Ultrafast Optical Pulse Compression using a Semiconductor Nonlinear Bragg Reflector

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Generation of ultrashort optical pulses plays a key role in ultrahigh-speed photonics technology. Optical pulse compression based on soliton pulse propagation in single-mode optical fibres has been extensively used as a technique for ultrashort pulse generation. In soliton compression, however, optical pulses are transmitted through optical fibres up to kilometres to achieve a high pulse compression factor for optical pulse generation in femtosecond duration. Pulse propagation in such a long travel distance through optical fibres causes fluctuation and drift in optical polarisation and pulse-to-pulse timing, both of which lead to degradation of the quality of signal transmission.

In this paper, we have demonstrated novel compact fibre-free pulse compression in which a semiconductor photonic structure was used as a high-optical-nonlinearity medium. The photonic structure was a semiconductor nonlinear Bragg reflector (SNBR) consisted of 20 periods of 10-nm InP/7-nm InGaAs quantum well (QW)/100-nm InP/109-nm InGaAsP composite layers grown on an InP substrate as illustrated in Fig. 1. Strong photon-exciton interaction due to constructive interference in the SNBR caused an enhancement of ultrafast optical nonlinearity associated with absorption saturation of QW excitons at wavelengths of 1500 nm [1]. The large ultrafast excitonic nonlinearity exerted carrier-induced self-phase modulation on reflected optical pulses and produced pulse chirping. The reflected optical pulses from the SNBR were compressed through a dispersive optical delay line introduced for chirp compensation.

Carrier-induced self-phase modulation was evaluated by wavelength-resolved pump-probe reflectance measurements. Spectral shift due to the carrier-induced self-phase modulation was as large as 3.5 nm in a time scale of 400 fs as shown in Fig. 2. Such a large and ultrafast spectral shift led to significant modulation and expansion of the optical pulse spectrum after a single reflection from the SNBR as presented in Fig. 3. Reflected pulses were compressed to 92-fs pulses after the chirp compensation when Fourier-transform-limit pulses of 136-fs duration were incident onto the SNBR (Fig. 4). Femtosecond pulse compression using the SNBR has thus been realised at lightwave communication wavelengths.

[1] K. Ogawa and Y. Matsui, Appl. Phys. Lett. **74**, 2569 (1999).

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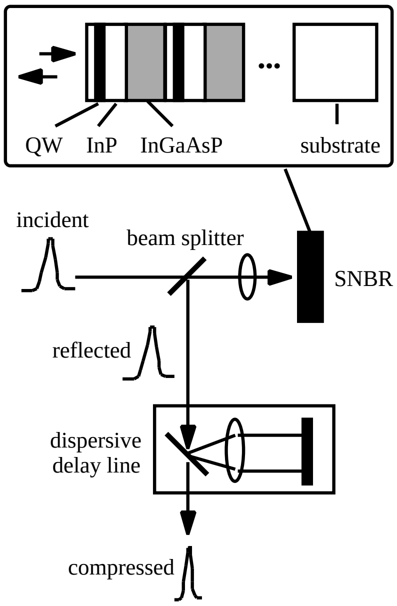

Fig. 1 SNBR and pulse compression set-up.

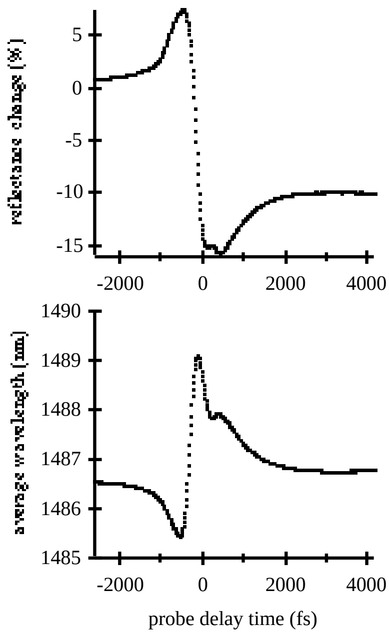

Fig. 2 Transients of pump-induced reflectance and wavelength shift.

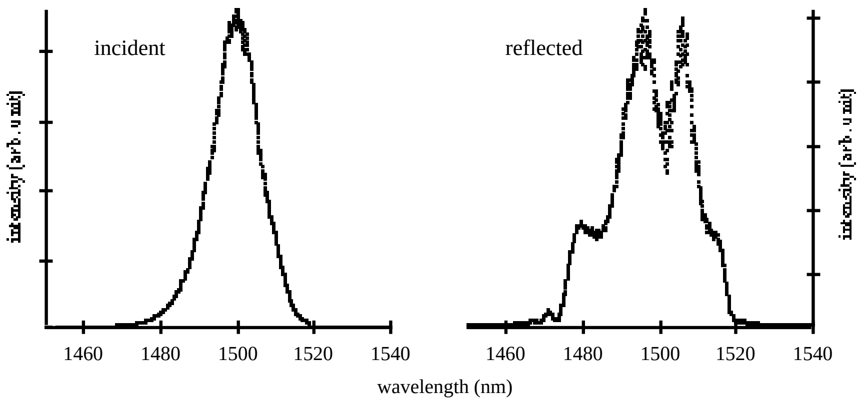

Fig. 3 Optical spectra of incident and reflected pulses.

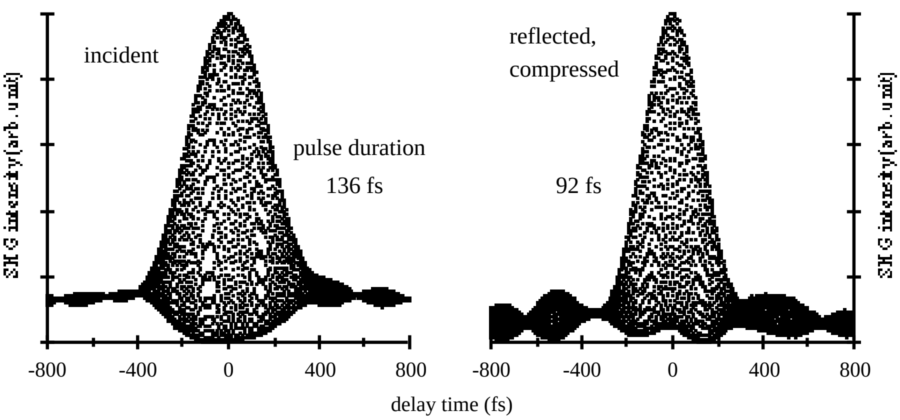

Fig. 4 Interferometric correlation traces of incident and compressed pulses.