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Broadband EDFA Used for the Experimental Study of Sensing

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***Abstract*— In this paper, We make a in-depth analysis of the influence of pump power coupling, erbium-doped and fiber length of EDFA. Design of a broadband erbium-doped fiber amplifier use in fiber optic sensing system. Further verified by experiments, and optimized the design. Utilizing the engineering design condition, Experimental study of a cascade of multi-link EDFA. This design has been successfully used in engineering practice.**

Keywords—Erbium-doped Fiber, Erbium-doped Fiber amplifier, Gain flattening, Multi-link

I. Introduction

With the rapid development of optical communication technology, erbium-doped fiber amplifier (EDFA) has been widely used in various fields. In numerous optical fiber sensing and optical fiber detection system, as a result of the fiber loss limit the fiber WuZhongJi transmission distance, in long distance transmission need to use erbium-doped fiber amplifier (EDFA) to amplify the signal relay and EDFA gain spectrum of the flatness and makes the signal after a certain distance of transmission signal strength imbalances and ber increases, caused the fall of transmission quality. How to obtain EDFA with high gain, high flatness and low noise coefficient has become a widely concerned issue [1-4]. In the multi-point fiber Bragg grating sensing system, the bandwidth energy is needed to cover the high-power broadband light source with the reflected wavelength of each fiber Bragg grating. As the number of measurement points increases, the bandwidth and power of the light source are also increasing. The erbium-doped fiber amplification spontaneous emission characteristic is utilized to obtain a super-fluorescent light source covering a bandwidth range from 1520nm to 1620nm and nearly 100nm, which can be applied to multi-point distributed fiber Bragg grating sensing system. Therefore, it is necessary for us to make an in-depth study of it. In this paper, a wideband erbium-doped fiber amplifier based on fiber grating sensing system is designed.

II. Operating Principle

Erbium atoms are doped into the glass of the optical fiber core. The light emitted by the external light source passes through the optical fiber and stimulates the erbium atoms to jump to the energy level that can emit light at the wavelength of 1530-1625nm through stimulated radiation. EDFA does not generate signals, but amplifies weak signals from its input end. Such amplification requires energy from a 980nm or 1480nm pumped laser. In a sense, fiber amplifier transfers energy from the pump light to the amplified signal light.

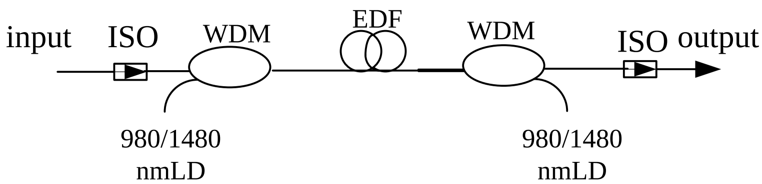

Figure 1.General erbium-doped fiber amplifier structure

A typical fiber amplifier consists of doped fibers placed between two polarization-independent optical isolators. As shown in figure 1, pump light input is achieved by configuring forward, backward, or bidirectional pumping through wavelength selective coupling. The pumped absorption along the length of the amplifier produces an inversion of the number of particles along the length of the fiber. For unidirectional pumps, the particle number reversal in the optical fiber terminal of the pumped laser reverse is the minimum, or in the case of the same pumping power, the particle number reversal in the middle length of the bidirectional pump is the minimum.

III. The Experimental Device

Based on FBG sensor sensing process is through the outside of the Bragg wavelength modulation to obtain information of a wavelength modulated optical fiber sensor is compared with other types of sensors, because of the strong electromagnetic interference resistance, anti-corrosion, sensing probe, simple structure, good repeatability, easy to form the advantages of all kinds of optical fiber sensing network, especially in some special or some power, Bridges and aerospace and other complex applications, is becoming a hot spot of research [1, 2]. In the petroleum industry, the application of fiber Bragg grating sensor detection system for long-distance oil and gas pipeline monitoring has become an important research topic..

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The structure of the light source designed in the experiment is shown in figure 1. The devices used include 980nmLD laser diode, 980/1550nm wavelength division multiplexer (WDM), insertion loss of 0.16db, 1550nm isolation of 26.8db, optical isolator (ISO), and erbium doped fiber (EDF) with the absorption coefficient of 9-11db /m at 1530. AQ6319 spectrum analyzer of ANDO company was used for analysis with a resolution of 0.01nm and a measurement range of 700nm to 1900nm. PMS-12 optical power meter, its measurement range is 0.1-100, the measurement accuracy is 0.01dBm. In the experiment, optical fiber fusion connection was used to minimize the connection loss of the port, and the connection loss was controlled between 0.00dBm and 0.01 dBm, so as to improve the utilization efficiency of the pumping source in the light source.

The experimental device is shown in FIG. 2. The basic principle of optical fiber light source of this structure is as follows: under the action of 980nm laser diode pumped by some optical fibers, particles undergo energy level transition and form particle number inversion. However, the particle is unstable in the high energy level, and soon returns to the low energy level and radiates light energy. As the propagation distance of light wave in EDF medium increases, the optical signal is amplified as a result.

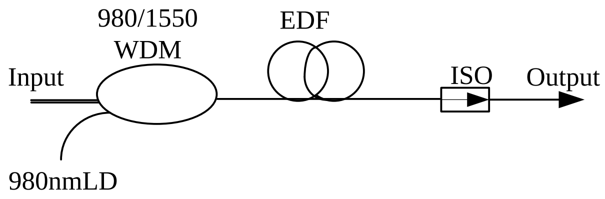


Figure 2.Erbium-doped fiber amplifier structure

On a single EDFA optimization performance and stable test conditions, we have multiple EDFA cascade experiment was carried out and the experimental device is shown in figure 3, we conducted among six EDFA experiment, by increasing the number of cascaded EDFA, in order to reduce the coupling loss as far as possible, we use when connect EDFA with APC joint tail fiber jumpers, measured spectrum is shown in figure 6.

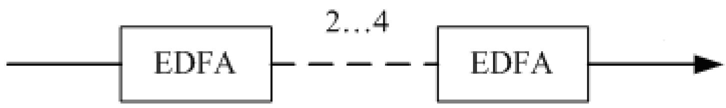


Figure 3.Multiple EDFA cascades

IV. Results And Data Analysis

Experiment, the pumping light source adopts the center wavelength of 979.04 nm to 980 nm LD, the threshold current for 30 mA, LD tail fiber optical power output along with the change of the pumping current relationship as shown in figure 4, when the drive current greater than 30 mA, began to have a power output, and with the increase of drive current, LD basic linear output power increases, when up to 200 mA gradually become saturated. In order to protect a diode, only 200 mA was measured in the experiment, but it was enough to show the power characteristics and optimal working area of the laser diode.

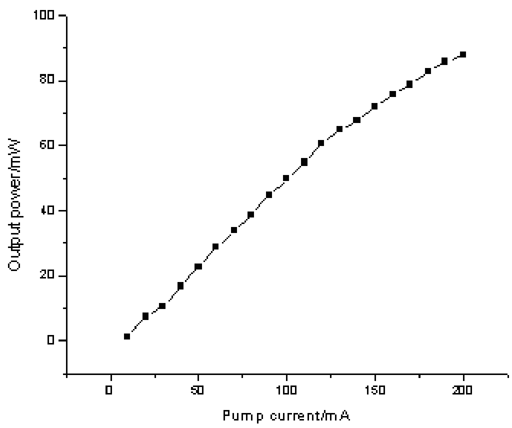


Figure 4.The relationship between output power and pump current

When the pumping power is 74mW, a relatively ideal high flatness output is obtained, and the spectrum is shown in figure 5. At this time, due to the low pump current, at 1530nm, erbium ion absorption pump light is relatively weak, which makes the output flatness of the entire spectrum higher. However, due to the limitation of the pump current, the total output power is very small, which is only 0.758mw (-1.2dbm) measured. If the pumping power continues to increase, the spectral shape will shift upward as a whole and the output power will increase significantly. However, due to the large absorption coefficient at 1530nm, the wave peak and its vicinity will increase by several degrees relatively quickly, thus weakening the flatness of the spectrum.

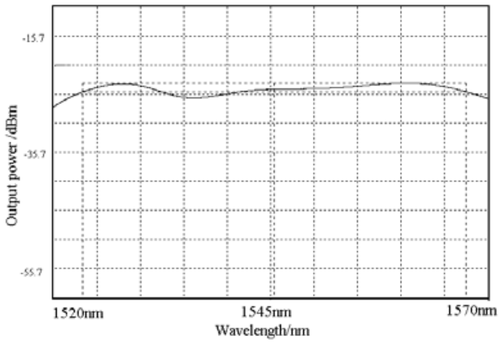
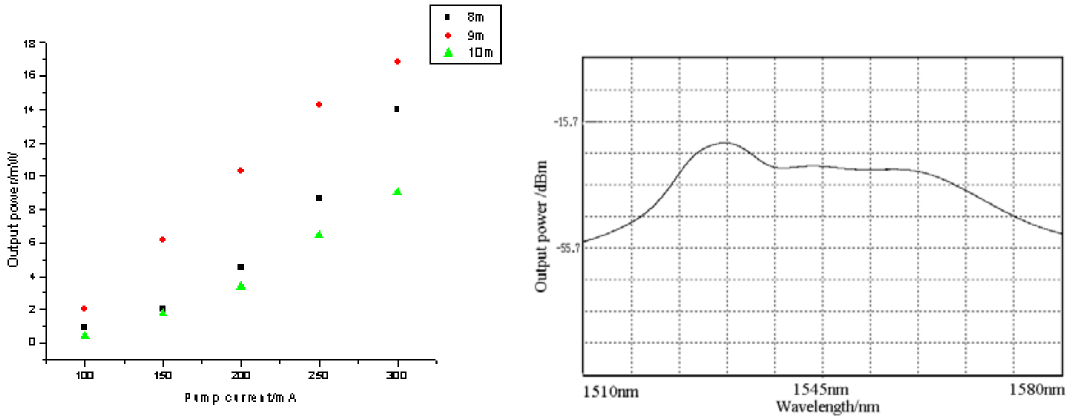


Figure 5.The high flat gain line obtained by experiment



a) Comparison diagram of output power of different erbium fiber lengths

b) Single-stage erbium-doped fiber amplifier output gain spectrum line

Figure 6. Single-stage erbium-doped fiber amplifier

According to the analysis in FIG. 6a, when erbium fiber of any length is connected, the output light power increases with the increase of pump current, but in comparison, when erbium fiber is 9m connected into the erbium-doped fiber amplifier structure, the output power is larger than 8m and 10m. Therefore, the optimal erbium fiber length obtained through experiments is 9m, which can be selected for the structural design of erbium-doped fiber amplifier to achieve high output power. FIG. 6a shows the output spectrum when the pump current is 200mA, and the erbium fiber length is 8m, 9m and 10m, respectively. According to the spectroscopic analysis, when the erbium fiber is 9m, the central wavelength of the output spectrum is 1550.3750nm, and the higher power is 15.8mW.

According to the structure designed in figure 3, multi-level cascade experiments were carried out for EDFA. First we measured level of EDFA spectrum diagram as shown in figure 7 in 1 line, its spectral shape with our previous experiment agree the gain spectrum form shown in figure 6 b (200 ma) pump power, increase to level two after get the gain spectrum of xing as shown in 2 lines, compared with the spectral line 1, it can be seen that with the increase of pump power and the degree of erbium long, makes the C band gain spectrum integral to the l-band drift. At 1550nm, with the continuous accumulation of gain, the gain spectrum line is lifted as a whole. With the continuous increase of cascade number, it can be seen from the gradual changes of spectral lines 3, 4, 5 and 6 that the gain spectral line at 1530nm of band C gradually weakens, and the gain at 1550nm becomes larger and larger, forming an absorption peak, and the overall spectral line constantly drifts to l-band direction.

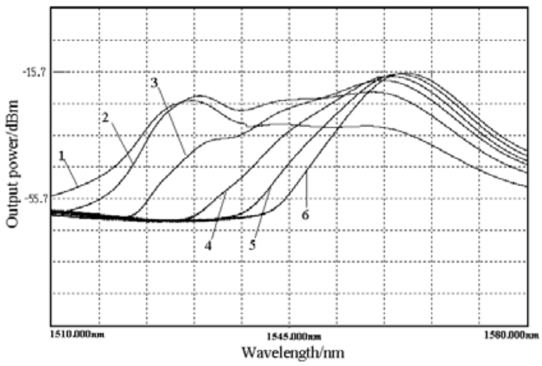


Figure 7. Multistage EDFA cascade gain line

V. SUMMARY

Through experiments, we have carried out in-depth analysis on pump power, coupling mode and length of erbium-doped fiber, and designed and manufactured a broadband erbium-doped fiber amplifier for fiber grating sensing system. Through optimization, a wide-band erbium-doped fiber amplifier for long-distance oil and gas pipeline detection and sensing system was obtained without any filtering or gain flattening measures, with the output spectrum width of 40nm (1525nm-1565nm), gain flatness < 0.3db and maximum output power of 15.8mw. Through the experimental study and analysis of multi-level cascade, the relationship between the gain spectrum line and the number of cascades is obtained. This has the important instruction function to the engineering practice application.

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