Chapter 6

Conclusions

We have investigated in this thesis three novel optical designs for all-optical gain-clamped EDFAs with the ring laser structure. The L-band EDFA gain linearization with a simplified ring laser structure (using a C/L-band WDM) is introduced in chaper 3. The serial broadband (1530-1600 nm) gain-stabilized EDFA is proposed and demonstrated in chapter 4. The novelty here is that the broadband gain linearization is achieved by applying the sole ring cavity. The novel technique for the suppressions of the relaxation oscillations and static power excursions is presented and studied in chapter 5. From these researches performed in this dissertation, some valuable features and contributions can be briefly summarized as follows.

(1) Two-stage L-band EDFA applying C/L-band wavelength division multiplexer with the counterpropagating partial gain-clamping

- The simplified ring laser configuration is formed by one C/L-band WDM instead with the coupler and the optical filter in a typical ring cavity.

- The low noise figures result from the gain-clamping in the second section of EDFA, and the two-stage configuration. The first-stage EDFA owned the gain-constant property, which arises from L-band weak gain saturation in the short EDF length. These designs restraining the decrease of population inversion in the front end of first stage lead to the reduction of noise figure degradation.

- The ring laser is excluded at the output end of EDFA since the counterpropagating optical feedback loop is used.

- The gain-clamping of L-band is demonstrated experimentally for the saturating tone (1587.6 nm) power up to -2 dBm.

(2) All-optical gain-clamped wideband serial EDFA with ring-shaped laser

- The simply ring laser configuration is used to perform wideband (1530-1600 nm) gain stabilizations of the serial EDFA. One FBG with the specific wavelength at the output end of EDFA is required to form an optical loop and obtain the same power dynamic range corresponding to C-band and L-band. The drawback of this way is to sacrifice the available power dynamic range. But in any event, to our knowledge, it is first successful demonstration on broadband gain-clamping by solely apply an optical feedback loop.

- The low noise figures result from the forward 980 nm pump and the copropagating ring-shaped schemes.

- The ring laser suffers hugely optical loss (>20 dB) due to the FBG so that the unnecessary laser power will not seriously affect the sequential EDFA performance.

- This design can simultaneously clamp the gains of 1547 and 1584 nm probes near 14 dB and shows the same dynamic range of input power up to -4 dBm for conventional band and long-wavelength band.

- The transient responses of 1551 and 1596 nm surviving channels exhibit small power excursions (< 0.54 dB) as the total saturating tone with -2 dBm is modulated on and off at 270 Hz.

(3) Suppression of relaxation oscillations and static power excursions in an optical gain-clamped EDFA using a control channel

- The extra control channel technique is used in an optical gain-clamped EDFA to suppress the relaxation oscillations and static power excursions. Through a control system consisting of the input channels power monitor, the simple circuit and a DFB laser diode, this error signal is used to compensated the optical loss due to the channel dropping. The experimental results show that the dynamic and static power excursions are mitigated even though this scheme only compensates for the part (22 channels) of 31 switched input signal channels.

- As the optical feedback laser is set at the wavelength of 1529 nm, the static power excursions corresponding to 1531.9 nm and 1548.5 nm surviving channels are suppressed from 0.77 dB and 0.7 dB to 0.35 dB and 0.3 dB respectively, in compared with the only optical feedback case. Furthermore, the frequency of relaxation oscillation is decreased to 45.4 kHz from 71.4 kHz.

- As the optical feedback laser is set at the wavelength of 1546 nm, the static power excursions corresponding to 1531.9 nm and 1548.5 nm surviving channels reduce to 0.28 dB and 0.18 dB from 0.41 dB and 0.34 dB respectively, in compared with the only optical feedback case. Meanwhile, the frequencies of relaxation oscillations corresponding to 1531.9 nm and 1548.5 nm surviving channels decrease to 26.3 kHz and 25 kHz from 50 kHz and 45.5 kHz respectively.