

Wavelength-swept fiber laser with frequency shifted feedback

S. H. Yun, D. J. Richardson, D. O. Culverhouse, B. Y. Kim*

Optoelectronics Research Center, Univ. of Southampton SO17 1BJ, UK

Tel :+44-1703-593138, Fax:+44-1703-593142

e-mail: sy@orc.soton.ac.uk

* Dept. of Physics, Korea Advanced Institute of Science and Technology,

Taejon 305-701, Korea

We report a frequency-shifted, wavelength-swept Er/Yb-doped fiber laser. By matching the intra-cavity filter sweep rate to the frequency shift per round trip controllable, high power (>100mW), cw modeless output over 38nm, with <0.1nm instantaneous linewidth is obtained.

Frequency Swept Fibre Lasers (FSFL's) incorporating Acousto-Optic Tunable Filters (AOTF's) offer great potential for use in a wide variety of applications e.g. spectral device characterization, grating array monitoring and low-coherence optical fibre sensing. However to date FSFL's have received little attention within the literature due to the restricted scanning ranges ($<20\text{nm}$) and $\sim 1\text{nm}$ instantaneous linewidths previously achieved [1].

In this paper we demonstrate a diode-pumped, high-power ($>100\text{mW}$), wavelength-swept, FSFL in which the output wavelength is continuously and repeatedly tuned over a broad range (upto 38nm) by modulation of the intracavity AOTF peak-wavelength. Furthermore, we demonstrate for the first time that resonant matching of the filter peak sweep rate to the acousto-optic frequency shift per round trip suppresses the nonlinear pulsing observed in conventional frequency-shift lasers [2,3], and results in significant narrowing of the instantaneous swept linewidth ($<0.1\text{nm}$).

Fig.1 shows the 19m ring laser cavity incorporating a bulk-optic AOTF (4 nm bandwidth, 68 MHz frequency upshift). The acoustic drive to the device was controlled with a phase-locked loop, with fast/independent electrical control of the acoustic power and frequency. Using two phase-locked, arbitrary function generators we could therefore synchronously, and independently temporally control the peak transmission and wavelength of the filter.

We investigated the laser performance under swept operation of the AOTF for a number of sweep ranges, functions and rates. The time averaged laser output was monitored using an OSA and the instantaneous linewidth determined by examining the temporal response of the laser output on reflection from a narrowband (7 GHz) fibre grating. In particular we investigated sweep rates around the resonant case in which the filter peak is moved so as follow the 720

GHz/ms frequency shift imposed by the AOTF. For a 20nm sweep range this corresponds to a sweep rate of ~ 288 Hz. In Fig.2 we plot measurements of the instantaneous linewidth as a function of sweep rate for the 20nm sweep range case. The results clearly show a strong spectral narrowing at the resonant sweep rate in excellent agreement with our theoretical expectations. Moreover, the laser's natural tendency to pulse [3] was suppressed. On resonance linear radiation moving under the filter peak experiences the lowest system loss making cw operation the preferred mode.

Figs 3a shows the peak-hold spectrum obtained by resonant tracking of the acoustic frequency shift over 20 nm for a fixed acoustic power. The sweep frequency and the output power were 290 Hz and 100 mW, respectively. The spectral shape and output power were almost independent of the sweep rate up to 7 kHz. Sweep ranges >38 nm were readily achieved. In Fig 3.b we show that control of the spectral form can be achieved with synchronous frequency and amplitude modulation. Triangular and square wave modulated forms were chosen for this purpose.

In summary, we have reported a wavelength-swept fiber laser with upto 38 nm sweep range, <0.1 -nm instantaneous linewidth, user definable spectral shape, and >100 -mW output power. We believe such sources to have great potential for use in applications requiring accurate spectral control, or measurements.

References

1. P. F. Wysocki, M. J. F. Digonnet, and B. Y. Kim, *Opt. Lett.* 15, 879 (1990)
2. W. Streifer and P. Saltz, *IEEE J. Quantum Electron.* QE-9, 563 (1973)
3. H. Sabert and E. Brinkmeyer, *J. Lightwave Technol.* 12, 1360 (1994)

Figure Captions

Fig. 1. Experimental wavelength-swept fiber laser with spectral analysis set-up.

Fig 2. Instantaneous linewidth: (a) Filled and Open circles are experimental values at 3 mW and 100 mW output power, respectively. The dotted lines are theoretical fits, assuming the dependence of $(f_{sweep} - f_{proper})^{1/3}$ with $f_{proper} = 288$ Hz [2].

Fig 3. Peak-hold spectrum of the laser output: (a) AO frequency swept from 68 MHz to 69 MHz at fixed RF power giving flat spectral output over 20nm, (b) triangular and square modulated output obtained by synchronous modulation of the filter transmission and peak wavelength.

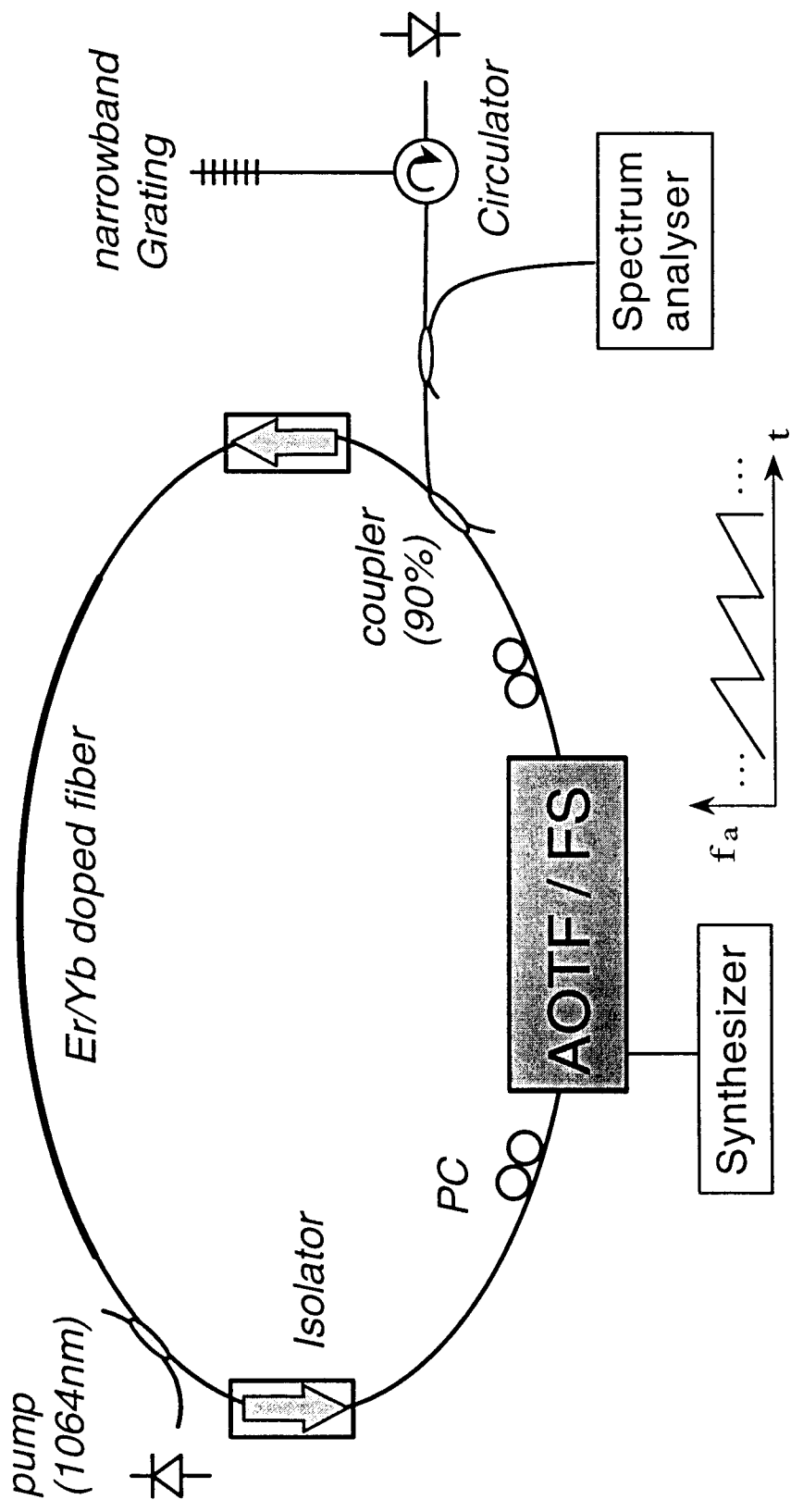


Fig 1

