PARAMETRIC GENERATION AT 648 NM IN A LMA PHOTONIC CRYSTAL FIBER

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There is a high demand for pulsed visible spectrum coherent light sources in applications like spectroscopy, microscopy and medical therapy [1]. For all-fiber laser systems, degenerate four-wave mixing process allows conversion of two pump photons of the same wavelength into two different photons - one of longer and one of shorter wavelength than the pump photon. For this process to happen, certain phase-matching conditions should be met so that phase velocity for all four interacting waves are the same within the optical fiber. In general, three members that contribute to phase mismatch (phase velocity difference due to waveguide structure, material dispersion and non-linearities) have to cancel each other out. To fulfill such requirements for specific wavelengths, usually custom-designed optical fibers are needed. One example is photonic crystal fiber (PCF). Due to unique structure of PCF, it can have shifted dispersion curve compared to ordinary single-mode fiber. This characteristic allows all kinds of phase-matching scenarios for different types of photonic crystal fibers [2].

In this work, a solid-core commercially available photonic crystal fiber was used with a mode field diameter of 7.5 µm (1064 nm) and length of 30 cm. Pulsed fiber laser operating at 1038 nm wavelength and generating 250 ps pulses with repetition rate of 100 kHz was used as our pump source for frequency conversion. Pump pulses were amplified in two fiber amplifier stages and a Yb-doped photonic crystal fiber amplifier at the final stage. After coupling the pump pulses into our frequency conversion PCF and increasing average power to 0.18 W (pulse energy 1.8 µJ) the peak at 648 nm was registered. This wavelength matches theoretical value calculated from phase matching condition for four-wave mixing process. By increasing energy of the pump pulses, maximum of ~2.6 µJ energy pulses at 648 nm were generated with the maximum conversion efficiency of 31 %. From energy conservation law follows that maximum conversion efficiency (to signal wave at 648 nm) can be up to 80.7 %, but in reality this value is much lower due to all kinds of imperfections like temporal walk-off of the interacting wave-packets, signal wave reconversion to pump waves as well as PCF geometry variations and pump pulse parameter fluctuations.

Our results show that frequency conversion in a photonic crystal fiber remains a good method to produce short optical pulses in a visible spectral region. The results of this research is a base for further investigations to build a tunable all-fiber pulsed laser source operating in wide spectral range.

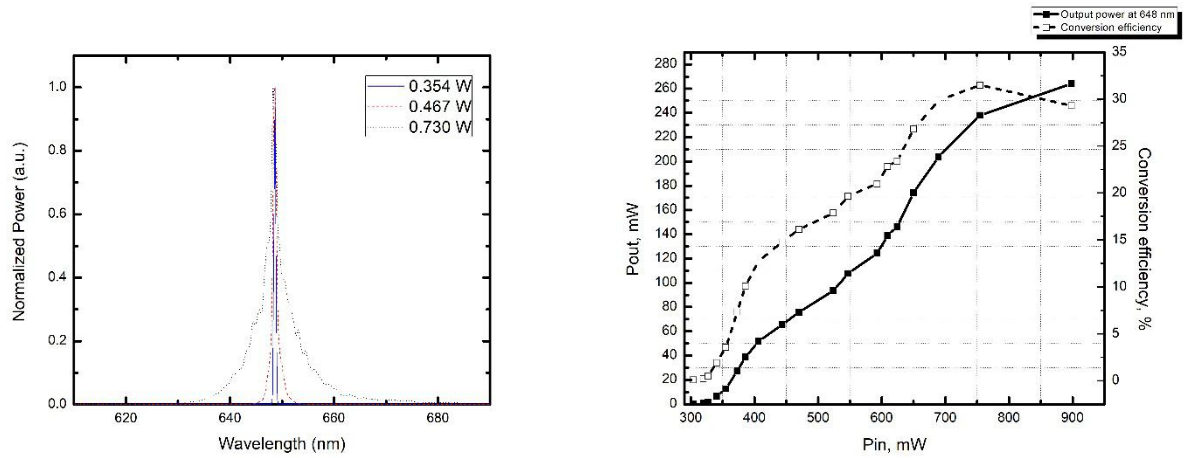

Fig. 1. Normalized spectrum of the signal wave at 648 nm (left). Average power of the signal wave and conversion efficiency vs pump power (right).

[1] C. Jauregui, A. Steinmetz, D. Nodop, J. Limpert, and A. Tunnermann, All-fiber parametric generation of sub-100ps pulses at 650nm with 9Watt average power, *Lasers, Sources, and Related Photonic Devices* (Optical Society of America, 2012).
[2] G. P. Agrawal, *Nonlinear Fiber Optics* (Academic, 2001).