Monolithically Integrated InP-based Optical Pulse Shaper

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Spectral phase control of optical pulses is often required to generate short pulses, and an important application of a pulse shaper is spectral chirp/dispersion (pre-) compensation. In this paper, we present the pulse shaping/compression capability of a monolithically integrated optical pulse shaper. Chip fabrication has been carried out in a standardized generic photonic integration platform which is available in the framework of European FP7 project EuroPIC. A key capability of this platform is the active-passive integration scheme which allows direct integration of active components such as semiconductor optical amplifiers (SOAs) with passive elements such as arrayed waveguide gratings (AWGs) and phase modulators (PMs) on a single photonic chip.

The pulse shaper device is designed with a reflective geometry. The light from the optical pulse source is injected into the pulse shaper chip via an AR-coated facet. The pulsed signal passes through an AWG which decomposes the light into its spectral components. Spectral components pass through PMs and SOAs and are then reflected back from a facet with a high-reflection coating. The PMs and SOAs are used to manipulate the spectral phase and amplitude of the components in order to achieve the desired pulse shape. The spectral components are then recombined in the AWG and return through the input/output waveguide. The two directions are separated by a circulator outside the chip. Fig.1 shows an image of the realized chip.

In order to demonstrate the functionality of the integrated pulse shaper, the device is tested using a mode-locked (ML) quantum dash laser diode which generates heavily chirped optical pulses. The ML laser is a single-section, 1mm-long, Fabry-Pérot device with no saturable absorber section [1]. The laser is dc-biased at 375mA. Optical pulses are characterized in time-domain using the stepped heterodyne technique which is particularly useful in phase characterization of passively ML lasers, where no external electronic clock is available.

By optimizing the control signals on the integrated pulse shaper, we were able to compress the optical pulses and obtain a nearly flat chirp profile [2]. Characterization of the input and output optical pulses in the frequency domain provides a clear insight on the so-called Fourier transform shaping capability of the device. Fig.2(a) shows the measured spectral power and phase of the optical pulse generated by the ML source and passed through the measurement setup, excluding the pulse shaper. The high resolution power spectrum is given and indicates the optical lines which are separated by 40GHz, i.e. the ML repetition frequency. Fig.2(b) corresponds to the optical pulse when the pulse shaper chip is included in the measurement setup. The spectral phase profile is nearly flat for 11 optical lines at the higher frequency side of the spectrum. In this experiment, the chirp is not fully compensated and the power spectrum is not flat due to the mismatch between the repetition frequency of the source and the channel spacing of the device, i.e. 50GHz.

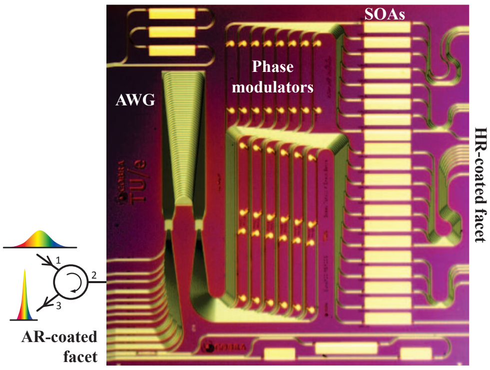

Fig. 1. A microscope image of the realized device. The total size is 6×6mm^2.

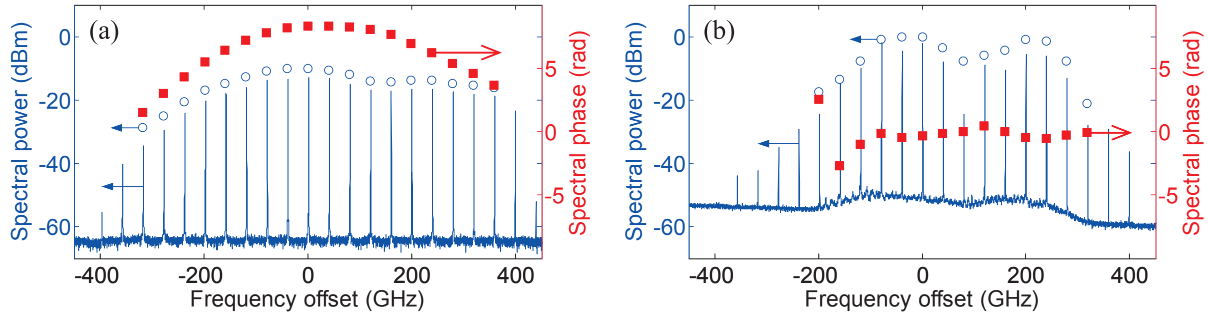

Fig. 2. Normalized spectral power (circles) and phase (squares) of the optical pulse (a) generated by the quantum dash laser and passed through the measurement setup only, and (b) with the pulse shaper chip included. High resolution (20MHz) spectra (solid line) show the laser modes. The retrieved spectral power (stepped heterodyne technique) is in agreement with the high resolution power spectrum which verifies the reliability of the measurement method, and sufficient stability of the laser. In (a) the circles are offset by −10dB for better visibility.

References

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