Kerr-induced Transient Long Period Grating in Single-Mode Fiber

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1. Introduction

With the advance in permanently written long period grating (LPG), dynamic control over modal content has become the subject of considerable interest. This can be achieved by optically induced LPG (OLPG). The basic idea of OLPG refers to the transient variation of intensity pattern due to superposition of two transverse modes via multi-mode interference which in turn influence the refractive index profile through optical Kerr effect. Recently, conversion of the transverse modal content on OLPG in multi-mode fiber has been demonstrated [1-3]. In this work, we demonstrate OLPG in low-cost, telecom-grade commercially available single-mode fiber (SMF28e) where pump is launched below the cut-off wavelength of the fiber at which the fiber supports LP_{01} and LP_{11} spatial modes.

2. Experimental set-up and result

The schematic of experimental set-up is shown in Fig. 1. The pump source is Q-switched micro-chip Nd:YAG laser of wavelength of 1064 nm, pulse duration of 0.77 ns and repetition rate of 23 kHz. The pump is p-polarized whereas the probe is s-polarized. The probe beam path experiences a delay (Δt) in order to achieve a good temporal overlap of pump and probe pulses. The cross-polarized pump and probe beams are combined at the second polarization beam splitter (PBS), i.e. PBS2. The combined beams are then coupled into a 1m long Corning® SMF-28e fiber through the microscope objective (L1, NA = 0.4 and 40X).

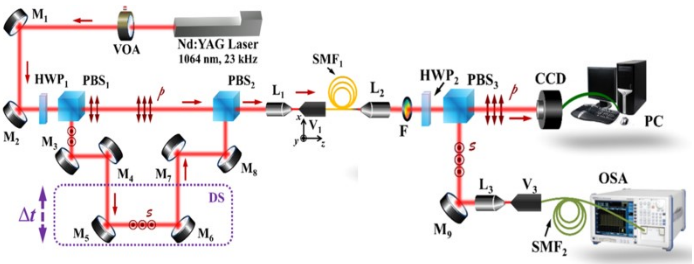

Fig. 1. Schematic of experimental set up. VOA: variable optical attenuator, M1- M9: silvered mirror, HWP: half wave plate, PBS: polarization beam splitter, L1-L3: microscope objective, V1-V3: v-groove, F: laser line filter, SMF1: Corning® SMF-28 fiber, SMF2: Single mode fiber, DS: delay stage, OSA: optical spectrum analyzer.

The pump is injected into the fiber to excite the 50/50 mixture of LP_{01} and LP_{11} modes with the help of precise opto-mechanic stages. The probe is initially launched into the LP_{01} mode. After passing through the laser line filter, the

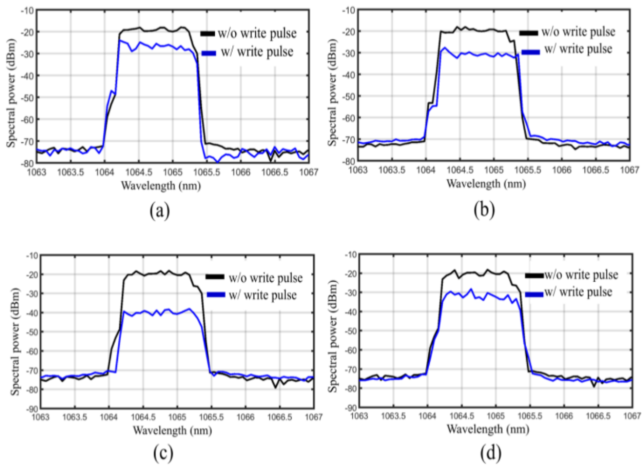

Fig. 2. Spectral power of the probe beam as a function of peak power of the pump beam for (a) 0.85 kW (b) 0.98 kW (c) 1.12 kW (d) 1.38 kW.

p-polarized beam has been minimized by the combination of HWP2 and PBS3. Finally, the beam is coupled into 1 m of SMF2 (HI1060-J9) which has cut-off wavelength of 920 nm. Thus, SMF2 serves as spatial-mode filter supporting only the fundamental LP_{01} mode. To reduce the nonlinear polarization rotation, we have followed the method demonstrated in [3]. Fig. 2 shows the measured modal conversion of the probe beam as a function of pump peak power. A periodic characteristics of modal conversion is observed. It is seen that maximum modal conversion occurred (almost 99%) for 1.12 kW peak pump power.

3. Conclusions

To conclude our work, we have demonstrated all optical transverse mode conversion through OLPG in step-index conventional single-mode fiber. The transient nature of the grating makes our approach unique from the existing results, making it suitable for several nonlinear and sensing applications.

References

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