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UV-DUV source based on IC-HCPCF filled with Hydrogen

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Abstract: We report on a compact multi-line Raman source with a spectrum spanning from 250nm to 750nm with spectral densities ranging from 0.2 to 4 μ W/nm between 250-300nm and 20 to 700 μ W/nm for 300-350 nm.

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1. Introduction

UV laser sources became a high differential in numerous material science applications [1]. We can find two main technologies on the market. The first one is the excimer laser enabling a direct emission in the UV lasers where the gain media is a mixture of a rare gas and a noble gas. However, these sources are cumbersome and need a high level of maintenance. The second one is based on the generation of higher harmonics of Yb and Nd:YAG sources thanks to nonlinear crystals that have a limited lifetime due to the damage caused by UV radiation. Another drawback using the harmonic of the pump, which is also true for the excimer lasers, is a limited range of attainable wavelengths.

To overcome these short settings, an excellent candidate is a Raman gas confined in a inhibited-coupling (IC) hollow-core photonic crystal fiber (HC-PCF) pumped with a microchip laser providing a high conversion efficiency on a broad band spectral range [2][3]. Moreover, the low overlap between silica and the guided light prevents any solarization or photodarkening of the fiber [4] making the HCPCF a perfect tool to achieve a long lifetime UV source. Before, the high losses exhibited by this kind of fiber in this spectral region that have limited the shortest wavelength to be around 350 nm in this configuration need to be highly decreased which is the case thanks to the recent developments in HCPCF [5].

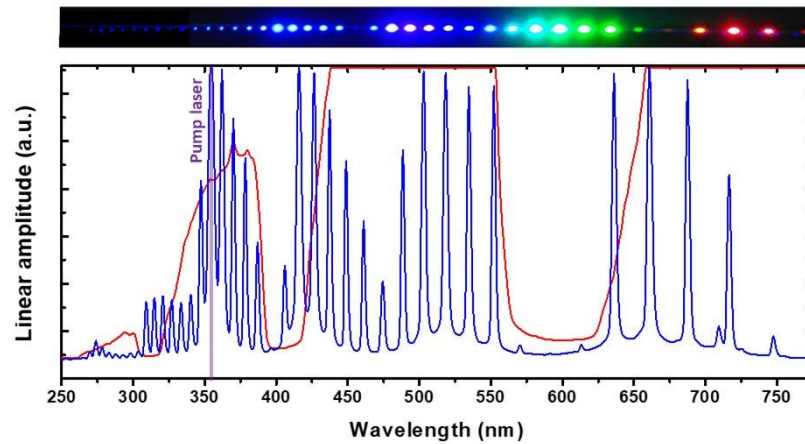
Here, we report on a fiber with losses beneath 100 dB/km in the UVA region (320-400 nm) filled in with Hydrogen gas and pumped with a tripled frequency Nd:Yag DPSS microchip laser. We obtain a Raman comb composed of 21 Raman lines ranging from 250 to 400 nm with spectral densities up to 4mW/nm.

2. Results

The fiber is an 8 tube IC HCPCF lattice with a core diameter of 27 μ m, a strut thickness of 540 nm and a gap inter tube ranging from 2.1 to 4.7 μ m. The transmission on the fiber is plotted in figure 1a) overlapping the Raman comb generated. The second higher order band covers from 425 nm to 550 nm, the third from 260 to 300 nm. This fiber is sealed in gas cells with an inlet for gas and a pressure gauge in order to monitor the pressure of hydrogen in these latter. The evolution of the spectrum is measured thanks to a spectrophotometer. In order to finely tune the Raman comb in the UV range, two systematic studies have been realized. The first one consists on playing on the fiber length and the second on the hydrogen pressure inserted in the fiber. The optimum fiber length is found to be 120 cm filled in with 2 bars. The resulted Raman comb covers 4 lines in the UV-C, 8 lines in the UV-B and 9 lines in the UV-A if we include the pump. The total energy was measured to be 12.5 μ J with high spectral densities ranging from 4 μ W/nm at 269 nm to 4 mW/nm at 362 nm.

If we focus on the lines generated beneath the wavelength of the pump 18 lines are generated. In these latter we can find the rotational anti-Stokes of the pump with spectral densities from 53 to 700 μ W/nm, the first order vibrational anti-Stokes at 309 nm acting as a pump for the rotational Stokes and anti-Stokes between 292 and 315 nm with spectral densities from 4 to 300 μ W/nm, the second order vibrational anti-Stokes at 274 nm also acting as a pump for the rotational Stokes and anti-Stokes from 249 nm to 287 nm with spectral densities ranging from 0.2 to 12.8 μ W/nm. This system has been integrated in order to realize a product which is coined UV-Comblas represented in figure 1b).

a)



b)

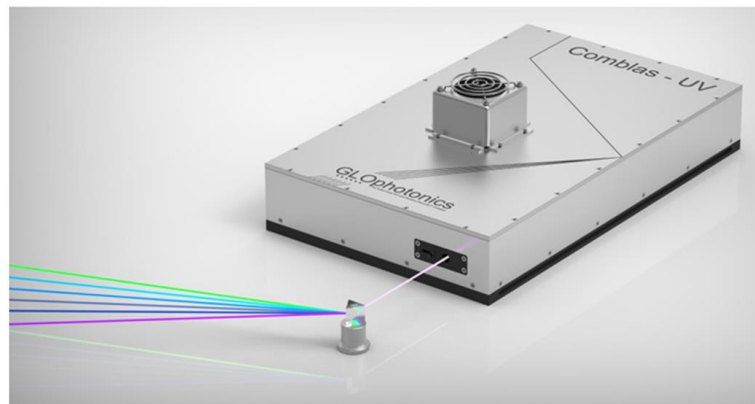


Figure 1: a) Spectrum of the Raman comb generated with its picture in 120 cm of HCPCF filled in with 5 bars and pumped at 355 nm (blue) transmission on 20 m of fiber (in red) b) Representation of the UV Comblas.

3. Conclusion

To conclude, a UV-DUV laser source also covering the visible range with high spectral density is proposed thanks to SRS in a HCPCF with record losses filled with hydrogen gas. This source can be of great use in a wide number of applications like spectroscopy, purification or cytometry to cite a few.

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