POWER HANDLING IN SINGLEMODE FIBERS

The power handling limit of an optical fibre is determined by the effects of three mechanisms, principally; stimulation of colour centres, non-linear scattering and localised heating. The effects of these mechanisms are most severe in singlemode fibers because of the extremely high power densities generated within their small cores.

1.0 Stimulation of Colour Centres

This phenomenon occurs most readily at argon-ion wavelengths (488m - 514nm). The stimulation of colour centres increases the intensity of the ultra-violet absorption edge of the fiber with the result that transmission is permanently reduced. The shorter the wavelength, the more severe the effect and the longer the length of the fiber, the more severe the effect.

Over 10m, if used intermittently (up to tens of minutes), the maximum power launched into a fiber at 488nm should be restricted to 75mW. This figure increases to 200mW at 514nm over the same length. If used continuously (several hours or more) launched power should be restricted to 10mW. The same losses will eventually result whether operation is continuous or intermittent - they simply build-up far more quickly in continuous use.

At argon-ion wavelengths, this mechanism is strong enough to mask the effects of non-linear scattering, outlined below.

2.0 Non-linear Scattering

At longer wavelengths, the effects of Brillouin and Raman scattering may be observed. These forms of scattering produce shifts in the wavelength of the launched power and therefore reduce the amount of useful power which may be detected at the end of the fiber.

The severity of non-linear scattering also varies directly with length.

2.1 Brillouin Scattering

When CW lasers of very narrow linewidth (MHz) are used over kilometre-lengths of fiber, Brillouin scattering can occur at powers of only a few milliwatts. In normal circumstances however, broader-band sources are used and so Brillouin Scattering should not create a problem.

2.2 Raman Scattering

When pulsed lasers are used, again over kilometre-lengths of fiber, Raman Scattering will begin to occur at peak powers of 2-3 watts. This scattering will begin to deplete the effective power of the pump-laser at around 10 watts peak. Over 10m, however, peak powers of 2-3 kilowatts should be possible.

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3.0 Heating Effects

Heating effects may occur at any wavelength and are independent of fiber length. They are probably the most serious problem encountered by high-power lasers users. The heating is caused by power averaged over time and so effects are most severe when lasers are used CW.

3.1 Localised Heating within the Fiber

Localised heating occurring within the fiber may cause physical damage at CW powers of 3-5 watts.

3.2 Ablation of Optical Surfaces

Extreme care must be taken over the cleanliness of optical surfaces, for example fiber-ends and objective lenses. If a surface is contaminated, say by atmospheric dust or finger-grease, the resulting concentration of optical power can melt (ablate) the surface at powers of one watt or less.

4.0 Summary

The commonly available singlemode lasers are: argon-ion (488-514nm), 780-830nm laser diodes, neodymium-YAG (1064nm), 1300-1550nm laser diodes. Power handling phenomena are most likely to be encountered with argon-ion and neodymium-YAG lasers because high powers are both difficult and expensive to achieve with other systems.

At argon-ion wavelengths, power handling capability will be decreased by stimulation of colour centres and the ablation of optical surfaces. For these reasons, power should be restricted to around 75mW (488nm) or 400mW (514nm) over 10m. There is insufficient experimental data to predict performance over longer lengths of fiber, but the power handling capacity will be dramatically reduced.

With neodymium-YAG laser, used CW, power handling capacity will be reduced by localised heating of the fiber and ablation of optical surfaces. For these reasons, power should be restricted to around 2 watts. When used pulsed, Raman Scattering will restrict the permissible peak power to around 2 kilowatts.

Please note that the various mechanisms which determine the power handling capacity of singlemode optical fibers are still not well understood by the scientific community as a whole. This note has been produced for guidance only and in no way guarantees the performance of any Fibercore products.

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