Why M^2 Is Important When Selecting Your Laser

The M^2 factor of a laser beam limits the degree to which the beam can be focused for a given beam divergence angle, which is often limited by the numerical aperture of the focusing lens. Together with the optical power, the beam quality factor determines the brightness (more precisely, the radiance) of a laser beam.

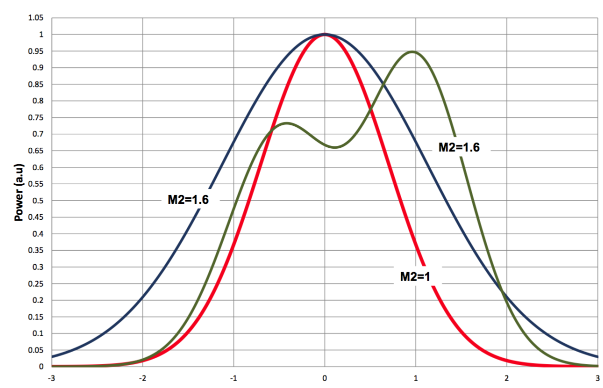
For example, if a beam has M^2 =1.6 (or greater), it cannot be focused down to a spot less than 1.6 times the focal spot diameter of a diffraction limited beam with the M^2 =1.

M^2	Usable Beam	Equivalent Power*
1	100 %	P_I
1.1	83 %	1.2 P_I
1.6	39 %	2.56 P_I
* to ideal diffraction limited		

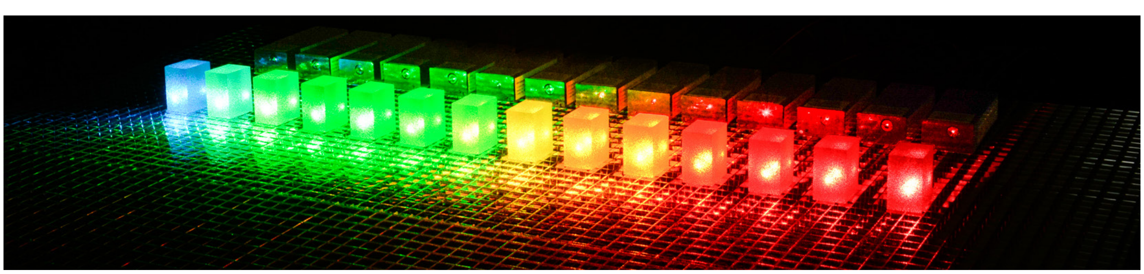
For many applications, especially in microscopy, only the "diffraction limited part" of the beam can be used and the usable part of the beam is proportional to $(1/M^2)^2$ (i.e. less the 40% of a beam with M^2 =1.6 is usable). This means that, in a microscopy application, a laser with M^2 = 1.6 needs to have an output power more than twice that of a laser with M^2 = 1.1 to provide an equivalent usable optical power.

In solid-state lasers and high power Vertical Cavity Surface-Emitting Lasers (VECSELs), the increased value of M^2 is usually a result of thermally induced wavefront distortions in the gain medium which typically lead to temporal fluctuations of the beam shape in the focal plane, thus decreasing the resolution of the microscope.

The outputs of fiber lasers based on single mode fibers most closely approach the best possible beam quality (i.e. a diffraction-limited Gaussian beam, having M^2 = 1) and do so in a reliable and stable manner.



Power distribution for the beams with different M^2



MPB Fiber Laser Product Line provide an M^2 of < 1.1 (typically 1.05) which translates into high beam density and excellent beam quality.