Tunable Erbium Doped Fiber Laser Using a Silicon Micro-Electro-Mechanical Fabry-Perot Cavity

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Abstract

We propose a novel tunable erbium doped fiber laser using a silicon micro-electro-mechanical (MEM) Fabry-Perot cavity. The cavity is made of two Bragg mirrors, one being actuated by comb drives. The MEM Fabry-Perot cavity and grooves for optical fibers are fabricated by DRIE on a 70 μm SOI wafer and integrated in a ring fiber laser configuration. The fiber laser has a tuning range of 7.7 nm in the C-band and a spectral width of 0.1 nm.

Keywords: Tunable fiber laser, Fabry-Perot cavity, silicon Bragg reflector.

1 INTRODUCTION

Tunable silicon optical filters using deformable Bragg gratings or tunable Fabry-Perot (FP) cavities were recently proposed [1] and demonstrated [2-4]. These tunable filters can be used for a variety of applications such as optical filtering in telecommunications, biochemical sensing and tunable lasers.

With the development of dense wavelength division multiplexing (DWDM) networks, numerous laser sources emitting at different wavelength are needed. The multiplication of laser sources has a large cost impact on DWDM networks. In this paper, we propose a micro-electro-mechanical system (MEMS) tunable erbium doped fiber laser, which could potentially replace several lasers at a reasonable cost. As the gain of erbium spans over a large wavelength range centered at 1550 nm, our device enables tuning over the whole C band [5]. Tunable fiber lasers using intracavity fiber Fabry-Perot filters have been previously reported [6]. In this paper, we report a novel tunable erbium doped fiber laser using an integrated silicon MEM Fabry-Perot cavity.

2 SILICON FABRY-PEROT CAVITY

The mirrors of the FP cavity are made of two silicon Bragg reflectors. One of these mirrors is fixed while the other one can be displaced by a comb drive actuator. Figure 1 shows the fabricated FP filter. When a voltage is applied, the combs get closer and thus the air gap of the FP cavity is tuned. Figure 2 is the simulated displacement of the comb versus voltage. When the combs come closer, the air gap of the FP is decreased. A smaller gap means a shorter filtered wavelength by the FP [4].

The MEM tunable FP cavity is fabricated by deep reactive ion etching (DRIE) on a silicon on insulator (SOI) wafer. A 70 μm thick silicon device layer is used in order to allow optical fiber integration in grooves etched during the same process step as the tunable FP cavity and the comb drives. The structure is released in liquid HF followed by supercritical CO_2 drying to prevent sticking of the devices. Such a FP filter was previously demonstrated with 20 nm wavelength tuning range [4].

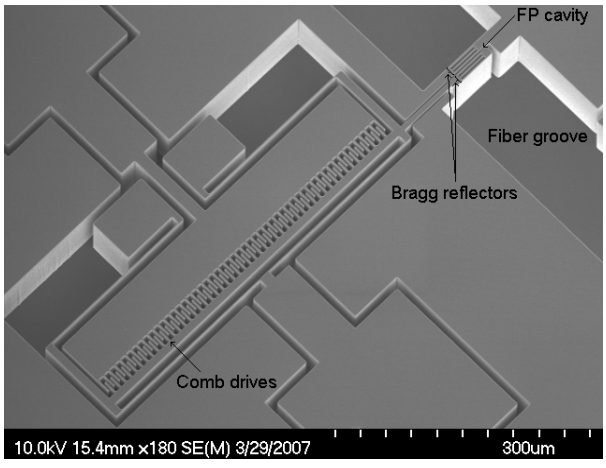

Figure 1. SEM photograph of the silicon microfabricated tunable Fabry-Perot device.

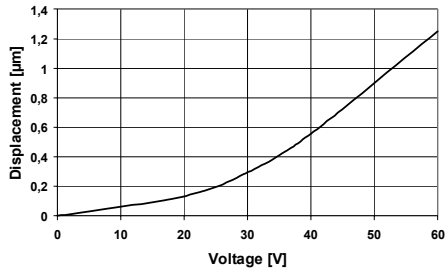

Figure 2. Simulation results of the comb drive displacement versus applied voltage.

3 TUNABLE FIBER LASER

The setup of the ring laser is shown in Fig. 3. The erbium doped fiber is pumped with a 1480 nm laser diode through a 1480nm/1550nm WDM coupler. We use an isolator to insure one way lasing direction. The MEM FP is positioned within the ring cavity to select the lasing wavelength. We use a 1 % tap as an output coupler to minimize losses in the cavity. Alignment of the optical fibers with the MEM FP is critical. The doped fiber and the output fiber are passively aligned by the silicon fiber grooves on each side of the tunable filter.
The transmission peak of the FP shifts to shorter wavelength, while increasing the applied voltage to the comb drive as shown in Figure 4. The largest tuning of the FP is reached at a voltage of 14.6 V. We measured 7.7 nm tuning range of the fiber laser from 1563.5 nm to 1555.8 nm with increasing voltage applied to the comb drive (Fig. 5). The spectral width of the fiber laser is approximately 0.1 nm (FWHM).

4 CONCLUSION

A MEMS tunable erbium doped fiber laser has been demonstrated for the first time to our knowledge. The fiber laser has a tuning range of 7.7 nm and a spectral width of 0.1 nm.

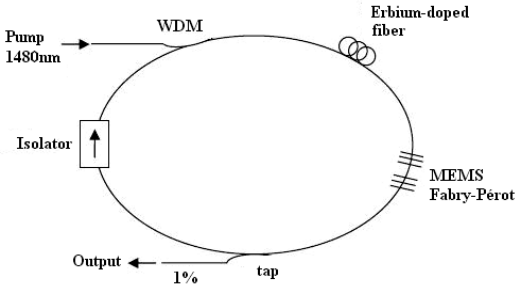

Figure 3. Optical setup of the ring fiber laser.

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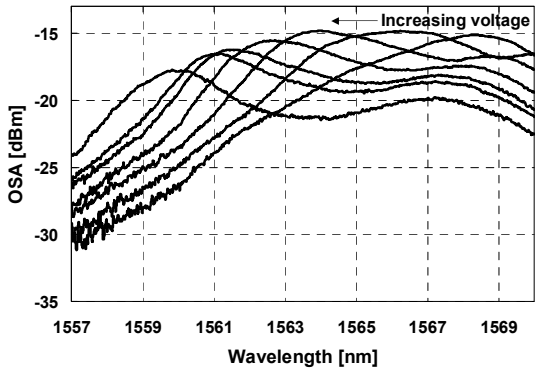

Figure 4. Transmission spectra of the tuned FP.

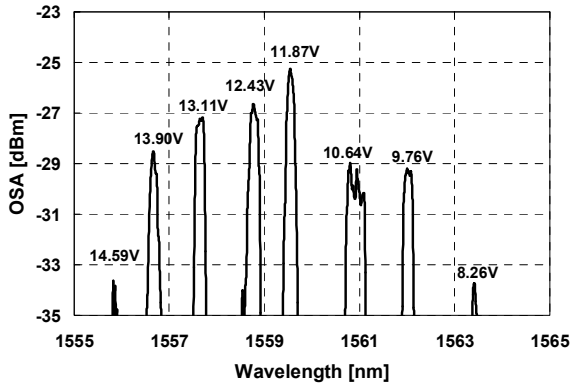

Figure 5. Measured fiber laser spectra at different voltages applied to comb drive of the Fabry-Perot cavity.

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