Abstract: A novel tunable fibre laser (TFL) operating in the ordinary band (O-band) of 1310 nm is proposed and demonstrated. The proposed TFL is developed using a 1×16 arrayed waveguide grating (AWG) as a slicing mechanism for the broadband amplified spontaneous emission (ASE) source and an optical channel selector (OCS) to provide the tunability. A semiconductor optical amplifier (SOA) with a centre wavelength of 1310 nm serves as the compact gain medium for the TFL and also as a broadband ASE source. The TFL has a tuning range of 1301.26 nm to 1311.18 nm with 9.92 nm span and a channel spacing of 0.7 nm. The measured output power is about –4 and –8 dBm and with a side node suppression ratio (SMSR) of 29 to 33 dB.

Novel O-band tunable fiber laser using an array waveguide grating

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1. Introduction

Course wavelength division multiplexing (CWDM) systems in passive optical networks (PONs) gives network providers a very cost-effective method to deploy wavelength division multiplexing (WDM) together with time-division multiplexing (TDM) technologies for access networks [1]. Although implementing CWDM in PON systems saves significant cost in terms of the transmission lines and other in-line components, the system still suffers a drawback from the extensive use of laser diodes required as signal sources for transmission. As a result of this, the cost-effectiveness of the CWDM system is negated by the need to deploy many cooled laser diode, which is especially not-effective in low-density bit data transfers.

A viable alternative to the use of both cooled and uncooled laser diodes is the use of fiber laser sources. Fiber lasers have very good potential to act as transmission sources for application in optical CWDM network systems due to their ability to select a single channel from a multiwavelength comb [2]. This makes the fiber laser a very versatile component which provides a high degree of flexibility to the CWDM system, whereby the fiber lasers can be manufactured from the same template en-mass and then tuned to the required frequency (as opposed to laser diodes which must be manufactured to the desired frequency). This provides significant cost savings using existing ex-stock components, which are readily available to the system.

Furthermore, fiber lasers have many advantages over conventional laser diodes such as lower noise output, higher power output and high side mode suppression ra-
tion (SMSR). In this regard, significant research has been put forward in the development of fiber laser sources [3–8], but currently most of the research work has focused on the 1550 nm telecommunications region.

In this paper, we propose a novel design for a tunable fiber laser (TFL) in the O-band (1310 nm) region that has multiple applications in access networks as well as in sensor applications. The proposed TFL uses a 1×16 arrayed waveguide grating (AWG) and an optical channel selector (OCS) to provide the tunability and a semiconductor optical amplifier (SOA) with a centre wavelength of 1310 nm as a compact gain medium for the TFL. The TFL has a tuning range of 1301.26 nm to 1311.18 nm with 9.92 nm spans and channel spacing of 0.7 nm.

2. Experimental setup

The proposed experiment setup is illustrated as shown in Fig. 1. The proposed O-band ring fiber laser setup consists of SOA acting as both the gain medium and also as an amplified spontaneous emission (ASE) source. The SOA is driven by a current of 300 mA at a temperature of 27°C to provide a wideband ASE spectrum from 1270 nm to 1355 nm. A 1×16 AWG with a wide band free propagation zone (FSZ) is used as a slicing mechanism and is able to generate up to 16 channels with 100 GHz spacing. To provide tunability switching a 2×16 OCS is also used in this setup. The 16 channels of the OCS are connected to the 16 output channels of the AWG, where channel 1 of the AWG is connected to the channel 1 of OCS and similarly until channel 16. The OCS (model Ando AQ3540) is a 2×16 motor driven optical switch with a maximum switching time of 500 ms between each channel that is currently available in the laboratory. Furthermore, the chosen OCS has a wavelength range of 1200 nm to 1650 nm (giving it a bandwidth of 450 nm), making it suitable for use as the bandwidth coincides with that of the AWG used falls well within the bandwidth of the OCS. An optical isolator is also used in the setup to ensure unidirectional travel of the lasing signal. The output spectrum is analyzed using a 3 dB fused optical coupler is connected to the output of OCS and tapped to an optical spectrum analyzer (OSA) (model Yokogawa AQ6370B) with 0.05 nm resolution for optical spectrum analysis. Most of these components are commercially available. The components and equipment are connected using single mode fiber (SMF-28).

3. Result and discussion

The tunability performance is shown in Fig. 2. As shown in the figure the tuning range is approximately 9.92 nm and ranges from Channel 1 at 1301.26 nm to Channel 16 at 1311.18 nm. The wavelength spacing between each channel is approximately 0.7 nm. This spacing can be tuned by selecting different channels on the AWG, which can provide a tuning range of a maximum of 9.92 nm as seen earlier. This variable spacing can be very useful in optical networks that utilize the 1310 nm band of the access network. The measured linewidth is approximately 0.1 nm for channels 1 to 8 but increases to a slightly wider linewidth of 0.3 nm at channel from channel 9 to 16. This could be attributed to the AWG that was used as it was optimized for signals in the 1550 nm region.

Fig. 3 shows the wavelength tunability for all channels from 1301.26 nm to 1311.18 nm, while Fig. 4 shows the stability of channel 15 at a selected wavelength of 1310.46 nm at 5 minute intervals for a period of an hour. As can be seen in Fig. 3, the different AWG channels all generate wavelengths with a uniform power. An exception to this is Channel 14, which is observed to have a slightly

![Figure 1](image1.png) Experimental setup of the proposed scheme for multiple and tunability of 1310 nm (O-band). AWG – array waveguide grating, OCS – optical channel selector, SOA – semiconductor optical amplifier, OSA – optical spectrum analyzer

![Figure 2](image2.png) (online color at www.lphys.org) The tunability of O-band fiber laser using an AWG
lower output, although this can be attributed to possible connector losses and also the optical path loss in the AWG for that particular channel.

Fig. 4 shows that the laser is highly stable and do not experience any observable power fluctuations during the entire period of testing; this thus demonstrates the stability of the system developed and also proves that it can be used as a multiple wavelength source for 1310 nm access networks. This is a beneficial characteristic of the laser, as it provides the same stability as the expensive cooled laser diodes while at the same time retaining a lower cost. Furthermore, the ability of the laser to be tuned makes it a multiple wavelength source with much potential application, especially as transmission sources for Fibre-to-the-Home networks.

Fig. 5 shows the performance of side mode suppression ratio (SMSR) and peak power for all wavelength channels. As can be seen in the figure, the SMSR is relatively flat with only minimal fluctuations of approximately 4 dB. The lowest SMSR observed is 29 dB at 1306 nm whilst the highest SMSR was 33 dB at 1303.33 nm. This is an important characteristic of the fibre laser as it indicates that the TFL has good stability. The peak power for every channel is also show in Fig. 5, and it is observed that the peak power has minor fluctuations of approximately 4 dB its output power varies from –4 dBm to –8 dBm. By fine tuning and optimizing the setup, these fluctuations can be further reduced.

From the above, we have demonstrated a very important and novel technique in producing a multiple wavelength output at the O-band region, which is currently very important with the implementation of Fibre-to-the-Home systems. This multiple wavelength laser can be integrated with different equipments which can be multiplexed and propagated in a single mode fiber. This will serve to reduce the usage of fibres and also become a platform for DWDM networks at the access point.

4. Conclusion

In this paper a novel TFL system operating in the O-band (1310 nm) region is demonstrated. The proposed TFL uses a 1 × 16 AWG and an OCS to achieve tunability as well as a SOA with a centre wavelength of 1310 nm as a compact gain medium for the TFL. The TFL has a tuning range of 1301.26 nm to 1311.18 nm with 9.92 nm spans and channel spacing of 0.7 nm. Furthermore, the TFL has an output power between –4 and –8 dBm and an SMSR between 29
and 33 dB. This variation can be further reduced by fine tuning some of the optical components.

References