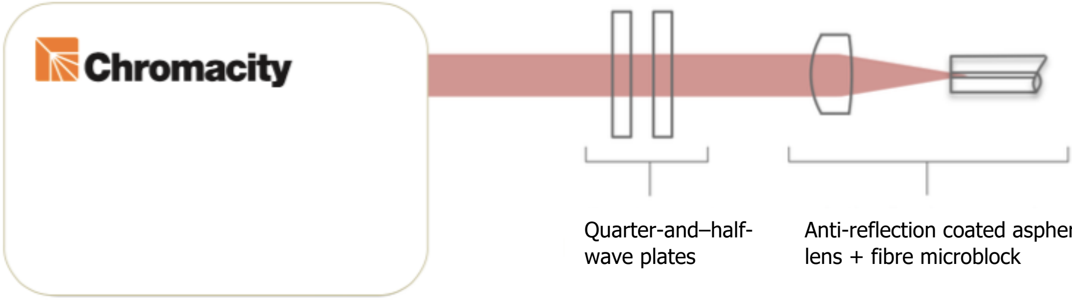

Fig. 1. Standard layout for coupling the Chromacity 1040 into a fibre

Near-Infrared Generation using the Chromacity 1040

The high-peak-power pulses (>100 kW) from the Chromacity 1040 femtosecond laser make it easy to drive nonlinear effects like optical parametric oscillation, supercontinuum generation and Raman soliton creation. We discuss how to implement supercontinuum generation in nonlinear fibre to provide a cost-effective means of producing broadband near-infrared light for spectroscopy, optical coherence tomography, CARS spectroscopy / microscopy and other applications.

Supercontinuum and Raman soliton generation

The 1040 is an ideal source to generate a cost-effective near-infrared supercontinuum by focusing ultrashort pulses into non-linear materials, such as photonic crystal fibres. The high energy per pulse, free-space beam from the 1040 is ideally suited for coupling into optical fibres. Unlike solid-state lasers, which tend to produce beams with an elliptical cross-section (due to astigmatism in the laser cavity), the 1040's output originates from a single-mode fibre, so it is perfectly symmetric.

Light from the 1040 can be coupled into commercially available photonic-crystal fibres with efficiencies of greater than 75%. We recommend the use of connectorized photonic crystal fibres to minimise the risk of fibre damage and also contamination. The recommended fibre-launch arrangement is shown in Fig. 1. Unlike Ti:sapphire lasers, the laser is insensitive to small amounts of light reflected from the fibre facet, eliminating the need for an optical isolator between the laser and the fibre.

The 1040 (shown in Fig. 2.) produces horizontally polarized light directly from the laser. When coupling into polarization- maintaining or photonic-crystal fibre it is important to align the polarization of the laser to the fibre's structure. This can be done by using a pair of quarter and half waveplates, available separately from Chromacity. Please contact us for details. When using photonic-crystal fibre, coupling efficiency improvements of around 10% are possible by optimizing the input polarization.

While a microscope objective may be used, for best efficiency and to reduce dispersive broadening of the pulses an aspheric lens is recommended whose focal length matches the beam diameter of the 1040 to the fibre core size. Careful selection avoids the need to telescope the beam prior to the fibre, improving stability and reducing unnecessary loss.

The data in Fig. 3 show supercontinuum spectra (right column) generated using 1.5 m of NKT SC-3.7-975 fibre, along with simulation results (left column) obtained using the measured pulses from the 1040. The ability to predict the supercontinuum which will be generated using the laser makes it easy to select the ideal nonlinear fibre for your application. Chromacity can provide customers with simulation data informing their choice of fibre type and length.

Fig. 2. Chromacity 1040

For some applications only the near-infrared output of the supercontinuum is required. When using pulses of sufficiently short duration, such as those produced by the 1040, the Raman soliton generated above 1200 nm can be filtered to produce transform-limited sub-100-fs pulses with average powers of up to 50 mW. The centre wavelength of this soliton can be tuned over 100 nm by adjusting the coupled power, depending on the nonlinear fibre used.

Summary

Exceptionally broad and flat supercontinua from 750-1300 nm can be produced using the 1040 femtosecond laser, which delivers excellent coupling efficiencies and easy fibre- launch requirements. The high natural stability of the system means that supercontinuum generation is stable and easily generated for real-world applications. Please contact us for advice on achieving your required supercontinuum spectrum.

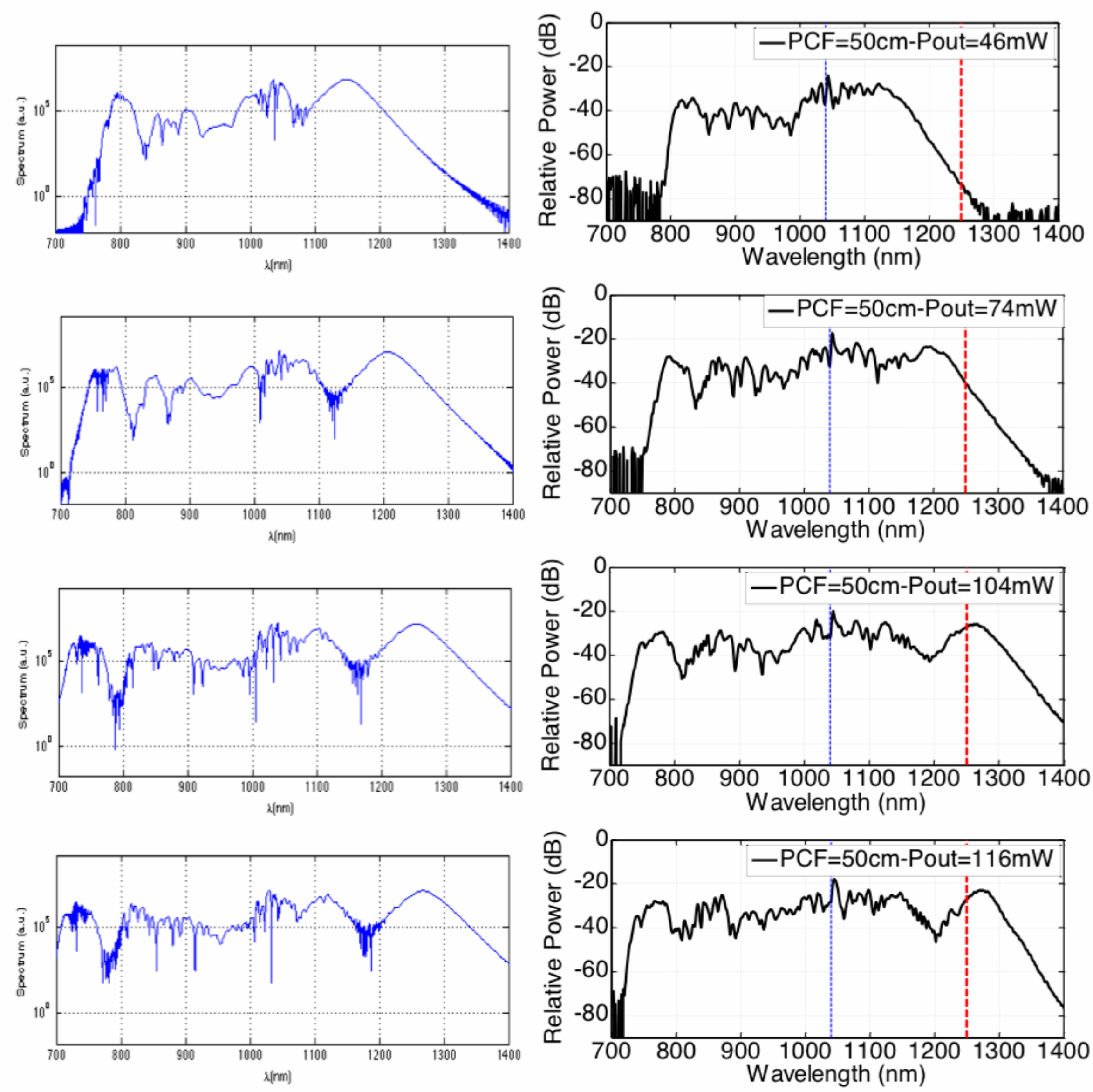

Fig. 3 Supercontinuum spectra generated using 1.5 m of SC-3.7-975 nonlinear PCF. (a), (c), (e) and (g) Simulated results. (b), (d), (f) and (h) Experimental results for same fibre and coupled powers.