CHAPTER 5
CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions

An EYDF with Yb$^{3+}$/Er$^{3+}$ concentration ratio of 30:1 has been investigated. From the EYDF absorption measurement, it is shown that the absorption band of Yb$^{3+}$ effectively extends over a broad range from 800nm to 1100nm in EYDF. In view of the EDF absorption, the absorption band of Er$^{3+}$ ion is a rather narrow in the region near 980nm only. It has been shown that an additional advantage and superiority of EYDF is the possibility of deploying high-power 805-860nm laser diode arrays for pumping. The EYDF absorption coefficients at 813nm and 980nm found from the experiment are 3.4dB/m and 31.9dB/m respectively.

The choice of pump wavelength is of importance in order to avoid the Yb$^{3+}$ emission in the Yb$^{3+}$ band. This Yb$^{3+}$ emission will degrade the EYDFA amplification in the 1.5μm region because the pump energy is not used for Er$^{3+}$ stimulated emission but instead decayed to the Yb$^{3+}$ emission band. A 910nm pump, which causes a large fluorescence emission in the 975nm region, is of interest to use as a pump source for amplifiers such as EDFA. From the experiment, it is shown that pump wavelength near 975nm will cause unsaturable population inversion and a large portion of the pump energy will be wasted on that account. Besides, it is also found that the Yb$^{3+}$ emission band shifts to shorter wavelengths with decreasing the fiber length.
The EYDFA system is also studied in the 800nm band to determine its optimum pump wavelength. It is demonstrated that the 810-816nm region achieves a high gain of \( \sim 20 \text{dB} \) because of the higher GSA and less possibility of detrimental ESA.

From the experiment, the 813nm counter-pumped EYDFA with an input pump power of 240mW enables a gain of \( \sim 21 \text{dB} \) to be obtained and a low noise figure of \( \sim 3.6 \text{dB} \) at 1550nm while the peak gain of 38.4dB is achieved at 1535nm. From the amplifier, two main phenomena are observed for increasing the input signal power: (i) the saturation of gain with the increase of output signal power and, (ii) the decrease of the ASE power spectrum. The effect of gain saturation by amplified signal can be alleviated by reducing the input signal power level. In addition, poor noise figure exceeding 8dB at large input signals in the amplification band is probably due to the effect of signal source spontaneous emission (SSE). One possible way to reduce the effect of SSE on the amplifier saturation is filtering the source.

In the gain saturation regime, the saturation output power of 9dBm and the maximum output power of 13dBm are achieved with a pump power of 200mW in a 3.1m long EYDF but the PCE and QCE obtained are rather low at \( \sim 9\% \) and \( \sim 17\% \) from the experiment. It is expected that higher saturation parameters can be achieved by optimizing the fiber parameters and the input pump power. Besides, it is demonstrated that an EYDFA with a backward pump has a better performance than the forward pumping owing to the effect of the backward and forward ASE in the fiber. However, the amplifier performance is almost the same for both pumping schemes when the amplifier is pumped with high input pump power.
In comparison with EYDFA, an EDFA tested in the experiment shows a lower gain in the 1.5μm region. This is due to the low Er$^{3+}$ absorption of the 800nm band without the presence of Yb$^{3+}$ and a short length of fiber is used at which the Er$^{3+}$ concentration is relatively low in the fiber.

In the study of the EYDFA between 813nm pump and 980nm pump, it is found that the 813nm-pumped EYDFA shows a better performance. In the Er$^{3+}$ system of an EYDFA, even though ESA is free at 980nm and the absorption of 980nm is an order magnitude higher than at 813nm, but from the experiment, it is found that the 980nm-pumped EYDFA experiences absorption instead of amplification. This is because the Yb$^{3+}$ ions at 980nm suffer nonsaturable population inversion in the Yb$^{3+}$ system.

Overall, the amplification characteristics of an EYDFA at 813nm and 980nm pump have been studied and comparisons have been made with an EDFA. In conclusion, EYDFA at 800nm band has potential to become a high gain optical amplifier.

5.2 Suggestions For Future Work

From the viewpoint of a possible optical amplifier optimization, promising results can be obtained by embracing new methods of gain control. Gain control mechanisms can reduce the amplifier dependence on the pump and the total input signal power levels. The gain control technique can be done by the use of a twin-core active fiber which can enhance the partial inhomogeneity of the amplifier’s transition line by periodically coupling signal and pump radiation between the two cores. The resulting spatial hole-burning
is much more effective in compensating gain variations than the spectral hole-burning observed in conventional amplifiers. Besides, double cladding codoped fiber also offers promising results for amplifier system since it expands the aperture of the pump light. Thus, the input pump energy is absorbed more effectively.

By optimizing the amplifier’s system design, fiber concentration and its design, the 800nm pump bands EYDFA is able to utilize highly nondiffraction limited AlGaAs diode laser arrays in a directly power scalable approach, and has potential as a low cost, high gain optical amplifier. Such a high gain optical amplifier is needed especially for CATV optical networks.