clipping carrier was absent [1]. Consequently, the power control requirement on S-CDMA technique can be relaxed significantly. Although the added coherent clipping carrier provides an excellent OBI suppression capability and a large system DR, it consumes a significant amount of RF driving power to laser A. Conversely, it is conjectured that the clipping carrier can suppress OBI more effectively than the S-CDMA signal. It is therefore important to find a balance between the driving power levels of the clipping carrier and the S-CDMA signal. Fig. 5 shows the results of $P_a$ against different values of $M_f$ and $M_c$ when the total driving power was fixed. We can see that there indeed exists an optimum (coherent) combination of the clipping carrier and the S-CDMA signal power, i.e., a minimum $P_a$, of -30.5 dBm was obtained when $M_f = 150\%$ and $M_c = 130\%$. Also, when most of the driving power is allocated to either the clipping carrier or the S-CDMA signal, the resultant power levels of $P_a$ were increased by 3 dB compared to the optimum case.

**Conclusion:** In this Letter, we have experimentally demonstrated that an in-band clipping carrier, when coherently combined with a Walsh-code-based S-CDMA signal, can effectively suppress OBI in a PON or WDMN network. When the total driving power was fixed, we found that an optimum combination ratio of the two signals exists to achieve a maximum system power budget. Our experimental results showed that, under the condition of no bandwidth wasted on the in-band clipping carrier, a negligible system power penalty can be achieved even when the OBI-induced intensity noise was as high as -90.9 dB/Hz. In addition, a large system dynamic range of 10 dB can be obtained to relax the tight power control requirement on S-CDMA signals.

**References**


**Time-space-conversion optical signal processing using arrayed-waveguide grating**


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**Fig. 1** Schematic diagram of time-space-conversion processing system using diffraction gratings (DGs), and arrayed-waveguide gratings (AWGs).

a DGs  

b AWGs

Optical signal processing based on time-space-conversion is highly attractive, especially for ultrafast signal processing applications in high-speed optical communication systems with a data rate of more than 100 Gbit/s. Such processing enables many operations such as the formation, reshaping, pattern recognition and even routing of an ultrafast bit stream, which are difficult to do by traditional electronic means. This technology has been widely demonstrated in the wavelength range of 0.4–0.85 μm by using free-space optics with diffraction grating pairs and lenses [1–4]. In such a grating system, however, the time window is determined by the size of the diffraction grating and spatial filter, and it is difficult to make it compact.

In this Letter, we propose time-space-conversion optical signal processing using an arrayed-waveguide grating (AWG) and demonstrate pulse train generation at the communication wavelength of 1.55 μm.

**References**


**Fig. 1** Schematic diagram of time-space-conversion processing system using diffraction gratings (DGs), and arrayed-waveguide gratings (AWGs).
Finally, we obtain the maximum bit number $K_{\text{max}}$ in the bit stream as $T_p/2e$,

$$K_{\text{max}} = \frac{\nu a N d}{2e}$$ for the DG system \hspace{1cm} (5)

$$K_{\text{max}} = \frac{N}{2}$$ for the AWG system \hspace{1cm} (6)

Fig. 2. Pulse processing performance comparison between AWG and DG at wavelength of 1.53 \mu m

Assume incident angle of light beam to DG is 60\(^\circ\), and size of spatial filter is one-tenth of lens focal length

Fig. 2 compares the pulse processing performance of an AWG and a DG at a wavelength of 1.55 \mu m. Conventional grating systems are suitable for the synthesis of pulses with a width of around 100fs within a time window of < 30ps. AWG systems, however, are suitable for handling subpicosecond pulses with long time windows up to one nanosecond. Moreover, they are compact, compatible with fibre optics, and can be integrated with other planar lightwave circuits (PLCs).

To confirm the feasibility of time-space conversion processing in an AWG system, we fabricated reflection-type AWG optical circuits and demonstrated pulse train generation. The experimental setup and a schematic diagram of the AWG are shown in Fig. 3. The AWG consists of an I/O waveguide with a singlemode fibre pigtail, slab waveguides with a focal length of 22.6mm, and an array of 340 waveguides. The diffraction order is 59 at the central frequency of 193.2THz (1552nm), so the minimum pulsewidth is ~0.2ps. The resolving power is ~10GHz, which means that the time window is ~100ps. The light source was a Cr:YAG modelocked laser that generates transform limited pulses (pulswidth: <0.1ps; repetition rate: 200MHz). Dispersion control fibres were used to compensate the dispersion of the experimental setup. Femtosecond pulses were spectrally sliced and amplified by an EDFA. After the second optical filter, the pulsewidth was 1.1 ps when dispersion was compensated; the central wavelength was 1549nm and the spectral width was 2.3 nm.

The pulses were input into and output from the AWG through an optical circulator. An amplitude spatial filter (patterned mirror) was placed on the focal plane, close to the facet of the AWG. The focal plane should have a slight curvature, although the spatial filter has a flat surface. The maximum phase mismatch due to the geometrical difference is calculated to be $< \pi/4$, which is negligible. Synthesised pulse waveforms were measured by a cross correlator [6]. Figs. 4a and b show the observed waveforms of 120 and 240GHz repetition rate for the amplitude filters with a mirror spacing of 60 and 120\mu m, respectively. The pulse width within the pulse train was ~1.2ps, almost the same as the input pulsewidth. The non-uniform envelope of the pulse train limited the time window (50ps), which is due to the binary amplitude pattern of the spatial filter we used.

In summary, we have proposed time-space-conversion optical signal processing using an AWG and demonstrated pulse train generation to confirm its performance at a wavelength of 1.55 \mu m. This will be a key technology for signal processing in future high-speed optical communication systems.

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References


Fig. 4 Examples of pulse train generation measured by cross-correlator

a 120GHz pulse train
b 240GHz pulse train

1m long continuously-written fibre Bragg gratings for combined second- and third-order dispersion compensation

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Indexing terms: Gratings in fibres, Optical dispersion, Optical communications

The authors present the realisation of high-quality 1m long continuously-written fibre Bragg gratings designed to compensate both second- and third-order fibre dispersion. These compact devices are ideal for counteracting the effects of fibre dispersion in high bit rate transmission systems.