Advanced Optical Technology Ltd

Technical Note (7)

Fibre Delivery of ACE Laser Pulses

A number of important laser applications benefit from use of fibre optic beam deliver. Advantages include the option of remote location of the laser, use of a very compact optical head at the distal end of the fibre (e.g. in applications where access is difficult), easy manipulation of the (compact) working head, and rapid reconfiguration or switching of the location of power delivery.

AOT have investigated the opportunity to achieve these advantages with the very short (~ 1ns) high intensity pulses generated by the ACE lasers. All ACE oscillators produce high quality TEMoo beams of ~ 200μm diameter, and only modest (~10%) change in divergence with rep-rate and average power.

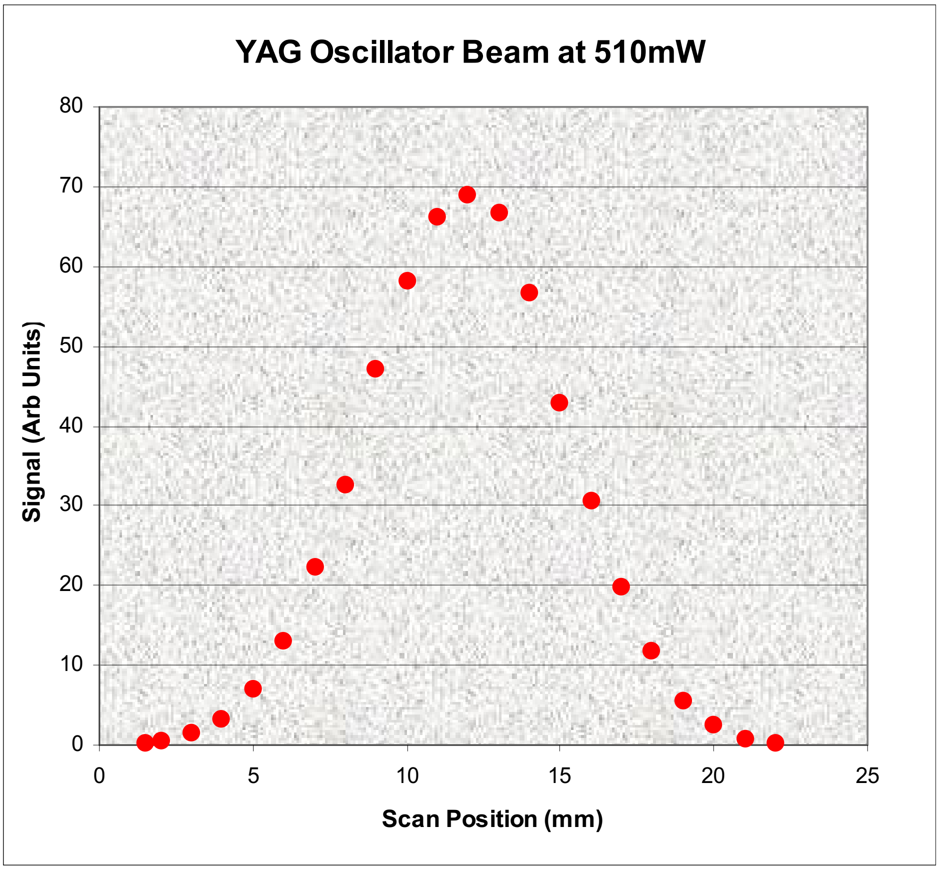

Figure (1)

A typical example of a laser beam spatial profile is shown in Figure (1). This was obtained by positioning a photodiode behind a ~ 0.5mm pinhole and scanning across the beam at a distance of ~ 1.4m from the laser. The 1064nm beam from the AOT-YAG-20Q laser at ~ 500mW has a divergence full angle of ~ 9 mrad.

1064nm Pulses

We have coupled the beam by simple relay optics into a 3m long all-silica 200μm core 0.2NA fibre with good efficiency. Since the input beam profile is not a 'top-hat' matching the fibre core diameter the relayed beam waist size was chosen to be smaller than the core to avoid overfilling of the fibre and significant loss of transmitted power. The (modest) demagnification was chosen to achieve high transmission but avoid excessive power loading on the input face of the fibre. Figure (2) shows a typical profile from the fibre, again recorded by a photodiode and pinhole combination scanned across the beam. Here the output beam full angle was ~ 130mrad and fairly insensitive to the disposition of the fibre – arranged in loops of ~ 200mm diameter with no tight bends. The 1064nm input power was > 600mW and the overall transmission ~ 85%. The fibre faces were not AR coated, so this compares with a maximum possible transmission of ~ 92%.

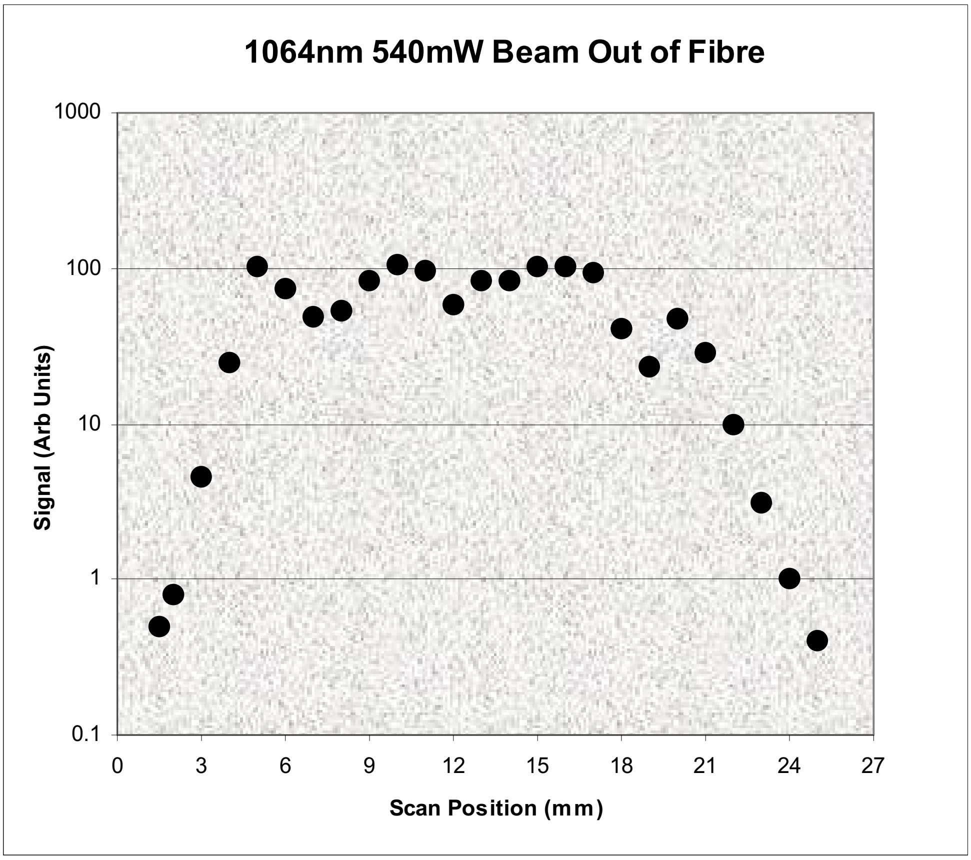

Figure (2)

AOT has undertaken many experiments at 1064nm of this type. Our particular interest has been in fibre performance at low/modest repetition rates where the laser pulses are shortest and therefore the intensities highest. In these trials, power densities at the fibre face have been up to ~ 200MW/cm^2 and the energy density up to 0.5J/cm^2. Operation under these conditions has not led to any problems in power coupling or fibre transmission.

532nm Pulses

AOT have conducted similar fibre transmission trials at 532nm. We used an AOT-YVO-50QSP with a standard KTP frequency doubler module. Again the ~ 200µm diameter beam waist from the laser was relayed into the fibre with modest demagnification to achieve good transmission. An example of a 532nm-beam profile from the fibre is shown in Figure (3). In this case, the pulses were of only ~ 0.7ns duration at 532nm. The intensity on the fibre input face was estimated by AOT to be ~ 60MW/cm^2. No change in the pulse temporal profile was measured following transmission, and we recorded no fibre damage/deterioration. Again the measured output beam full angle was ~ 130mrads and the power transmission ~ 80%.

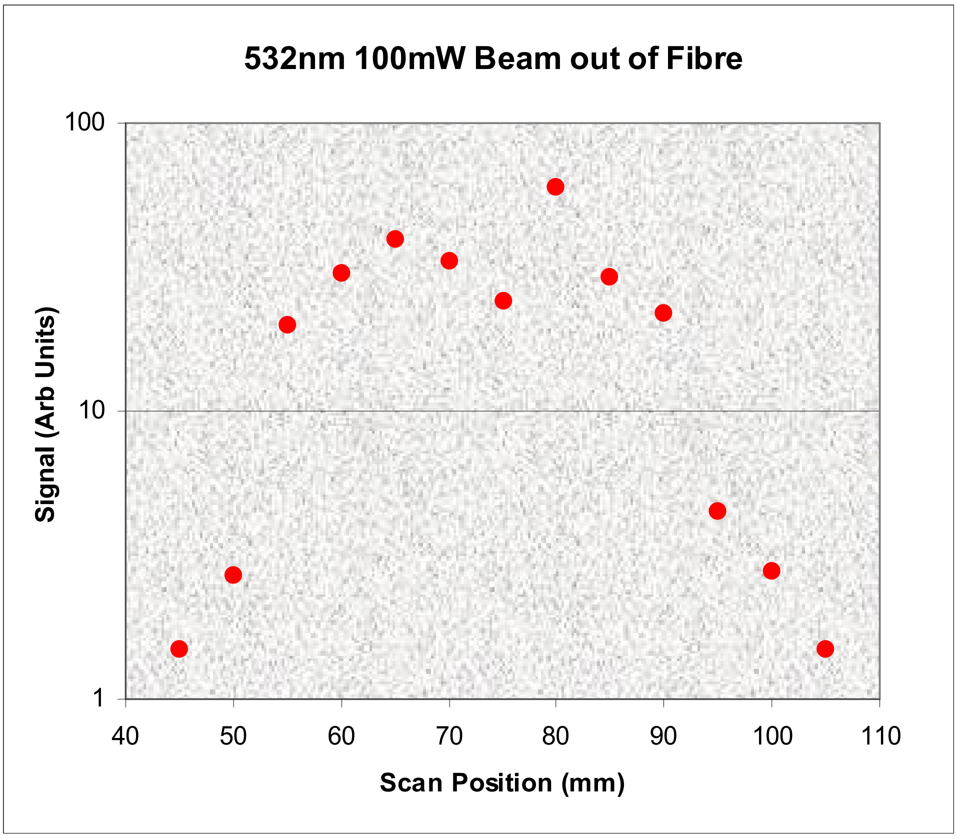

Figure (3)

355nm Pulses

Performance with UV pulses has been similarly investigated by AOT and is equally good. We again concentrated on fibre trials with short pulses to identify possible issues related to high intensity but found no problems. As an example, Figure (4) shows power transmission using 355nm pulses of ~ 1.0ns duration. It can be seen that transmission remained constant at ~ 80% up to the maximum input laser power of ~ 75mW, corresponding to a power density of ~ 20MW/cm^2 at the fibre input face.

Measurement of the 355nm transmitted beam showed that the cone angle was again fairly insensitive to the lie of the fibre, but in this case, was lower and of ~ 100mrads full angle i.e. somewhat lower than measured at 1064nm or 532nm. AOT consider this most probably due to a smaller input beam cone angle in the 355nm trials (resulting from use of LBO harmonic crystals with modest acceptance angle to generate the UV power).

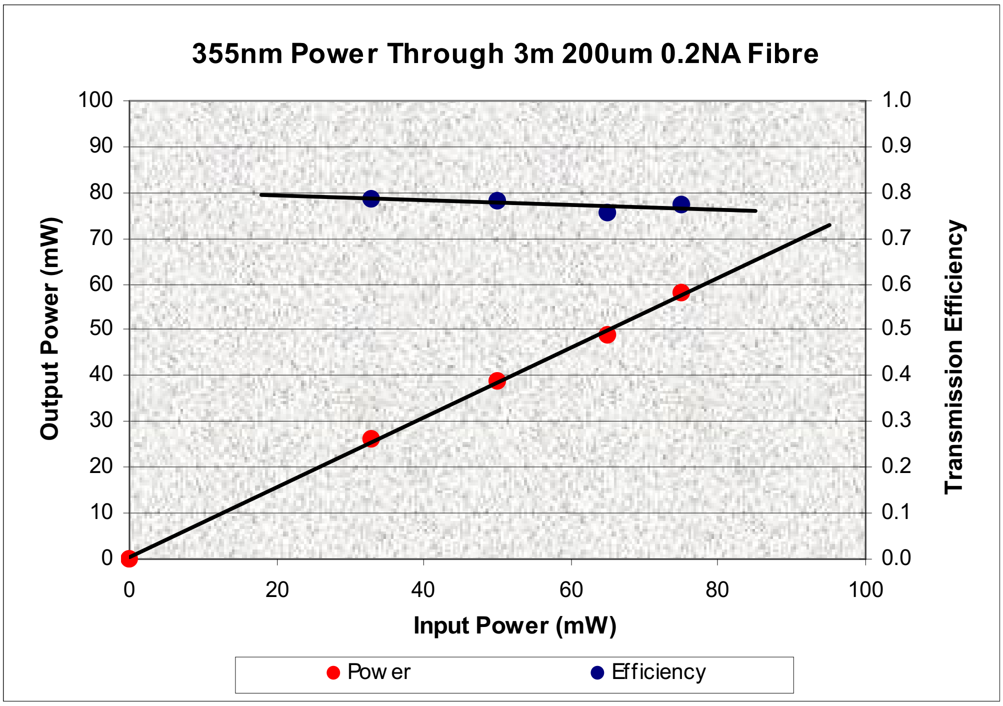

Figure (4)

In all the cases investigated, the beam was found to be transmitted reliably by the 200µm core diameter fibre without any adverse effects. Notably, the output beam cone angle was significantly lower than the limit (~ 25 degrees) set by the fibre NA. These results show that fibres of useful/practical length can be excellent delivery tools for IR, visible and UV laser beams comprising short (~ 1ns) pulses of high intensity.