Supercontinuum Spanning 2.8 Octaves in 4H-Silicon-Carbide Waveguides

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Supercontinuum generation has been widely investigated as a way to considerably extend the span of an optical frequency comb, while maintaining its coherence. One area of application is gas-phase spectroscopy in the molecular-fingerprint mid-infrared region. 4H-Silicon-Carbide (SiC) on insulator has emerged as a competitive platform for non-linear optics. Recent progress in the fabrication process of waveguides have lowered the propagation loss down to 0.08 dB/cm [1], while the material exhibits strong second and third order optical non-linearities, a wide transparency window, and a high refractive index contrast with the silica cladding.

Here, we explore the potential of the SiC platform for ultrafast nonlinear optics. We experimentally broaden a telecom-wavelength frequency comb over 2.8 octaves, up to mid-infrared wavelengths (3.5 μm), in a lithography-engineered SiC waveguide. The spectrum features a smooth envelope in the mid-infrared and is obtained with on-chip pulse energies as low as 0.19 nJ, making SiC a promising candidate for future integration of power-efficient spectrometers.

Under anomalous dispersion, a high-power optical pulse coupled to the SiC waveguide will split into first order solitons according to the supercontinuum theory. Dispersive waves are then expected to form at wavelengths which are phase matched with the main soliton. A numerical simulation shows that the phase mismatch $\Delta\beta(\lambda)$ can be kept close to 0 on a wide spectral range, for a waveguide cross-section of 483 × 2000 nm (Fig. 1 (a)). Under such circumstances, dispersive waves are expected to connect with the main body of the supercontinuum.

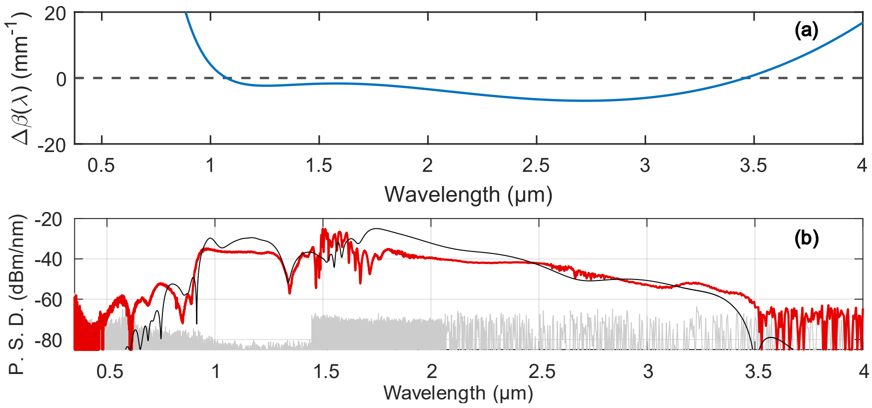

Fig. 1 (a) Simulated phase mismatch as a function of the wavelength for a 483×2000 nm SiC waveguide. (b) Simulated (black) and experimentally measured (red) supercontinuum obtained in such a waveguide. The measurement is done with optical spectrum analyzers (0.35-2.4 μm) and Fourier-transform spectrometer (2.4-4.5 μm) (noise floor in light grey). Oscillations in the 1.5-1.7 μm range and in the 2.5-2.8 μm range are attributed to interferences between the solitons and to water absorption, respectively. P.S.D.: Power spectral density.

Fig. 1 (b) shows the experimental measurement (red) of a supercontinuum generated from sending 1.57 μm centered, 70-fs optical pulses from a 100 MHz erbium mode-locked laser, inside the 4 mm-long 483 × 2000 nm SiC waveguide. The on-chip pulse energy used to obtain this supercontinuum is about 0.19 nJ which is lower than pulse energies used in SiN [2] or AlN [3] waveguides to reach the mid-IR in previous reports (0.6 nJ and 0.7 nJ, respectively). The spectrum extends in the 1.7-3.5 μm window without a major gap, and features a smooth envelope. Such a broad continuum could benefit spectroscopy applications. Moreover, second-order nonlinearities in SiC paves the way towards energy-efficient on-chip self-referencing of low-power frequency comb sources.

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