Chapter 5

Summary

5.1 Summary

First, we compare the noise properties of the harmonic mode-locked erbium-doped fiber laser (HML-EDFL) and gain-switched laser diode erbium-doped fiber laser (GSLD-EDFL), including SSB phase noise, timing jitter, SMN. In addition, we also compare the 3-dB detuning bandwidth of the HML-EDFL and GSLD-EDFL. The comparisons between HML- and GSLD-EDFL are demonstrated that the GSLD-EDFL exhibits better performances than HML-EDFL. The 3-dB detuning bandwidth of 17.78 kHz in GSLD-EDFL has 2.54 times larger than that of 7 kHz in HML-EDFL. Moreover, the high peak power of 40.7 mW and a smaller pulsewidth of 22 ps can be obtained in GSLD-EDFL. In GSLD-EDFL, the FPLD acts as a SMN suppressor due to its relatively fast carrier recovery rate (from 0.5 to 1 ns) and gain saturation effect. So the SMN is suppressed by the FPLD itself, and the SSB phase noise correlated the intensity noise can be effectively reduced. By this reason, the SSB phase noise and timing jitter of -121.2 dBc/Hz, and 0.25 ps in GSLD-EDFL are indeed lower than that of -114 dBc/Hz and 0.6 ps in HML-EDFL. Because the FPLD acts as a SMN suppressor, the SMN suppression of 91 dB in GSLD-EDFL is higher than that of 45 dB (RBW=VBW=1 Hz) in HML-EDFL. Furthermore, the side-mode in GSLD-EDFL can be entirely suppressed due to the effects of intra-cavity OBPF and injection-locking. Further, we add an intra-cavity SOA and OBPF to improve the SMN suppression ratio without sacrificing the SSB phase noise in HML-EDFL. We use an intra-cavity SOA and OBPF to improve the supermode noise suppression ratio without sacrificing the SSB phase noise of a

HML-EDFL. The inserted SOA greatly enhances the SMN suppression ratio from 32 dB to 76 dB (RBW=VBW=300 Hz) at a cost of larger SSB phase noise (degrading from -114 dBc/Hz to -96 dBc/Hz) and timing jitter (degrading from 0.6 ps to 1.4 ps). The SMN suppression ratio saturates at higher driving current of SOA, whereas the pulsewidth of the EDFL is significantly broadened from 36 ps to 61 ps. By driving the SOA at transparent condition and adding an OBPF, the SMN suppression ratio is up to 81 dB and the SSB phase noise further reduces to -110 dBc/Hz even. The EDFL pulsewidth and jitter can be reduced to 42 ps and 0.98 ps, respectively. The amplified pulse can be shortened to 3.1 ps with a time-bandwidth product of 0.63 after pulse compression with a DCF and SMF link. Theoretical and experimental results conclude that the optimized driving current of the SOA based high-pass filter for the EDFL is its transparent current, while the SSB phase noise can be greatly suppressed without sacrificing the SMN suppression ratio of the EDFL. Finally, we succeeded in constructing the RML technique with a repetition rate of 10 GHz from phase lock loop (PLL) and PZT controller link. We have measured the SSB phase noise and timing jitter from the noise spectra of the RML-EDFL. The measured SSB phase noise and estimated timing jitter are -86.2 dBc/Hz and 61.3 ps, respectively, which indicate the bad laser output characteristics as compared with the free-running case. This is because the noise source is mainly introduced from the CDR due to amplified supermode noise beatimg.