Infrared ultra-short pulses generation using Stimulated Raman Scattering in gas-filled HC-PCF

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Today, a lot of compact and reliable 1 micron fiber laser sources are available. They deliver high energy and tunable-duration pulses. For a number of different applications like surgery, spectroscopy or IR vision, it would be of major interest to have infrared sources with the same properties. Indeed, a lot of molecules have strong absorption bands in the 2 – 20 μm frequency range [1]. Among the different techniques are under study, some of them use gas lasers [2], frequency mixings in OPOs [3] or quantum cascade lasers [4].

Here we propose a new path based on Stimulated Raman Scattering (SRS) in Hollow-Core Photonic Crystal Fibers (HC-PCF). This technique has been proved to be an outstanding frequency converter. As an example, it has been possible to generate ultra-wide Raman frequency combs [5], from the UV to the IR. However, questions remain on the viability of this route for Ultra-Short Pulse (USP) frequency conversion because of the dramatic reduction of the Raman gain coefficient with decreasing pump pulse-width. Secondly, the spectral-temporal structure of the Stokes pulse needs characterization to ensure the USP temporal integrity and how it compares with that of the pumping pulse. More recently, 1.8 μm pulses have been generated by Transient SRS in a gas-filled HC-PCF. The duration was less than 20 ps and the energy 33 μJ [6].

The present work follows on the aforementioned work by demonstrating the generation of Stokes source pumped with pulse as narrow as 250 fs. Here the used source emits from 250 fs to 10 ps pulses at 1030 nm, with an energy up to 200 μJ and a 250 kHz repetition rate. As in [6], we keep on generating the first vibrational Stokes in hydrogen at 1.8 μm , polarization is then linear. The Raman medium is composed of a 3 meters length Kagome HC-PCF with a 57 μm inner diameter, filled with a 20 bars pressure.

Fig. 1(a) shows measured autocorrelation traces (blue) obtained at 1.8 μm and their respective sech² fit traces (red). The corresponding spectra are represented in Fig. 1(b) and shows both pump and first vibrational Stokes, respectively at 1030 nm and 1.8 μm . Fig. 1(c) illustrates the obtained IR pulse duration with respect to the input pump pulse duration. Both IR and pump pulse durations are comparable from 10 ps to 1 ps. However, for pump pulse width of less than 1 ps pump, we observe a temporal broadening, limiting the shortest durations slightly under 1 ps in the IR.

Fig. 1: (a) Autocorrelation traces, (b) Corresponding optical spectra and (c) measured IR pulse duration regarding input pump pulse duration.

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