TRANSIENT RESPONSE OF WAVELENGTH-SWITCHABLE ERBIUM-DOPED FIBER LASERS WITH LINEAR COUPLED CAVITIES

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ABSTRACT: *The transient characteristics of an erbium-doped fiber (EDF) laser, which can switch between wavelengths, are investigated. The laser has a set of coupled linear cavities. The slow gain dynamics of EDFs and the cross-gain saturation in the coupled cavities give rise to delayed switching responses and relaxation oscillations, which are respectively measured to be 1 ms and 3.5 ms for the worst case, and which may be decreased by increasing the pump power. Thus, the switching speed of the laser may be higher than 100 Hz.* Microwave Opt Technol Lett 35: 330–333, 2002; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.10598

Key words: *Erbium-doped fiber; fiber lasers; switching; relaxation oscillation*

1. INTRODUCTION

Multiwavelength fiber lasers are very important light sources for WDM fiber communication systems, fiber sensors and spectroscopy. Significant progress has been made in improving the schemes and performance of the multiwavelength lasers based on erbium-doped fibers (EDFs) during the past few years [1–9]. However, tuning and switching the lasing lines still present great challenges. Recently we proposed and demonstrated a multiwavelength erbium-doped fiber laser with coupled linear cavities formed by cascaded fiber Bragg gratings (FBGs) [9]. For this kind

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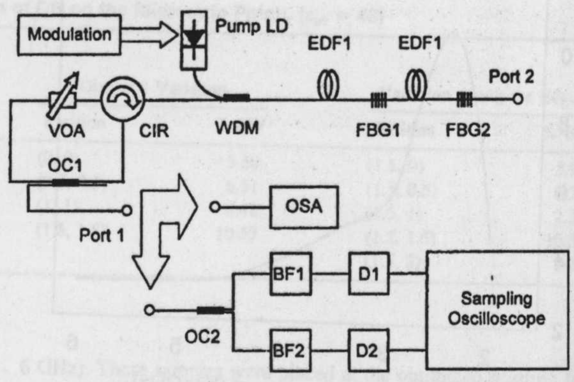

Figure 1 Experimental setup. OC: 3-dB optical coupler; VOA: variable optical attenuator; FBG: fiber Bragg grating; WDM: wavelength division multiplexing coupler; EDF: erbium-doped fiber; CIR: optical circulator; OSA: optical spectrum analyzer; BF: band-pass filter; D: photo-detector

of coupled cavity laser, when any one potential lasing wavelength is emitted, the round-trip gain is clamped at the round-trip loss of the corresponding cavity for that lasing wavelength. Meanwhile, because all potential lasing lines share all sections of the EDFs, which have homogeneous broadening properties [10], the cross-gain saturations cause the lasing wavelengths to suppress each other, giving rise to the wavelength competition effects. When the cavity losses and EDF lengths are suitably chosen, the strengths of the gain clamping effects and the wavelength competition effects depend only on the pump conditions. Thus, the laser may be made to lase an individual potential line by suitably adjusting the pump input alone; this means the laser can operate in multiwavelength switching mode.

In this letter, we report on the measurement of the transient characteristics of such a fiber laser with coupled linear cavities, which was designed to switch between two potential lasing wavelengths. A delayed switching phenomenon was observed in our experiments. In addition, during the switching operations the two wavelengths experienced initial power excursions and relaxation oscillations before steady states were re-established. In the worst case the delayed response was about 1 ms and the relaxation oscillations could be damped within 3.5 ms. This indicates that the wavelength switching speed could be higher than 100 Hz.

2. EXPERIMENTS

The experimental setup [9] is shown schematically in Figure 1. Two separate ports of an optical circulator were joined together to form a feedback loop, which functioned as a broadband reflector. This broadband reflector and the FBG 1,2 formed overlapping Fabry-Perot (FP) cavities for lasing wavelengths λ_1, λ_2, respectively. A variable optical attenuator (VOA) was inserted into the feedback loop, thus the reflectivity of the optical circulator reflector could be finely adjusted by changing the loss of the VOA, which could help vary the cavity loss so as to optimize the shape of the gain spectrum of the cavities [7]. The EDFs had an absorption of 5.2 dB/m at 1531 nm and were pumped with a 1480 nm LD through a WDM coupler. Port 1 from a 3-dB optical fiber coupler (OC1) in the feedback loop and port 2 beyond FBG2 were used for the laser outputs. The laser output was measured with an optical spectrum analyzer. A function generator was used to supply the modulation currents to the pump LD to investigate the transient responses of the wavelength switching operations. Another 3-dB optical fiber coupler (OC2) was placed in the output of the laser