Dual-pumping supercontinuum generation and temporal reflection in a nonlinear photonic integrated circuit

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Abstract: We report the observation of temporal reflection using dual pumping in a high-index doped silica waveguide. We further demonstrate that this dual-pump scheme enables a substantial broadening of the supercontinuum bandwidth, underscoring its strong potential for advanced photonic applications.

There is growing interest in enhancing supercontinuum (SC) bandwidth in nonlinear waveguides by exploiting temporal analogs of optical reflection and refraction [1,2], which occur when ultrashort pulses encounter a temporal index barrier. In this work, we provide experimental and theoretical evidence of multiple temporal reflections enabled by dual-wavelength pumping in a high-index doped silica glass integrated waveguide [3,4]. Using synchronized Ytterbium- and Erbium-based femtosecond lasers operating at 1040 nm and 1550 nm, respectively, we observe temporal reflections of the 1040 nm pulse from the 1560 nm soliton barrier. These reflection dynamics also generate resonant radiation components, resulting in substantial SC broadening. Figure 1(a) shows the waveguide cross-section with a highly doped silica glass (HDSG) core of refractive index n=1.7. The corresponding dispersion curve is plotted in Fig. 1(b). Pump pulses at 1040 nm and 1560 nm are coupled into a 50-cm-long waveguide with an electronically controlled time delay. Figures 1(c) and 1(d) reveal that as the delay approaches zero, strong cross-phase modulation (XPM) induces frequency chirps and temporally localized spectral peaks, corresponding to reflection-induced resonant radiation observed near 722 nm (experiment) and 735 nm (simulation). These results are further supported by simulated temporal evolution maps [Fig. 1(e)] and phase-matching analysis [Fig. 1(f)]. For a shorter 30-cm-long waveguide with different core dimensions and dispersion profile [Fig. 1(g)], Fig. 1(h) reveals a significant increase and smoothing of the SC bandwidth when the 820 nm and 1550 nm pulses are synchronized, compared to the asynchronous case.

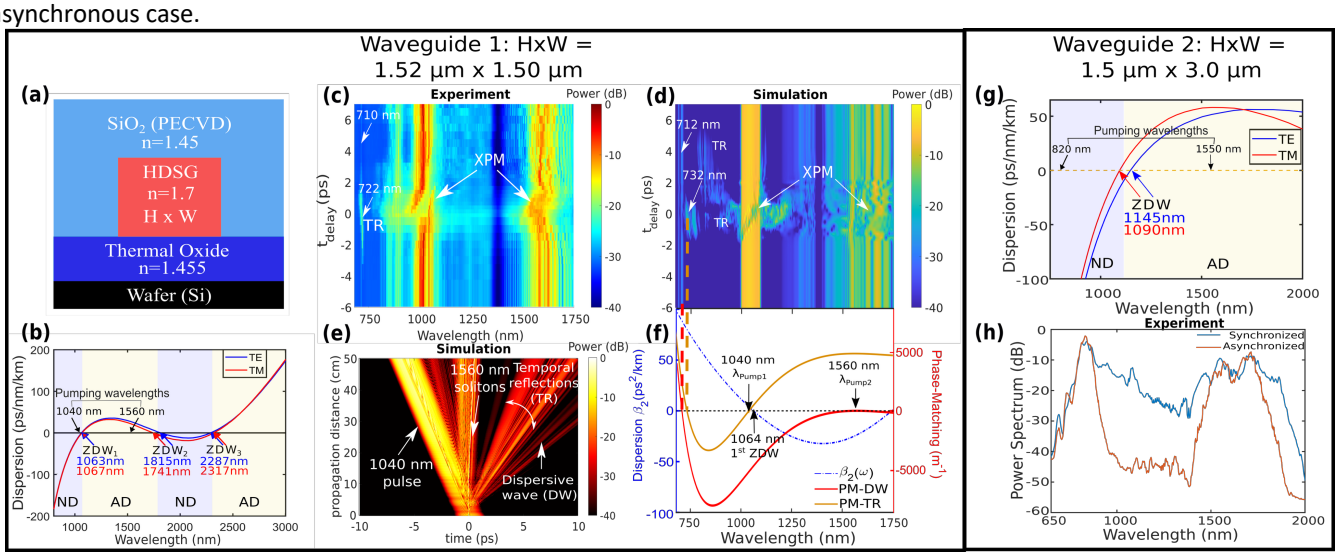

Figure 1 : (a) Waveguide cross-section. (b) Group-velocity dispersion of TE and TM modes for Waveguide 1. (c) Experimental and (d) numerical output spectra for dual pumping at 1040 nm and 1560 nm versus relative delay (t_{delay}). (e) Temporal reflection of the 1040 nm pulse from the 1560 nm soliton index barrier. (f) Phase-matching curves for dispersive wave emission (red) and temporal reflection (TR, yellow, right axis). (g) Group-velocity dispersion of TE and TM modes for Waveguide 2. (h) Experimental output spectra for synchronized versus asynchronous dual pumping at 820 nm and 1550 nm.

References:

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