320 GHz Time-Domain Multiplexed Pulses From Quantum-Dash Mode-Locked Semiconductor Laser Diodes

Ramón Maldonado-Basilio, Sylwester Latkowski, and Pascal Landais
School of Electronic Engineering, Dublin City University, Glasnevin, Dublin, Ireland

Quantum-dash (QDash) mode-locked (ML) Fabry-Pérot laser diodes have attracted significant interest in optical time-division multiplexing and wavelength-division multiplexing systems due to their variety of applications such as sub-picosecond pulse generation, frequency multiplication, multi-channel transmission, clock recovery, and clock generation [1-5]. In particular, clock generation has been demonstrated by using a programmable notch filter at the output of a 40 GHz QDash-ML laser [5]. Selection from two to three longitudinal modes at a given wavelength separation allows for the generation of sinusoidal clock signals at different repetition rates. In this work, an alternative approach based on optical time-domain multiplexing is experimentally investigated. Optical pulse-streams at 80, 160 and 320 GHz featuring optical signal-to-noise-ratios of 12, 9 and 6 dB, respectively, are obtained. Time-domain multiplexed pulses exhibit a full-width at half maximum (FWHM) of 1.8 ps irrespective of the pulse repetition rate.

The QDash-ML laser diode under investigation is 1 mm long single section device, without saturable absorber [1], DC-biased, and temperature controlled at 25 °C. Experimental setup is depicted in Fig. 1a. Whilst biased at 110 mA, the QDash-ML laser is synchronized to an optical pulse stream from a tunable mode-locked laser (TMLL) at 1550 nm. As depicted in Fig. 1b, the QDash laser generates stable clock pulses at 40 GHz under optical synchronization (and also in passive mode-locking operation). At these conditions, pulses exhibit a FWHM of 1.8 ps after a passive compression scheme based on the reduction of pulses' chirp by the chromatic dispersion in a standard single mode fibre [1]. The TMLL is locked with a 10 GHz electrical clock, which is also used as the trigger to an optical sampling scope. An optical time-domain multiplexer (OMUX) allows for the generation of pulses at repetition rates of 80, 160, and 320 GHz. Optical power at the input of the OMUX is enhanced by an erbium-doped fibre amplifier (EDFA-2). A 6 nm optical band-pass filter (OBPF) is utilized to suppress both the spontaneous emission from EDFA-1 and the synchronizing signal from TMLL. Eye diagrams of the generated clock pulses are recorded by the sampling scope with a resolution of 0.8 ps. Pulses at 320 GHz are depicted in Fig. 1c. Such suitable multiplexed pulses are obtained providing a fine tuning in the OMUX (in terms of power and delay between the multiplexed pulses), the OBPF (in terms of bandwidth and central wavelength), and the length of single mode fibre utilized for passive pulse compression.

In conclusion, the generation of short pulses from a QDash-ML laser at repetition rates of 80, 160, and 320 GHz has been investigated. The time-domain multiplexing approach provides flexibility in terms of the repetition rate of the generated pulses and releases stringent conditions imposed by the selective filters utilized in other approaches.

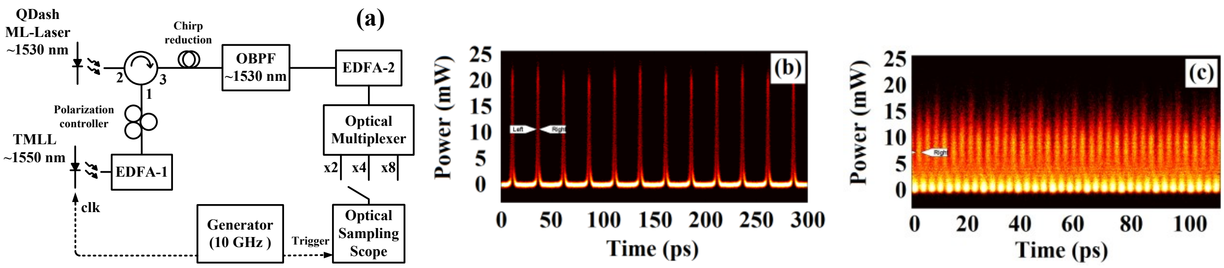

Fig. 1. (a) Experimental setup. (b) Sub-picosecond pulses at 40 GHz measured at the output of the QDash ML laser. (c) 320 GHz pulses generated after the optical time-domain multiplexing scheme.

References

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