

# Fiber optical parametric oscillator delivering signal pulse tunable in wavelength and pulse duration

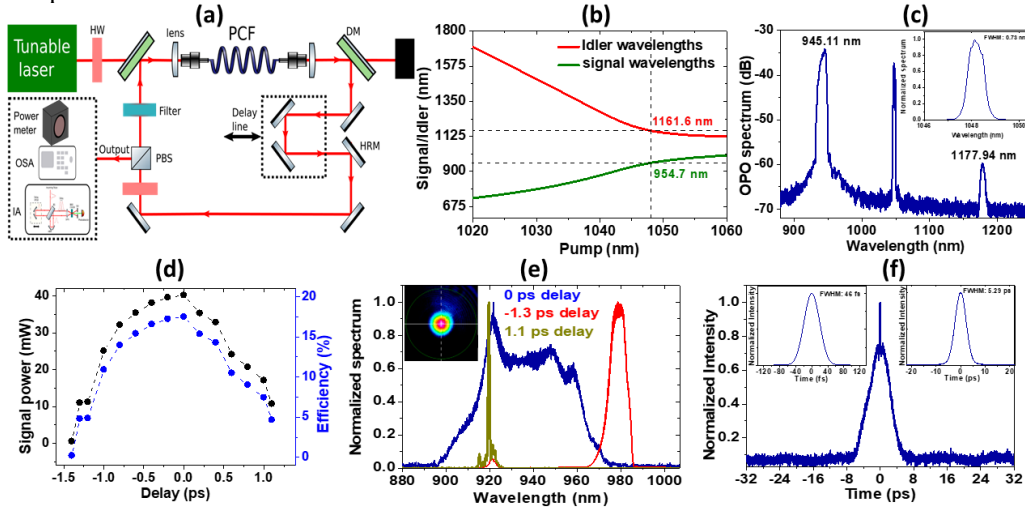
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The fiber-based OPOs based on four-wave-mixing have been shown to exhibit interesting features such as good beam quality, robustness, and compactness [1-3]. Hereafter, we present the compact fiber OPO delivering signal pulse tunable in wavelength and pulse duration and analyzed its capabilities and performance.

The fiber OPO is built around 184 cm-long single-mode photonic crystal fiber (PCF) (Fig. 1a). Based on the dispersion properties of the PCF and tunability of our homebuilt self-locked ytterbium pump source [4], a very broad tuning range is calculated for the signal ( $\sim 730$  nm to  $\sim 990$  nm) and idler ( $\sim 1120$  nm to  $\sim 1695$  nm) (Fig. 1b). The results achieved when the OPO is synchronously pumped around 1048 nm, are presented in this work. The measured signal/idler spectrum is shown in Fig. 1c, while the inset figure displayed the spectrum of the injected pump (input power: 100mW, FWHM: 0.73 nm). To ensure the OPO cavity is singly-resonant for the signal wave, two dichroic mirrors and a short-pass filter were inserted. The measured conversion efficiency for the signal shows an increasing trend as the pump power is increased and reached a plateau of about  $\sim 20\%$  above 250 mW of pump power. Contrary to the conventional FOPOs, in which a long dispersion fiber is used to achieve a narrow bandwidth amplification [3], the delay line in our setup makes it possible to delay the signal pulse with respect to the pump at the entrance of the PCF fiber. This, allows us to switch from broadband to narrowband signal, at the expense of higher to lower conversion efficiency, respectively. The signal power and the corresponding conversion efficiency evolutions versus the delay are plotted in Fig. 1d. As shown in Fig. 1e (blue), at the input power of 230 mW, the signal pulse, having a good beam profile, spans over  $\sim 65$  nm due to the large parametric gain, the signal spectra for different delays are displayed as well. The achieved pulse duration for the signal (Fig. 1f) is around  $\sim 3.25$  ps, while the inset-right shows the pump autocorrelation trace (pulse duration  $\sim 3.75$  ps). The Fourier-limited pulse duration (Fig. 1f (inset-left)) for the broadband signal is  $\sim 46$  fs, meaning it is highly chirped in our PCF fiber.



**Fig 1.** (a) Fiber OPO setup. (b) PCF phase-matching curves for signal and idler. (c) Pump, signal, and idler spectrum (Inset: injected pump spectrum). (d) Measured signal average power and conversion efficiency at different delay positions  $\epsilon$  Broadband (blue) and narrowband (red and yellow) signal at 230mW pump power (inset: signal beam shape) (f). Signal autocorrelation trace (inset left: FFT signal pulse duration, inset right: Pump autocorrelation trace).

Although our tuneable pump laser can provide  $\sim 25$  W average power [4], the unwanted higher non-linear effects induced in the small PCF core limit the highest pump power up to 300 mW. Alongside, other detailed discussions, the modifications to the fiber OPO setup to achieve an average watt-level output power for the signal will be presented.

## References

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