Towards supercontinuum generation by stimulated Raman-Kerr scattering in an integrated nonlinear liquid core fiber

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Integrated liquid-core optical fibers (LCOF) have recently emerged as new photonic platforms for their wide range of potential applications in nonlinear photonics [1,2]. Their advantages over solid-core glass fibers include broad transparency from the UV to the mid-IR and enhanced nonlinear optical effects. For instance, enhanced stimulated Raman scattering (SRS) has recently been demonstrated using carbon disulfide, Toluene or ethanol nonlinear liquids in integrated all-fiber systems compatible with standard single-mode fibers (SMFs) [1,2].
In this work, we demonstrate another original nonlinear optofluidic fiber arrangement that allows coupling light first into a solid-core fiber and then into a fiber filled with Toluene, as shown in Fig. 1(a) [3]. With this optofluidic system, we report the generation of a broadband Raman cascade ranging from the visible to the near infrared simply by use of a compact microchip nanosecond laser. It is shown in particular that the Raman lines strongly broaden and merge, and giving rise to a quasi supercontinuum (SC) spanning from 630 nm till 870 nm.
The capillary fiber has a central hole of 8 µm where light is guided and nonlinearly interacts with the liquid. This arrangement limits the detrimental effect of laser-induced bubble formation, and improves the injection of the laser beam into the fundamental mode of the fiber. We used a 2-meter-long fiber filled with Toluene pumped with a compact microchip laser at 532 nm with 600-ps pulse duration. Figure 1(b) shows a color plot of output experimental spectra for an increasing pump power. The top spectrum corresponds to the highest coupled peak power of 5 kW. We clearly observe the emergence of a Raman frequency comb with up to 8 Stokes orders from the pump wavelength at 532 nm till 1 µm. All Raman lines are equally shifted by 30 THz in agreement with the Raman vibrational frequency of the aromatic ring breather mode of Toluene. From the second Raman order at 600 nm, we can see a strong spectral broadening of Raman lines towards the Stokes wavelengths. This is actually caused by the stimulated Raman-Kerr scattering (SRKS) due to the inertial nature of the reorientational motion of anisotropic Toluene molecules [4]. This broadening is increasingly important when increasing the pump power and the number of Raman orders filling the gap between Raman lines.

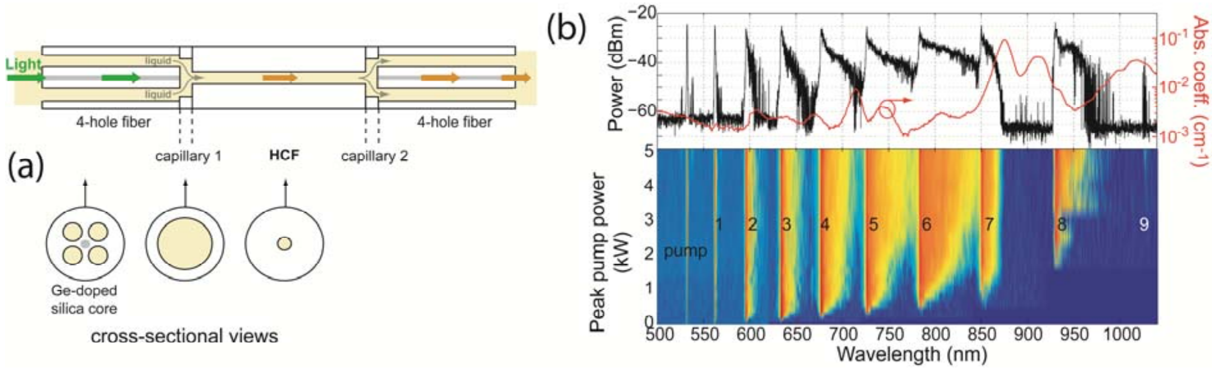

Fig. 1 (a) Schematic of the hermetic liquid-core optical fiber arrangement for nonlinear applications. (b) Output experimental spectra showing the cascaded Raman generation and its significant spectral broadening by SRKS. Top: Output spectrum for the highest pump power (solid curve) and Toluene absorption spectrum from Ref. [5] (red curve). Bottom: Color plot of output spectra for an increasing input pump power. Raman peaks are numbered.

References

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