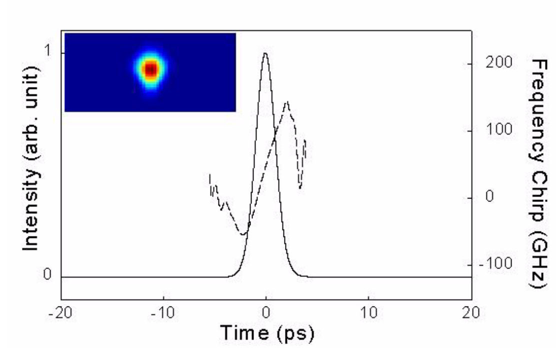

Fig. 3(a): FROG retrieved pulse shape and frequency chirp of the original soliton pulse. Inset: The corresponding spectrogram.

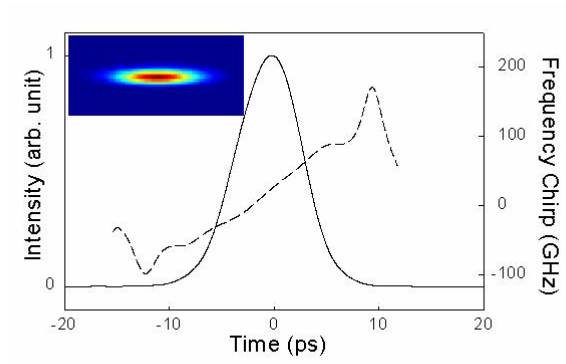

Fig. 3(b): FROG retrieved pulse shape and frequency chirp of the filtered output (Channel 24). Inset: The corresponding spectrogram.

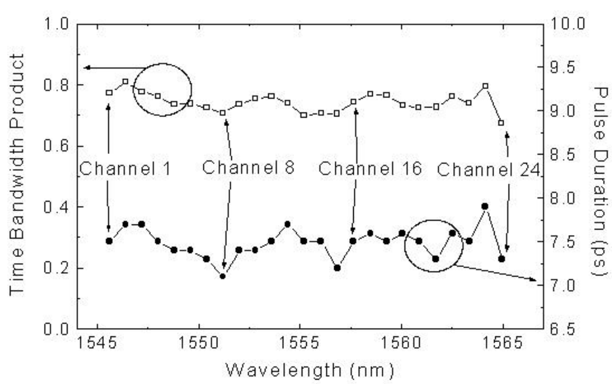

Fig. 4(a): Pulse width and time-bandwidth product.

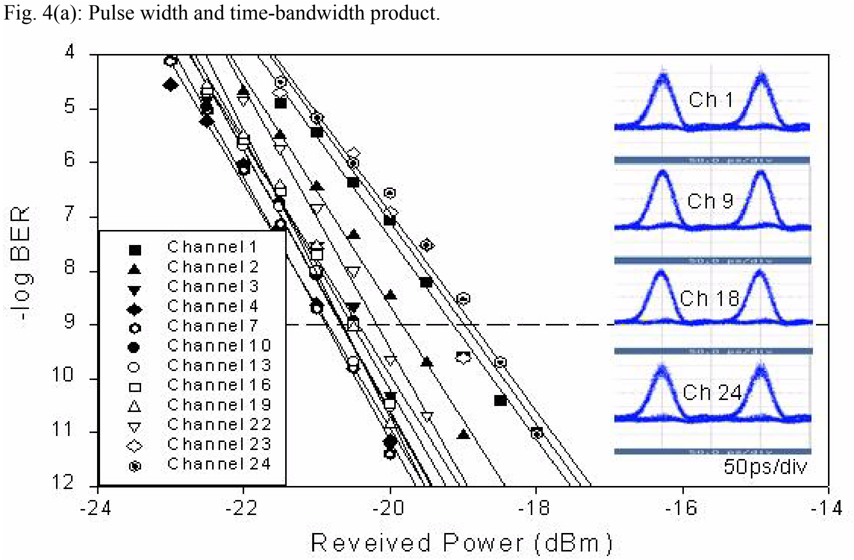

Fig. 4(b): BER of twelve selected channels. Inset: Eye diagrams of four selected channels.

3. Conclusions

In conclusion, we have experimentally demonstrated a 10GHz multiwavelength pulse source based on just 20m of polarization maintaining HF. The relatively low input power of ~240mW is sufficient to produce 24 channels of high quality WDM pulses. We have shown that the pulse width and time-bandwidth product were almost constant across the full wavelength operating range, and that error-free operation was readily achievable for all channels. The short device lengths enabled by the use of highly nonlinear holey fibre enhances system stability and reliability and facilitates ready synchronization of all WDM channels relative to the input seed pulse train. Further extensions in SC source operating bandwith and channel flatness along with reductions in optical power requirements/device lengths should be possible with realistic improvements in holey fiber fabrication.

Acknowledgement
The authors gratefully acknowledge JDSU Waveguide Business Unit for the provision of the AWG's used in these experiments.

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FH4 **9:00 AM**

Silica/Air-Clad Dual-Core Tapered Fiber for Polarized Supercontinuum Generation

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We report the generation of a polarized supercontinuum using a specially fabricated silica/air-clad dual-core tapered fiber. Output spectra cover range of 400-1220 nm at femtosecond Ti:Sapphire laser pump with the pulse energy 0.6 nJ.

Introduction

Supercontinuum (SC) based fiber devices are very attractive candidates to serve as a main building block of transmitters in dense wavelength-division-multiplexed (DWDM) communication systems. In the DWDM applications SC-based sources can provide for high coherence and high signal-to-noise ratio. Supercontinuum is also a very useful laser source in many other applications such as, for instance, optical measurements. SC manifests itself as a spectral ultra-broadening resulting from nonlinear effects in fiber. To enhance the nonlinearity special fibers with low effective area are exploited. Different realizations of highly nonlinear media lead to a variety of possible properties of the generated SC both in the spectral and time domains. At the moment it is not clear yet what is an optimal way to create SC-based DWDM source and this problem is still a subject of intensive research.

Generation of SC has recently been demonstrated in fibers with a small-core that partially or entirely borders air [1-4]. Fibers with a core size of a few-microns are characterised by the shift of the zero group velocity dispersion to the visible spectral range and by a small effective mode area, resulting in a dramatic increase of the effective nonlinearity. This makes it possible to generate SC by self-phase modulation of ultra-short non-amplified nanojoule pulses from a Ti:Sapphire laser (700-1000 nm range). Another advantage of the tapered fiber is that the output is naturally compatible with conventional fibers and fiber-based devices. To control the polarization properties of the SC polarization maintaining, highly nonlinear fibers have been utilized in [5,6].

In this work for the first time we have applied a specially fabricated dual-core tapered fiber for generation of a polarized supercontinuum.

Silica/air-clad dual core tapered fiber

The novel fiber has been fabricated by stacking two SMF-28 fibers that touch each other along the axis using technology developed in [4]. During the draw process the cross-section shape of the fiber changed from a figure-of-eight shape to quasi-elliptic. Figure 1 (left) shows a cross-sectional microphotograph of the fabricated fiber when the other ends were illuminated. The corresponding field distribution obtained by numerical modeling is shown in the right-hand figure.

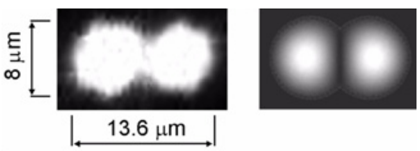

Fig. 1. Cross-sectional microphotograph of the fiber dual waist (left) and results of numerical modeling (right).

The microphotograph had been taken before the final stacking, with the strand sizes being decreased by a factor of 4. Final strand radii along the minor and major axes are 2.0 µm and 3.4 µm, the length of the dual uniform waist is 8 cm. Dual core tapered fiber kept in dustproof case is rather stable to mechanical and acoustic perturbations and preserves its properties with time (control measurements have been performed over a period of a month).

SC occurs as a result of a combined action of nonlinear effects (self-phase modulation, cross-phase modulation, four-wave mixing and Raman scattering) and dispersion. Therefore, the properties of the generated SC, as well as its occurrence, are rather sensitive to the interplay between nonlinearity and dispersion. In particular, features of SC strongly depend on the amount and sign of the dispersion of the nonlinear fiber used. By varying the nonlinear fiber dispersion it is possible to change the characteristics of the resulting SC. The dispersion of circular silica/air-clad tapered fibers at the pumping wavelength is determined by the silica core radius. Using dual-core tapered fiber, a new geometry and a new degree of freedom (the core separation) are introduced that can be used to design fibers with characteristics optimal for SC generation. Dispersion of the dual core fiber has been investigated numerically using full vectorial mode simulations. A dual core fiber configuration is characterized by the core diameter *d* and distance between the cores *a* or aspect ratio $\alpha = a/d$. Aspect ratio exceeding 1 corresponds to separated cores while $\alpha = 0$ corresponds to a single air clad fiber. A few first modes for each configuration have been computed and identified. Experimental picture shown in Fig. 1 can be interpreted as a hybrid LP01/LP11 mode which exists as LP01 mode in separated cores and as LP11 for small aspect ratios when the both cores almost coincide. This conclusion was confirmed by extensive numerical modelling. A corresponding eigenvalue (propagation constant) β of determines dispersion of this

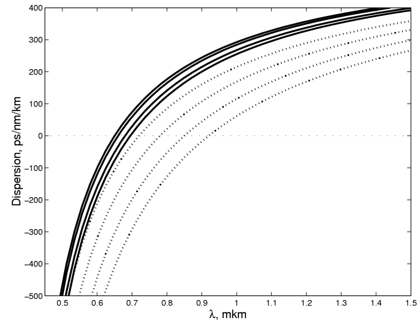

Fig. 2. Dual core fiber dispersion for the hybrid LP11/LP01 mode. Solid lines - core diameters 2 mkm dotted lines - 3 mkm.

mode. Typical dispersion curves of dual-core fiber obtained by numerical modelling for core diameters 2 mkm and 3 mkm are shown in Fig 2.

Different curves in each family correspond to different distances between the core centres. Four solid curves correspond to distances of 0.6, 1.0, 1.4 and 1.8 mkm in case of smaller core diameter 2 mkm and a second set of dotted curves corresponds to a larger core diameter of 3 mkm with the same aspect ratios as in the first case. Several general features can be observed from Fig. 2. Smaller core diameters and larger distance between them correspond to higher dispersion. Another distinctive property is a noticeable shift of zero dispersion wavelength. Zero dispersion point (ZDP) is very sensitive to a core diameter and this sensitivity can be measured in terms of zero dispersion wavelength shift per 1 mkm of distance between the cores. In the case of smaller core of 2 mkm it was approximately 10 nm/mkm whereas in case of core diameter of 3 mkm it was about 30 nm/mkm. This gives an additional possibility to vary ZDP by design of dual-core fiber.

Experimental results

Optical pulses of 50 fs duration centered at 806 nm from an 82 MHz repetition rate mode-locked Ti:Sapphire laser with average power of 100 mW have been launched through one of two inputs of the dual core tapered fiber using a 10 x microscope objective. A double-pass dispersive prism delay line has been applied to vary the chirp of the input pulses (Fig. 3). Adjustable chirp has been used to optimize the interplay between the overall dispersive and nonlinear effects.

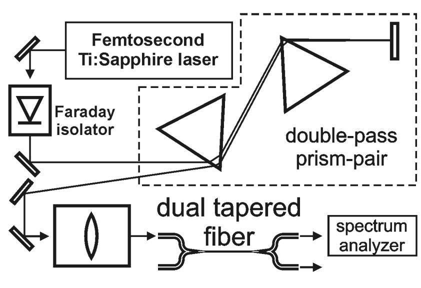

Fig. 3. Experimental setup for supercontinuum generation.

Figure 4 shows the observed spectrum from one of two output ports of the dual core tapered fiber of 8 cm length. The supercontinuum power is distributed in nearly equal parts between the two output cores of the taper and it amounts to 15 mW for each port. The output spectra cover the range 400-1220 nm at the -39-dB level. Observed continuum polarization extinction ratio exceeds 12 dB. Even though the tapered fiber is multimode, the supercontinuum has been generated in the fundamental mode. As it is shown in Fig. 5, the light beam in both fiber output ports has a Gaussian-like transverse field distribution and is polarized along the major axes of the quasi-elliptic waist.

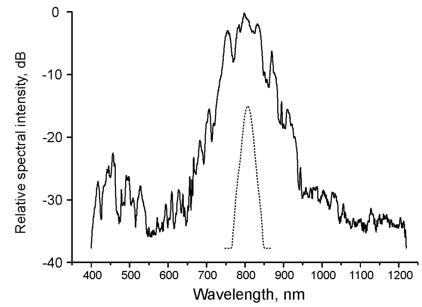

Fig. 4. Output spectrum of the polarized continuum generated in the 2.0/3.4 µm dual core-waist tapered fiber. The dashed curve shows the spectrum of the initial pulses.

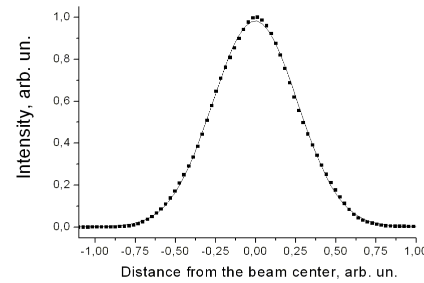

Fig. 5. Experimentally measured output beam profile (points) from an output port of a ~8 cm long dual tapered fiber and Gaussian approximation (solid line).

We believe that results obtained in the present work can be reproduced/improved by using specially designed photonic crystal (holey) fibers [7,8] as their properties have many similarities with silica/air-clad tapered fibers as far as group velocity dispersion and effective core area are concerned. On the other hand, the tapering technique has the advantage of relative simplicity and using only widely available standard fibers.

Conclusions

To the best of our knowledge, for the first time the generation of a polarized supercontinuum using a specially fabricated silica/air-clad dual-core tapered fiber is reported. SC spectra from 400-1220 nm were obtained. The input signal has been provided by an unamplified 82 MHz repetition rate femtosecond Ti:Sapphire laser pump with the pulse energy of 0.6 nJ.

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FH5 **9:15 AM**

Frequency Resolved Optical Gating at 1550 nm Using Semiconductor Optical Amplifier Four-Wave Mixing

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We describe a frequency resolved optical gating geometry based on four-wave mixing in a semiconductor optical amplifier, exhibiting high sensitivity and broadband tunability as compared to previously reported fiber setups. Experimental results are discussed.