Bandwidth Studies on a 1.4 m Long Multimode Polymer Spiral Waveguide

Jian Chen, Nikos Bamiedakis, Richard V. Penty, Ian H. White

Centre for Photonic Systems, Electrical Engineering Division, Department of Engineering, University of Cambridge, 9 JJ Thomson Avenue, Cambridge, CB3 0FA, United Kingdom, Author e-mail address: jc791@cam.ac.uk

P. Westbergh, A. Larsson

Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-412 96 Göteborg, Sweden

1. Introduction

In recent years, there has been a rapidly growing demand for high bandwidth short-reach optical interconnects that can readily be formed on electrical circuit boards. This is in particular because traditional electrical interconnections are widely regarded to be reaching their performance limits due to their inherent drawbacks such as high frequency losses, crosstalk and power dissipation issues. Optical interconnections can provide a solution to this issue owing to their larger bandwidth, immunity to electromagnetic interference and compactness. Polymer multimode waveguides are potential candidates for use in on-board optical interconnections owing to favourable material properties which show low optical losses even at the high temperatures (> 250 °C) needed for solder reflow [1] and the relaxed alignment tolerances they can offer in the system production and assembly [2]. This paper presents bandwidth studies on a 1.4 m long spiral waveguide demonstrating a measurement limited bandwidth of 30 GHz. The results suggest that on-board data rates higher than 25 Gb/s can be achieved with optical interconnects based on polymer multimode waveguides.

2. Experimental Results

The 1.4 m long spiral waveguide is fabricated on a 6-inch glass substrate. It has a cross section of 50×20 μm^2 with bulk refractive indices of 1.52 and 1.50 for the core and cladding (Dow Corning® OE-4140 and OE-4141 Cured Optical Elastomers) polymer materials respectively. The S_{21} parameter of the optical link with and without (the back-to-back case) the waveguide is recorded using a vector network analyzer. The frequency response of the waveguide is obtained by subtracting the recorded frequency responses for the link with the waveguide from the back-to-back link. The waveguide bandwidth is launch condition dependent as different waveguide modes are excited which have different propagation speeds for different launch conditions. Thus, the measurement is done for both single-mode fibre (SMF) and multi-mode fibre (MMF) launches.

The experimental set-up is shown in Fig. 1a and comprises an 850 nm vertical-cavity surface-emitting laser (VCSEL) (bandwidth of ~ 25 GHz) [3], the waveguide sample, a photodiode (bandwidth of ~30 GHz) and a variable optical attenuator (VOA). The VCSEL is butt-coupled to an input fibre patchcord (either SMF or 50 µm MMF), and a 50 µm MMF is used to couple the light out to a detector. The VOA is employed to introduce loss in the back-to-back link comparable with the waveguide loss. The frequency dependence of the received optical power is recorded for different launch offsets. Fig. 1b and 1c show the obtained frequency response of the waveguide for a SMF and a 50 µm MMF input respectively. The plotted curves are normalised with respect to that of the back-to-back link, so that the relative low frequency response powers are due to the reduced coupling efficiency for different input offsets. It can be seen that the frequency response remains approximately constant up to ~ 30 GHz for all launch conditions. The maximum bandwidth that can be observed in the experiment is limited by the bandwidth of the active devices used. The simulated bandwidth-length product for an ideal straight waveguide is ~ 7 GHz.m for an overfilled launch and ~ 100 GHz.m for a SMF input. For the spiral waveguide however, higher-order modes exhibit higher attenuation due to its bending structure, and thus a higher bandwidth is expected. Detailed simulation studies on the light propagation in the spiral waveguide will be presented at the conference.

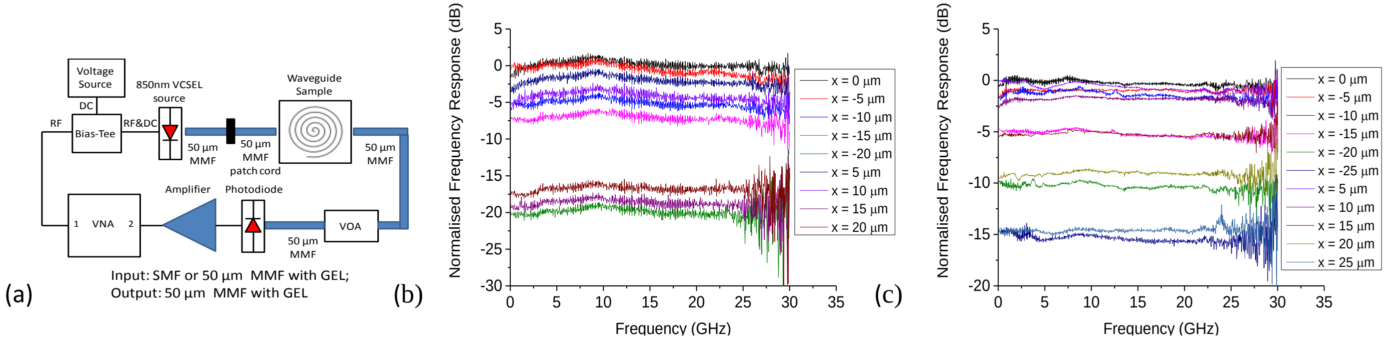

Fig. 1. (a) Experiment set-up of S_{21} parameter measurement; (b) and (c) are normalised frequency response of the spiral waveguide for different horizontal offsets under a SMF and 50 µm MMF input, respectively.

3. Conclusion

Bandwidth measurements have been carried out on a 1.4 m long spiral polymer multimode waveguide. The results indicate that the waveguide exhibits a bandwidth of at least 30 GHz for both a SMF and 50 µm MMF launch for all input offsets, demonstrating the potential of transmitting data rates higher than 25 Gb/s over such structures.

4. Acknowledgement:

The authors would like to acknowledge Dow Corning for the provision of the spiral polymer waveguide samples, IQE Europe for providing the epitaxial material used for VCSEL fabrication and EPSRC for supporting the work.

5. References:

[1] N. Bamiedakis et al, IEEE Journal of Quantum Electronics, vol. 45, no. 4, pp. 415–424, 2009.
[2] N. Bamiedakis et al, IEEE Transactions on Components, Packaging and Manufacturing Technology, vol. 3, no. 4, pp. 592–600, 2013.
[3] P. Westbergh, et al., Electronics Letters, vol. 48, pp. 1145-1147, 2012.