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# Tunable polarization-maintaining single-mode fiber laser based on a MEMS processor

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**Abstract:** A tunable from the C-band polarization-maintaining single-mode fiber laser is proposed based on a MEMS processor. The MEMS processor can select any part of the gain spectrum from the EDFA into a fiber ring, leading to a high-quality laser output.

**OCIS codes:** (060.2320) Fiber optics amplifiers and oscillators; (140.3600) Lasers, tunable

## 1. Introduction

Tunable lasers are currently used in a wide range of applications such as wavelength-division-multiplexing networks, optical sensors, spectroscopy, and testing of optical components and instruments. Compared to tunable semiconductor lasers, fiber lasers have advantages of narrow linewidth, low intensity noise, high output power, and inherent compatibility with fiber optics. Up to now, there are several approaches to realize single-mode tunable fiber laser, including the use of fiber Bragg grating (FBGs) [1, 2], acousto-optic tunable filter [3, 4], Fabry-Perot filter [5, 6] and Opto-VLSI processor [7, 8] etc.

In this paper, we demonstrate a compact tunable polarization-maintaining (PM) single-mode fiber laser based on a MEMS processor and an erbium-doped fiber amplifier (EDFA). The MEMS processor is able to arbitrarily select any waveband from the amplified spontaneous emission (ASE) signals of an EDFA and route them back into a fiber ring cavity to generate laser output. The experiment shows a tunable fiber laser with linewidth 20pm (2.5 GHz) and the tuning step 0.08nm over the C-band. The side mode suppression ratio (SMSR) of signals is greater than 50 dB. The laser output is vertical linear polarization with polarization ratio more than 100:1. Due to the whole PM components used in the system, the output signals are insensitive to the environment vibration. The measured laser power and wavelength fluctuation are less than 0.013dB and 0.01nm at room temperature, respectively.

## 2. Laser structure and operation principle

Figure 1(a) is the MEMS-based tunable fiber laser structure, which consists two parts including PM fiber system and bulk optics part. A broadband ASE provided by an EDFA is split by an optical coupler with 10:90 coupling ratio, where 90% of ASE power is recirculated into a fiber ring cavity and directed to the bulk optics part via a dual PM fiber collimator. A ruled diffraction grating with 1200-lines/mm disperses the incident light in different directions and maps linearly along the active window of a 0.5 XGA DMD (digital micromirror device) by a lens 2 with a focal length 75mm. The DMD, as a core component of the MEMS processor is a semiconductor-based 1024×768 array of addressable mirror-pixels with pitch 10.8  $\mu\text{m}$ . These microscopic mirrors can be individually rotated  $\pm 12^\circ$  along each diagonal line. By uploading the addressing voltage on the appropriate mirrors, the corresponding part of the ASE spectrum hitting the tilting pixel block can diffract efficiently (see Fig. 2). In the

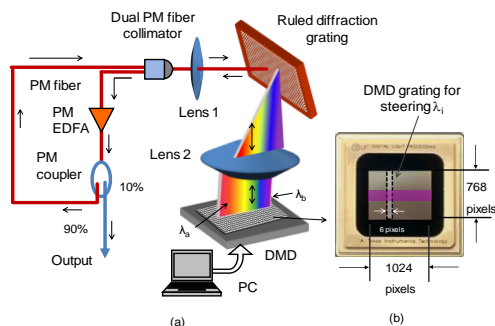


Fig. 1 Schematic diagram of a MEMS-based tunable fiber laser

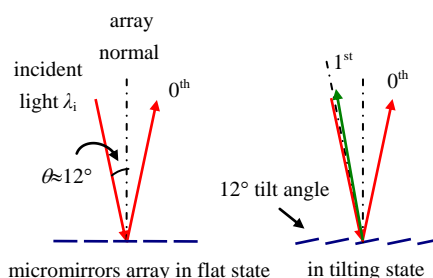


Fig. 2 Incident light illuminating a DMD grating in flat state versus mirrors in tilting state. In the approximate “blazed” grating condition (on right), most of the diffracted radiation is concentrated in the 1st order that reflects nearly along the incident path.

approximate “blazed” grating condition, most of the diffracted radiation is concentrated in the 1st order which couples back nearly along the incident path into the collimator, while the others are dropped out with dramatic attenuation. The selected wavebands are amplified by the EDFA, leading, after several recirculations, to high-quality PM single-mode laser generation. Hence, the fiber laser can be tuned by simply driving the various pixels of the DMD.

### 3. Experimental results

A PM EDFA is a C-band amplifier with 20dB signal gain and the ASE noise is shown in Fig. 3. When the optical loop is open, an arbitrary wavelength selected by the MEMS processor is obtained by addressing the DMD. The total loss of the bulk optics part is around 11.6 dB by detecting the input and output ports of the collimator. It is mainly due to the lens reflection loss, the blazed grating loss, diffraction loss and insertion loss of the DMD.

When the optical loop is closed, the MEMS processor is driven by different addressing maps, each corresponding to a single-mode lasing at a specific wavelength. Figure 4(a) shows the measured output of the fiber laser, it illustrates an excellent tuning ability over the whole C-band through the generation of 6×768-pixels addressing map at different position on the DMD. The linewidth is 0.02nm compared to 0.5nm when the loop is open. The side-mode suppression ratio (SMSR) is greater than 50dB. The output power ripple is less than 0.6dB over the C-band. Figure 4(b) is the results of fine wavelength tuning with the tuning step 0.08nm.

Finally, the laser exhibits stable operation at room temperature when it is turned on for a long period. Figure 5 shows the measured laser wavelength fluctuation and power fluctuation are less than 0.01nm and 0.013dB respectively during a period of one hour observation. Besides, due to the whole PM fiber components used in the system, the output signals are insensitive to the environmental vibration. The laser is vertical linear polarization with polarization ratio more than 100:1.

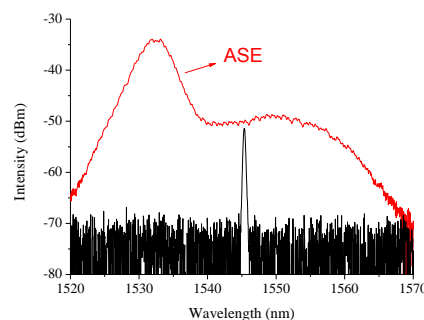


Fig. 3 The amplified spontaneous emission (ASE) noise from the EDFA and a wavelength selected by the MEMS processor.

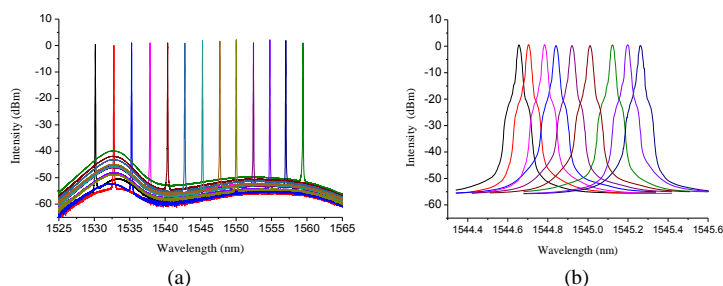


Fig. 4 Measured output intensities of the MEMS-based fiber laser (a) coarse wavelength tuning over C-band, and (b) fine wavelength tuning

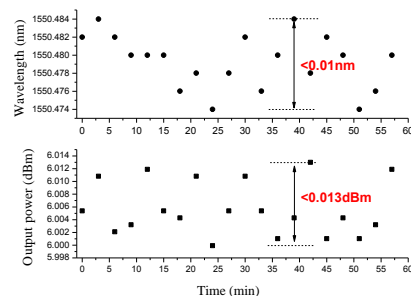


Fig. 5 Measured output wavelength fluctuation and power fluctuation for 1 hour

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