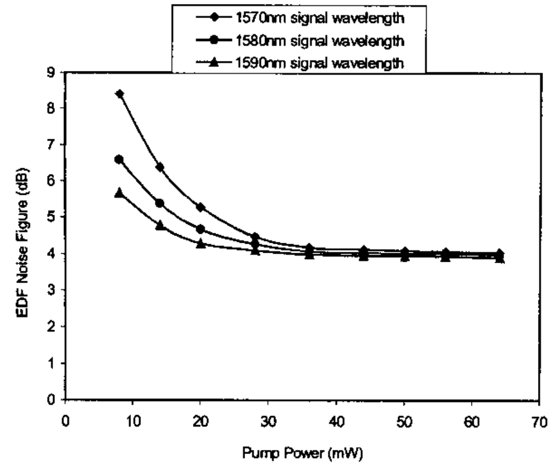

ThGG15 Fig. 5. Noise Performance of Dual-core L-Band EDFA.

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ThGG16 **5:30 pm**

An Insertion Loss Insensitive and Mean Wavelength Stable Polarized Superfluorescent Fiber Source

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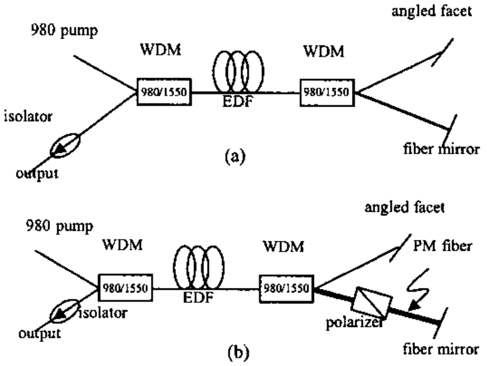
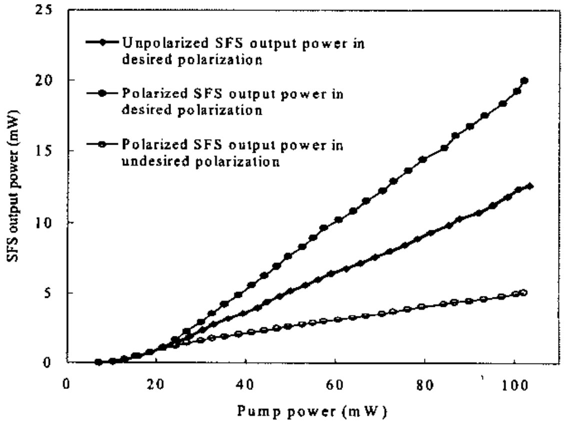
A mean wavelength stable and broadband light source is desirable for the characterization of WDM components and also essential to the stringent requirements of a fiber optic gyroscope (FOG) for the reduction of noises and bias errors. Recently, superfluorescent fiber sources (SFSs) become popular as broadband light sources for such applications due to their little sensitivity to environment factors (e.g., temperature) and better spectral quality. Four common basic configurations of SFSs have been studied: single-pass forward (SPF), single-pass backward (SPB), double-pass forward (DPF), and double-pass backward (DPB) configurations.[1–5] When a standard unpolarized SFS is used as the source for polarization sensitive applications, half of its power is lost, for example, to the polarizer at the input of the sensing coil in an FOG. If the light produced by the SFS is polarized instead, the loss would be eliminated. In this work, we propose a novel linearly polarized SFS based on DPB configuration. Compared with the conventional unpolarized SFS, its output power in the desired polarization is increased to nearly 1.7 times by inserting a polarizer between the rear WDM and the fiber mirror. Moreover, accompanying advantage such as insensitivity to the polarizer insertion loss and wide operational range of wavelength stability shall be demonstrated.

A conventional unpolarized DPB SFS is shown in Fig. 1(a). To obtain a polarized output, the simplest way is to insert a polarizer at the output end. However, half of the power will be strongly attenuated in this situation. For the sake of conserving the output power, we propose a new setup as shown in Fig. 1(b). A polarizer is inserted between the rear WDM coupler and the fiber mirror instead of placing it at the output end. A few advantages resulted from this change can thus be obtained.

Fig. 2 shows the dependence of output power on pump power for polarized and conventional unpolarized DPB SFSs. In the conventional unpolarized case, a polarizer is placed at the output



ThGG16 Fig. 1. Experiment setup for (a) conventional unpolarized DPB SFS configuration, (b) our polarized DPB SFS configuration.



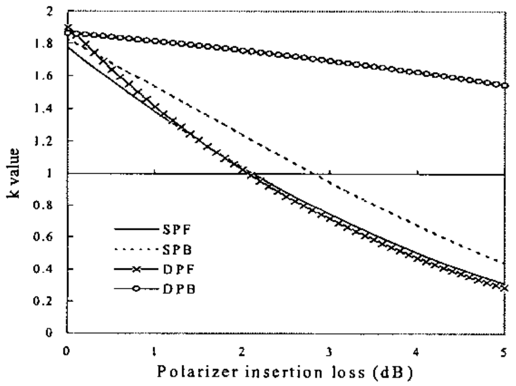
ThGG16 Fig. 2. Dependence of output power on pump power for polarized and unpolarized DPB SFS.

end and the optical power is measured in the desired and undesired polarization. Powers in both polarization are apparently equal. However, when we replace the polarizer at the output end with one placed between the rear WDM and the fiber mirror, the power in the desired polarization component is nearly 1.7 times higher than that in the unpolarized one. Although half of the forward power is filtered out after the polarizer, the final polarized output power is still much larger than the conventional case. This is because only the desired polarization component travels in the backward direction and thus the gain competition does not exist. Therefore, the desired polarization component will not share gain with the undesired one. Theoretically, the output power should be twice as much as the conventional unpolarized case. It is expected a higher value can be achieved if the losses due to fiber mirror and WDM couplers can be further reduced.

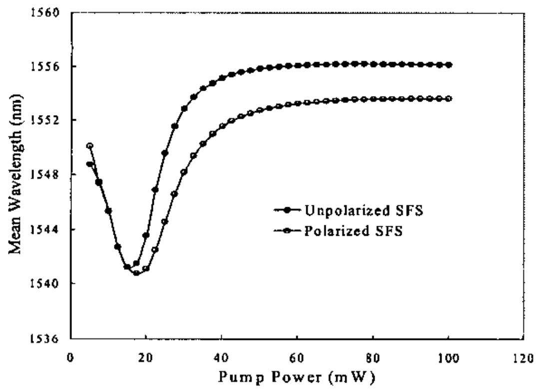
The parameter *k* is found to depend weakly on the position and extinction ratio of the polarizer but fairly sensitive to its insertion loss. For comparison, Fig. 3 shows the results of all the four configurations. The polarizer with a fixed extinction ratio of 20 dB is optimally positioned to obtain its best *k* in each configuration. For all the configurations, *k* decreases monotonically with the insertion loss of polarizer. Except for the DPB configuration, the other three configurations must keep the loss below ~0.5 dB to maximize *k*. This is because the total output power decreases quite slowly with the effective reflectance (fiber mirror plus polarizer insertion loss). The measured slope is about –0.05/dB, comparable with the simulation result.

Fig. 4 shows the measured pump power dependence of mean wavelength stability. We have simulated the stability of different EDF lengths, and found that a length of 11 m could give the best stability above a certain pump level. So we choose a 11-m EDF in our experiment. It is shown that both the polarized and unpolarized configurations do have a zero slope over a large pump-power region, which demonstrates that the mean wavelength stable operation with respect to pump power is also possible for a polarized DPB SFS.

In conclusion, we have developed a linear polarized SFS in DPB configuration by inserting a polarizer between the rear WDM and the fiber mirror. Compared with the conventional unpolarized SFS, the current polarized SFS can provide nearly 1.7 times power when pumped at the same level. In addition, our polarized DPB SFS shows less sensitivity to the insertion loss and conserves the mean wavelength stability over a large pump power region as the conventional DPB SFS.



ThGG16 Fig. 3. Dependence of *k* on polarizer insertion loss for each SFS configuration in its optimum condition.



ThGG16 Fig. 4. Dependence of mean wavelength on pump power for polarized and unpolarized DPB SFS.

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ThGG17 **5:30 pm**

Time-Domain Characterization of Transient Effects and Double Rayleigh Backscattering Noise in Raman Amplifiers

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1. Introduction

The use of Raman optical amplifiers (ROAs) in optical communication systems has become increasingly important. In distributed operation, Raman amplifiers can improve the optical signal to noise ratio (OSNR) by about 5 dB due to their low equivalent noise figure. The low noise nature of ROAs can be used to increase system reach or to reduce inter- and intra-channel nonlinear impairments. Further advantages of using ROAs include the ability to operate in various amplification bands and simplicity of construction. As high power pumps become available, Raman amplification becomes practical and favorable for long-haul and high bit-rate systems. A great amount of research effort has been directed to the study of ROAs.[1-3]

There are several effects limiting the usefulness of the Raman amplifiers. These effects include gain transient effects,[4] double Rayleigh backscattering (DRBS)/multiple path interference (MPI) noise,[5] intensity noise induced by pump fluctuation,[6] gain spectral dependence on signal loading and pump power,[1] crosstalk among carrier signals, etc. We will focus on Raman transient effects and double Rayleigh backscattering noise because they impose significant limitations on ROA application.

2. Time-Domain technique

Both transient effects and double Rayleigh backscattering noise can be modeled by a set of time-dependent partial differential equations that include bidirectional pump-signal interactions through stimulated Raman scattering and Rayleigh scattering. The equations are written as follows:[4]