Chapter 3 Experiments

3.1 How to Generate Supercontinuum Source

In this experiment, supercontinuum source is generated by launching ultra-short pulses into the microstructured fibers (MFs). The mode-locked laser system and the structured of MFs will be introduced in the following sub-sections.

3.1.1 Pumping Laser Source

In this work, the light source for coupling into the microstructure fiber is the Kerr-lens mode-locked Ti: sapphire laser, and the experiment setup is shown in Figure 3.1. Here the mark M represents mirror, B is beam splitter, P for prism, and D for detector. For generating femtosecond pulses, an SF-10 prism pair, P1 and P2, was used to compensate group velocity dispersion (GVD) for compressing the laser pulses.

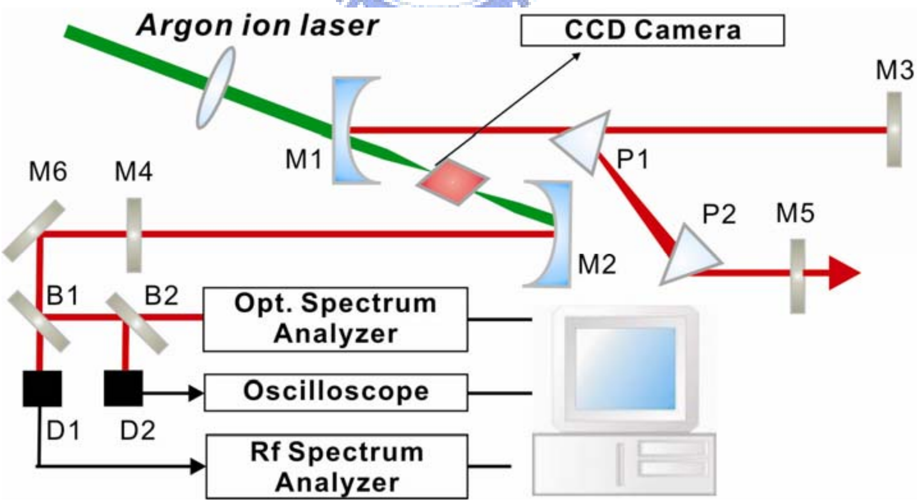

Fig. 3.1 Setup of Ti: sapphire laser system.

The measured interference autocorrelation and optical spectrum of output laser pulses from the output-coupler M5 were shown in Figs. 3.2 (a) and (b), respectively.

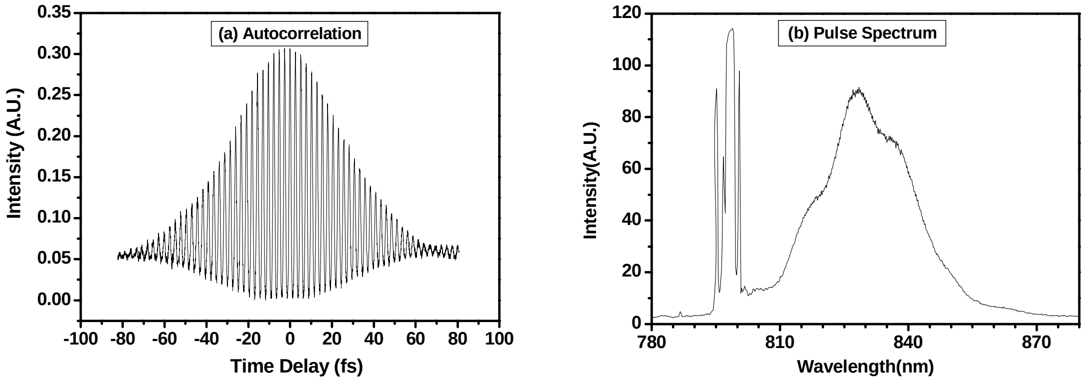

Fig. 3.2　Interference autocorrelation and optical spectrum of the output laser pulses.

Form Figure 3.2, the pulse-width, pulse center wavelength, and power of output pulse were estimated to be about 50 fs, 830 nm, and 300 mW, respectively.

3.1.2 Supercontinuum Generation in MFs

Supercontinuum generation in the microstructured fiber depends on both the specification of fiber and laser central wavelength. The core diameter of the used microstructured fiber is about 1.7 μm and the pitched (spacing between the adjacent holes) is about 1.4 μm. The diameter of holes is about 0.6 μm except for the two holes near the core whose diameter is about 0.7 μm. The cross sectional scanning electron microscope (SEM) image of the used fiber is shown in Figure 3.3.

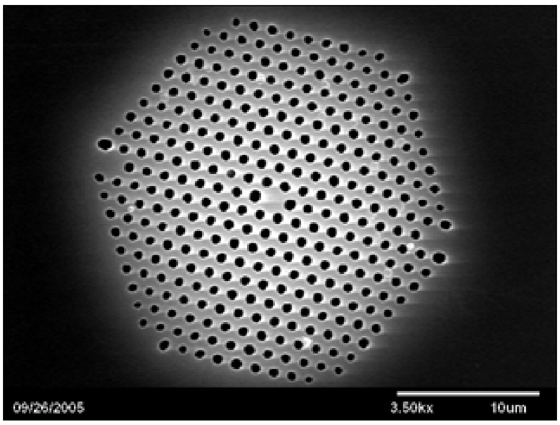

Fig. 3.3　SEM image of the microstructured fiber.

The fiber has quite high nonlinearity with nonlinear coefficient γ being 74 $km^{-1}W^{-1}$ due to its small core diameter. It also has two zero dispersion wavelengths which are located at 790 nm and 1190 nm. Therefore the pumping laser central wavelength (830 nm) we used is in the anomalous dispersion region of the MFs. The dispersion curve can be simulated by importing the properties and SEM image of MFs from the "*Mode Solution*" software; it is shown in Figure 3.4.

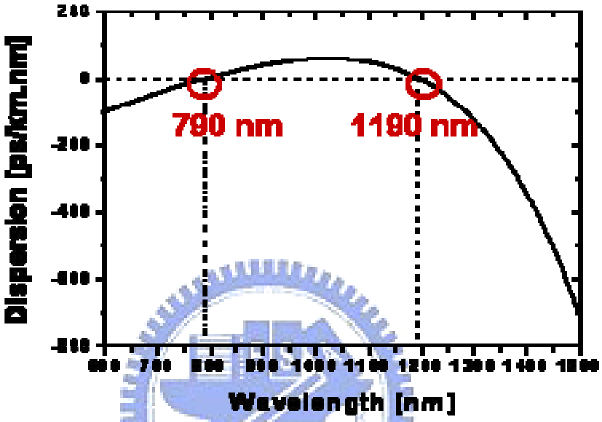

Fig. 3.4 Dispersion curve of the microstructrued fiber.

Supercontinuum generation is obtained by launching laser pulses into the MFs by a 40X objective microscope, and the fiber is put on the XYZ stage to fine-adjust for the best coupling efficiency. The optical spectra of generated supercontinuum light and that passing through three single line wavelength band-pass filter with bandwidth of 10 nm at 532 nm, 670 nm, and 780 nm (FL532-10, FL670-10, and FL780-10 from the ThorLab Inc.), were shown in Figure 3.5. The total spectral range of supercontinuum light is from 460 nm to 1530 nm. The insets on the top of Figure 3.5 are the true color optical dispersion photograph and traverse pattern from output of the MFs. Figure 3.6 is the photograph of fiber on working.

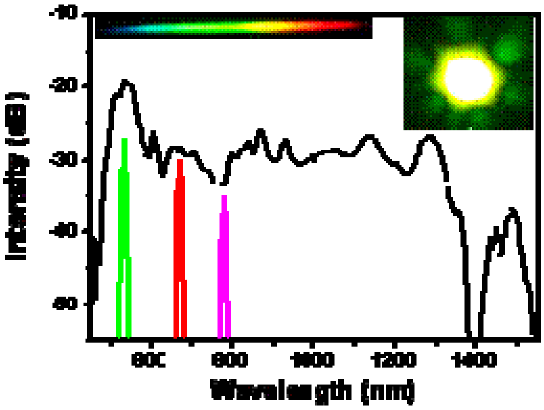

Fig. 3.5　Optical spectra of supercontinuum (460 nm~1530 nm, and line wavelength 532 nm, 670 nm, and 780 nm).

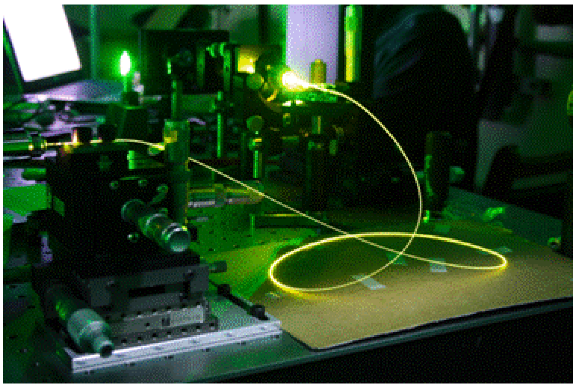

Fig. 3.6　Photograph of the microstructured fiber on working.

3.2　Generation of Optical Bottle Beam

Shown in Figure 3.7 is the experiment setup for generating optical bottle beam using an assembly of an axicon with a positive lens.　We first collimated the SC source output from the microstructured fiber by a microscope objective (40X) the passed through an axicon and a lens.　The axicon is made of BK7 glass material, and its angle between the flat surface and the conical surface is 5^0 and the focal length of positive lens is 35.08 mm at center wavelength 670 nm.　The distance between the axicon and the lens, defined as Z_0, is 72 mm.　After the assembly of axicon and lens, a beam profiler, named *WinCamD*, is put on a translation stage to monitor the beam profile along the propagation. It will be discussed in detail in the next section.

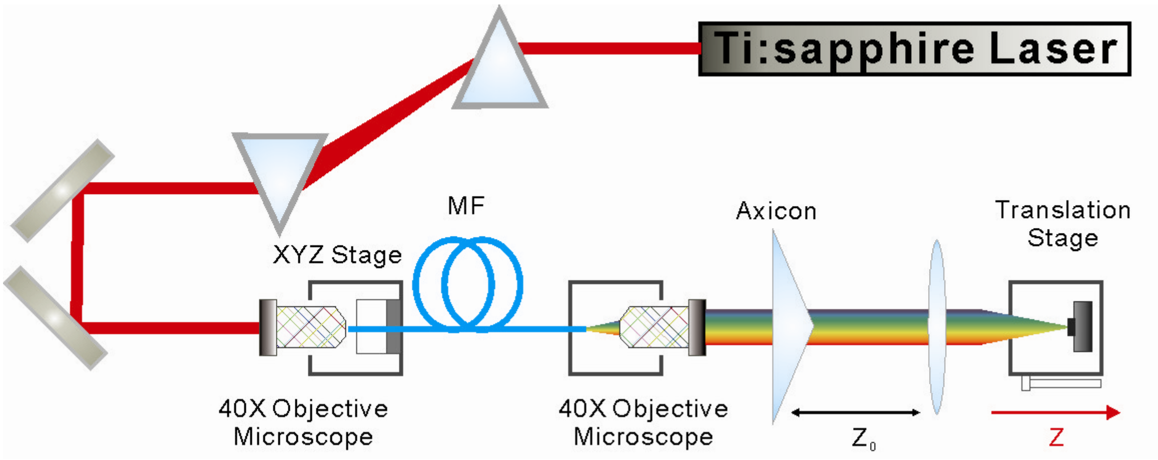

Fig. 3.7 Experimental setup for generation of SC optical bottle beam.

3.3 Measuring Supercontinuum Optical Bottle Beam

WinCamD is a beam profiler or CCD connected with computer to provide the cross sectional light intensity distributions of the propagating light beam. The characteristics and suitable working regions of *WinCamD*'s series are different from another, the complete working wavelength of the one we used is from 355 nm to 1100 nm with the working area of 6.32 × 4.76 mm^2 and 1360 × 1024 pixels. The detail specification is shown in Figure 3.8.

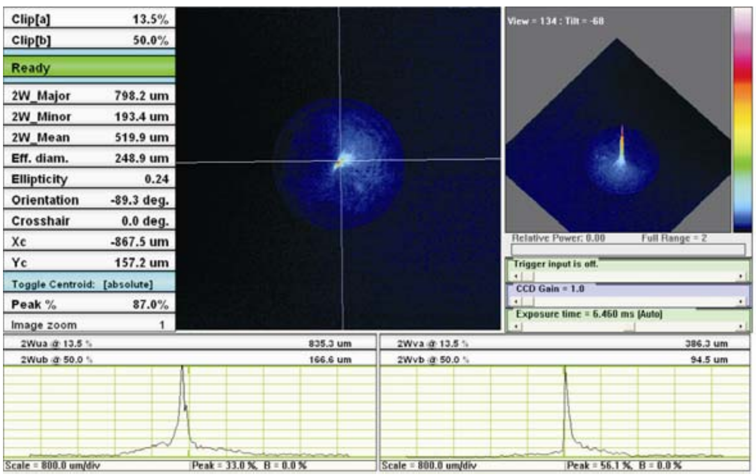

Fig. 3.8 Information of *WinCamD.*

In this figure, listed on the left hand side is the physical parameters of beam, the 2D beam distribution or image is in the middle, 3D beam distribution is on the top right-hand side, and the bottoms are two 1D intensity distribution plotted from two standard cross lines on the 2D distribution. Using the 2D *WinCamD* image, we can observe and estimate the different beam distributions at different distances behind the lens by translating the stage.