Pulse shaping by phase-modulated fiber gratings in transmission

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Introduction

We propose a novel approach to pulse shaping using phase-modulated fiber Bragg gratings (FBGs) in transmission. This enables the simplification of the device fabrication. while retaining the substantial advantages of FBGs in transmission.

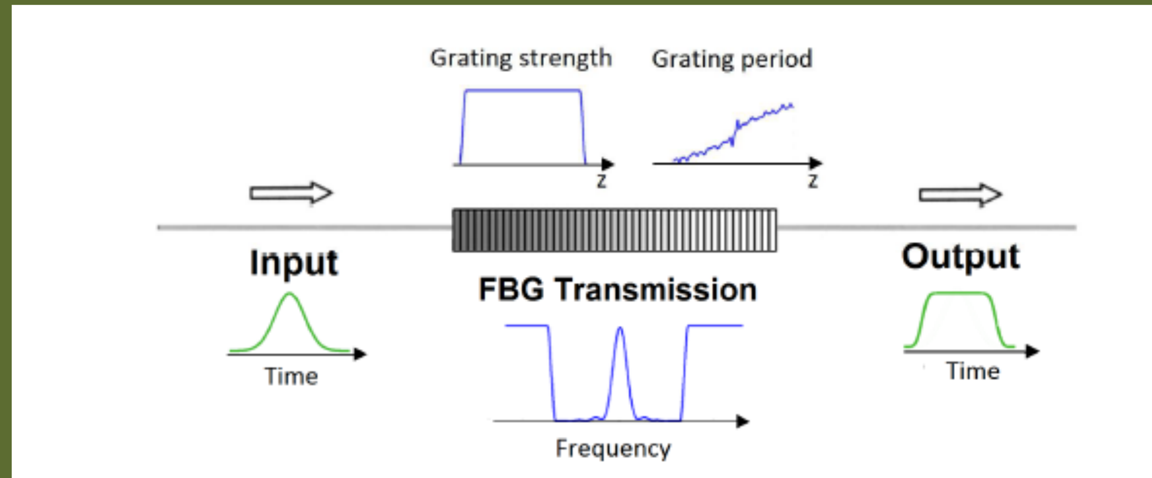


Fig. 1. Schematic of a pulse shaper based on a phase-modulated FBG in transmission.

Numerical design method

A numerical optimization algorithm calculates the grating modulated phase, or equivalently $\Lambda(z)$, in order to obtain a spectral response in transmission that attempts to better approach the objective spectral response in transmission in terms of least minimum squares over a desired bandwidth.

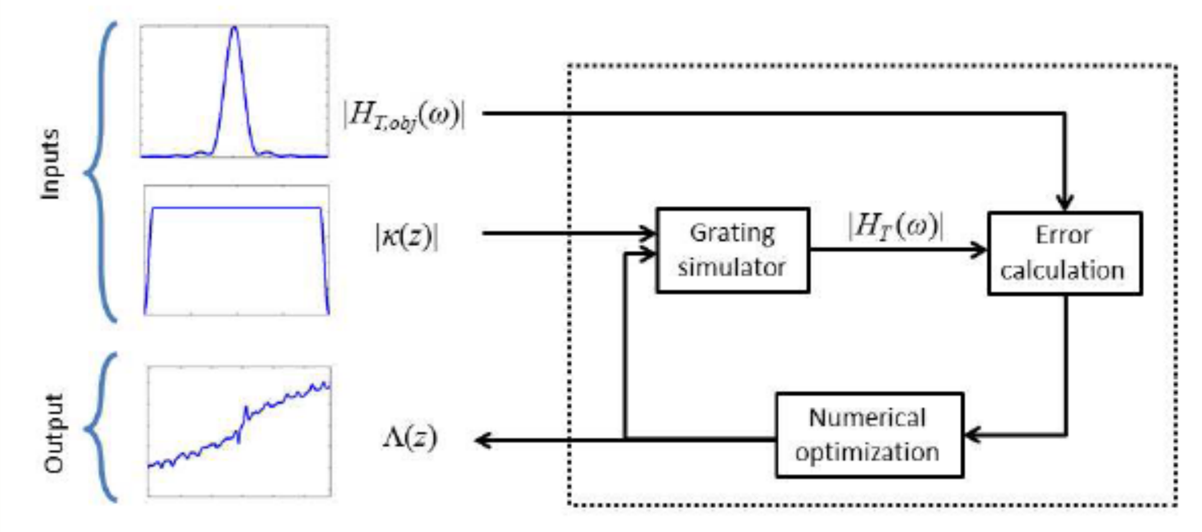


Fig. 2. Proposed method schematic based on numerical optimization.

Conclusions

- No optical circulator or additional element
- Typically optimal energy efficiency
- Phase response is less sensitive to grating fabrication errors
- The coupling strength remains basically uniform in the grating
- The phase-modulation profile can be directly encoded on a phase mask, and therefore has very high reproducibility.

Preliminary experimental in good agreement with the theoretical and numerical results

When all of this is considered, the use of phase-modulated FBGs in transmission appears to be a very attractive solution for pulse shaping.

Examples and results

As examples we design six phase-modulated FBGs in transmission for several waveforms generation.

(a) 40-ps flat-top pulse shaper.
(b) 40-ps saw tooth pulse shaper
(c) 80-ps dark parabolic shaper
(d) 40-ps bright parabolic shaper.
(e) 80-ps double saw-tooth pulse shaper type I.
(f) 80-ps double saw-tooth pulse shaper type II

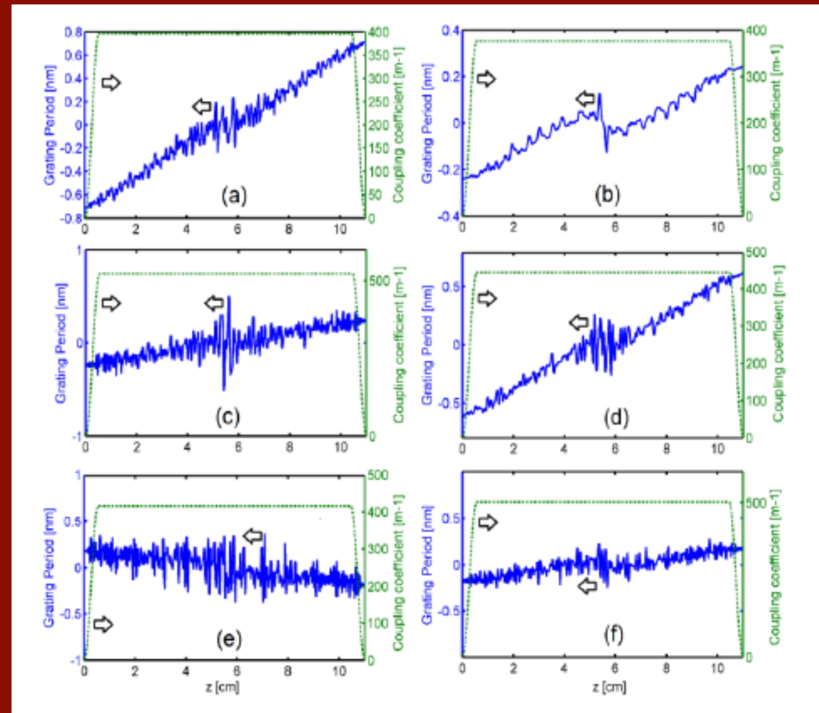


Fig. 3. (Color online) Grating period (blue-solid) and strength (green-dotted) of the phase-modulated FBGs for examples (a) to (f).

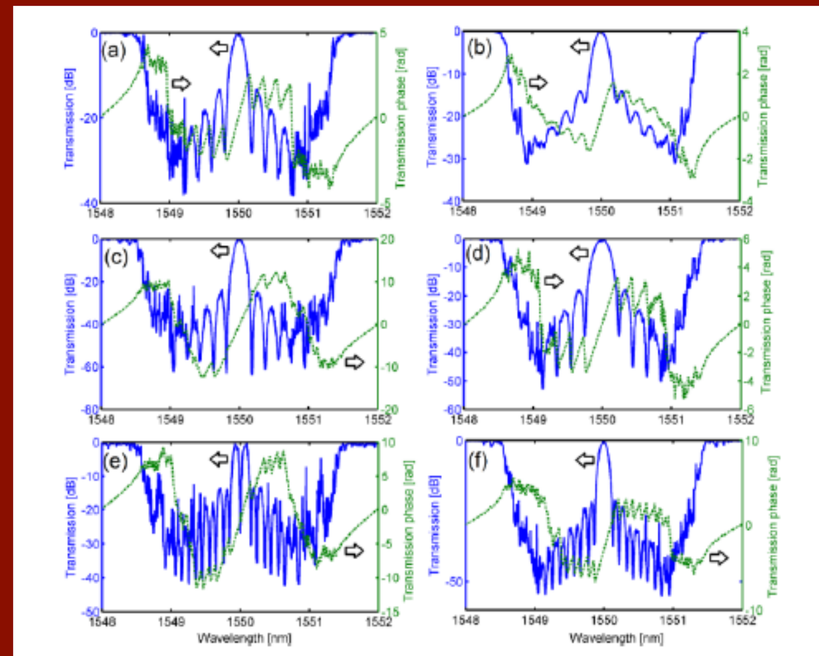


Fig. 4. (Color online) Amplitude (blue solid) and phase (green dotted) of the spectral response in transmission for examples (a) to (f).

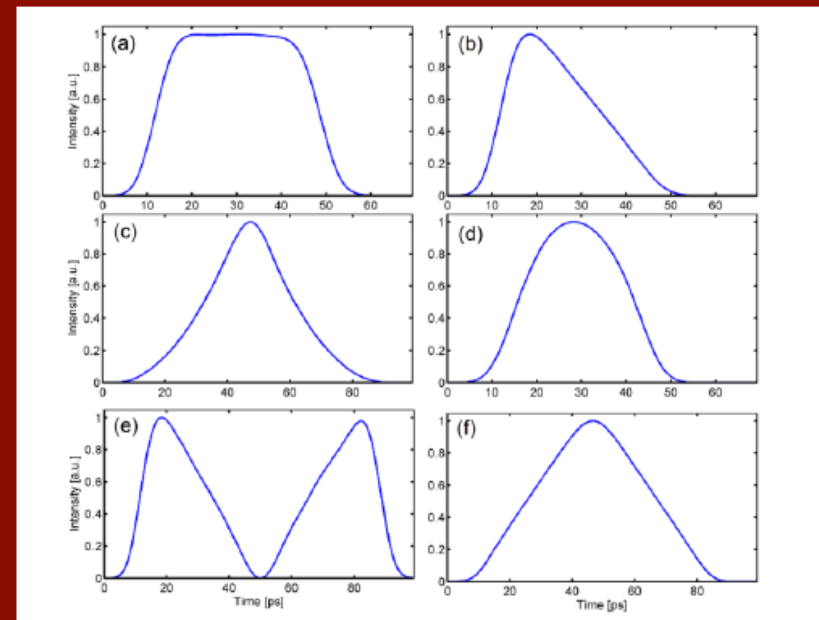


Fig. 5. (Color online) Resulting output waveforms by applying a 7ps FWHM Gaussian pulse to the designed FBGs for examples (a) to (f).

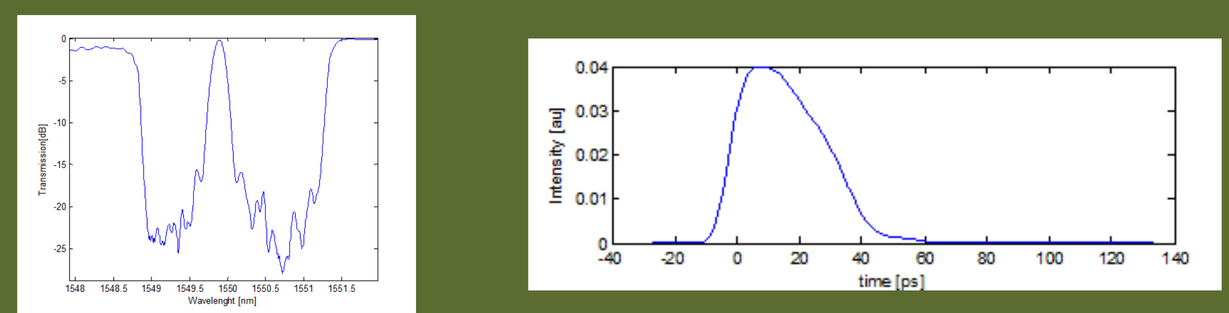
Preliminary experimental results from fabricated FBGs

The designed grating structure was fabricated with the UV laser direct-writing system

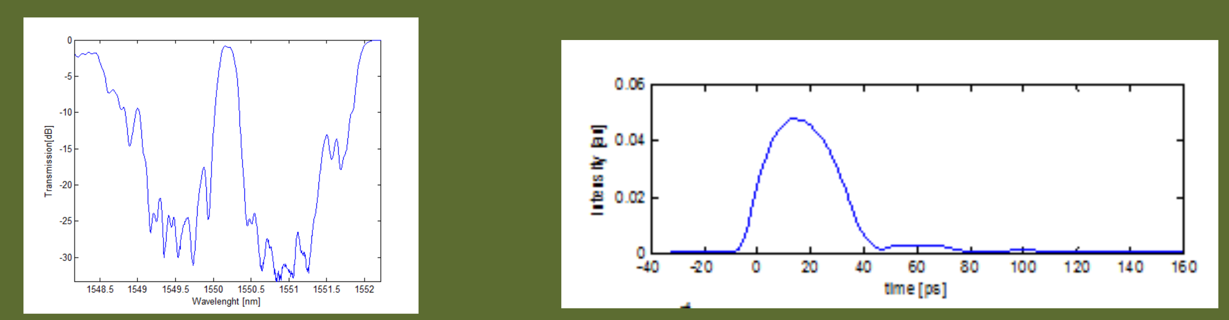
- Grating created pitch-by-pitch.
- Hydrogen-loaded photosensitive fiber
- Stabilized by annealing at 80ºC for 60 hours

The temporal results are obtained from experimental measured spectral responses of the fabricated FBGs, which phase was numerically recovered by using the Hilbert transform relation. A Gaussian pulse with 7-ps input was assumed.

Saw-tooth



Parabolic



Flat-top