Mode-locked ytterbium-doped fiber laser operating in the positive dispersion regime tunable over the range 1045-1065 nm

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Summary

A mode-locked ytterbium-doped fiber laser operting in the normal dispersion regime has been demonstrated in a all-PM cavity. The laser is tunable over the wavelength range 1045-1065 nm with transform-limited pulse duration of 15 ps and repetition rate below 20 MHz.

Introduction

Ultra-short pulse generation has become an increasingly important technology for many industrial and research applications. Among different materials which have been introduced for mode-locking operation, ytterbium-doped fiber oscillators offer compactness, high efficiency and environmentally stable solutions at 1 μm. Due to the limited maximum peak power set by nonlinear effects in a whole-fiber technology, seeding solid-state amplifiers with fiber-based picosecond oscillators is an interesting approach requiring pulse durations in the range 10-20 ps and tunability to cover the emission peaks of the different amplifier media. In recent years passive mode-locking operation has been demonstrated in ytterbium-doped fiber laser both in the soliton regime and in the normal dispersion regime [1]. Since the commonly-used FBGs for all-fiber solutions do not offer tunability over a many-nanometers range, the typical approach for tunable picosecond fiber sources include bulk optics components like grating pairs [2] or electronically driven acousto-optic tunable filters [3]. These schemes suffer from complexity and allow for the generation of few picosecond long pulses in the soliton regime, which is beyond the scope of solid-state amplifier injection. We report a cavity layout for generation of 15-ps pulses over a tunable range of about 20 nm by simply using a single external grating in a all-PM fiber cavity.

Experimental setup and results

The oscillator layout is shown in Fig. 1. Due to the high efficiency and pulse energy limitations of passively mode-locked fiber oscillators, a 150-mW laser diode with

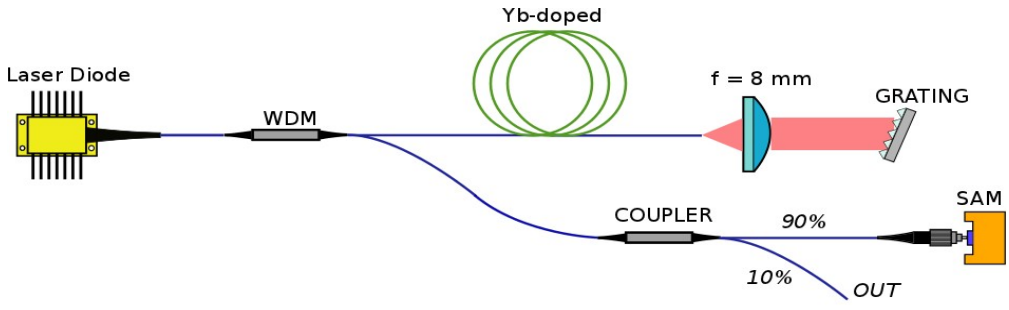

Fig 1. Oscillator layout

HI1060 fiber pigtail emitting at 975 nm has been used as the pump device. As a consequence of high unsaturated pump absorption at this wavelength experienced by the high-doped single-mode single-clad ytterbium-doped active fiber used (250 dB/m) the active medium was only 35-cm long. The pump was coupled to the cavity via a PM WDM, which was part of the 6-m-long all-PM cavity. A 90/10 PM micro-optic coupler was used to provide both output coupling and polarization selection while a fiber-pigtailed 23%-absorption 13%-modulation depth nonresonant saturable absorber was used to establish mode-locking operation. By splicing a 0.7-nm FWHM bandwidth 85%-reflectivity FBG to the free end of the active fiber in Fig 1, stable and turn-key mode-locking operation was easily achieved at 1064 nm with transform-limited pulse duration of about 15 ps and 16 MHz-repetition rate (see Fig 2). By replacing the FBG with an external 1200 lines/mm blazed aluminum grating it was possible to obtain stable mode-locking operation in the continuously tunable range between 1045 nm and 1065 nm (see Fig 3). By using a 8-mm-focal length aspheric lens to collimate the output beam from the angle-cleaved active fiber, a comparable spectral filtering with the previously mentioned FBG was possible, allowing a comparable pulse duration without loss of stability. With only 20-mW absorbed pump power, mode-locking operation was established with 0.5 mW of output power from the 10%-coupler output port and 1 mW from the grating zero diffraction order. For absorbed pump power higher than 30 mW multiple pulses per round-trip has been observed.

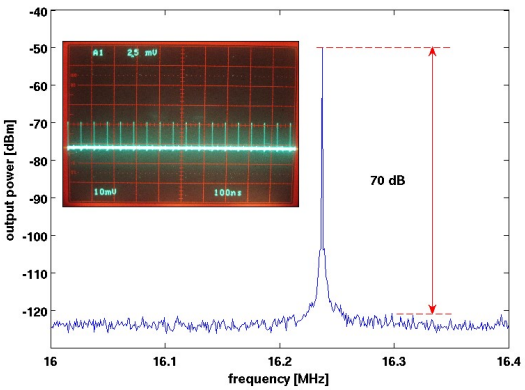

Fig 2. RF spectrum and ML pulse train (inset)

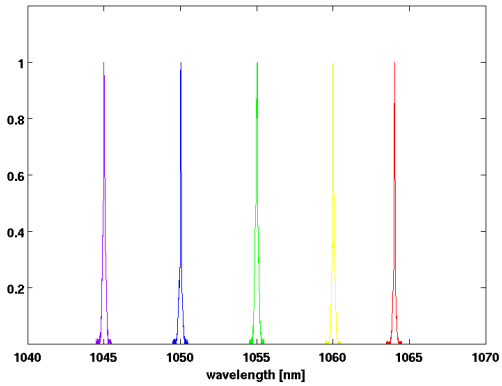

Fig 3. Mode-locking tuning range

Conclusions

Stable mode-locking operation has been observed with pulse duration of about 15 ps and tunability over 20 nm in the range 1045-1065 nm in an ytterbium-doped fiber oscillator by using a single external grating. These performances fit the requirements for a low-repetition rate master oscillator to be used as a seed for solid-state amplification stages.

References

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