, and extremely high cost of diode lasers prevented any serious application for laser pumping until the mid-1980s.

The major attributes of diode pumping can be summarized as follows:

- Increased system efficiency.
- Improved beam quality.
- Enabling technology for compact and versatile laser systems. - Enabling technology for new laser materials.
- Increased component lifetime.
- Benign operating features.
- Increased pulse repetition rate.

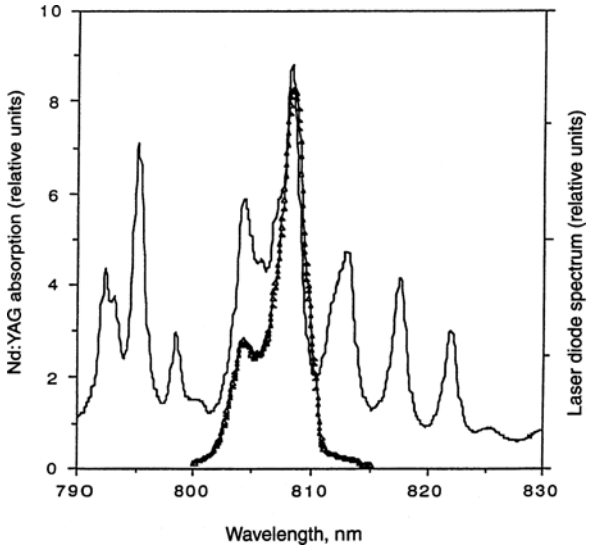
Spectral Properties

The spectral properties of laser-diode arrays that are most critical for the pumping of solid-state lasers are the center wavelength and the spectral width of the emission and the wavelength shift with temperature.

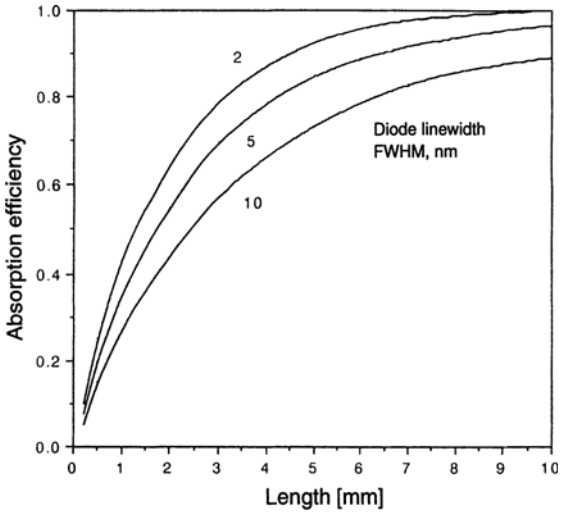
The wavelength of a laser diode is inversely proportional to the energy difference ΔE between the conduction and valence band

$$\lambda = hc/\Delta E, \qquad \ldots (1)$$

where h is the Planck's constant and c is the speed of light. The bandgap depends on the crystalline structure and chemical composition of the semiconductor.



Spectral overlap between Nd:YAG absorption and emission spectrum of a 10 bar array



Absorption efficiency of Nd:YAG as a function of absorption length for a pump wavelength of 808 nm

In a GaAlAs structure the peak emission changes 0.3 nm/◦C. Therefore, the material composition has to be chosen such that the desired wavelength is achieved at the operating temperature of the junction.

The average temperature changes as a result of varying operating conditions of cw or high repetition rate diode pump sources can often be mitigated by temperature controlling the heat sink. In pulsed diode bars, the temperature rise during the pulse causes a change of the center wavelength, known as chirp, and a reduction of efficiency and output power, known as sag. This effect becomes particularly noticeable if a laser crystal with a narrow absorption width is pumped with a relatively long pump pulse. The transient temperature rise is determined by the heat sink properties.

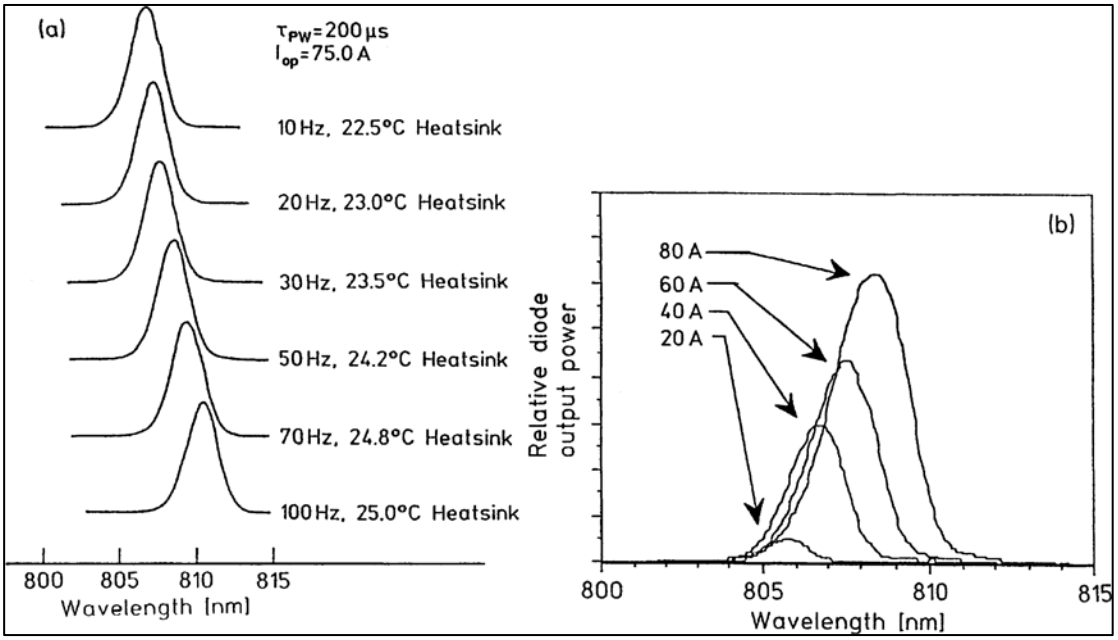


Fig.3 (a) Diode array linewidth vs. repetition rate and (b) wavelength shift vs. drive current