Bend-Insensitive Wideband Multimode Fiber and Cable for SWDM Systems

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Abstract: 4*25 Gbps SWDM transmission is demonstrated over the novel bend-insensitive wideband multimode fibers in the 850-950 nm wavelength range. The wideband multimode cable shows negligible macro-bending loss with 2 turns at bending radius of 7.5 mm.

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1. Introduction

With the development of the Internet and the advent of the Internet of Things, the whole industry needs to deal with increasing data traffic. Data center scale grows rapidly and extends to a higher bandwidth, higher speed and more flexible evolution. VCSEL based Multimode fiber system technology has been proposed as a low cost and power efficient solution for 100 Gbps data center networks over parallel multimode fibers [1]. Short Wavelength Division Multiplexing (SWDM) is a promising technique to increase the transmission capacity of multimode fibers and cables. In June 2016, the Telecommunications Industry Association (TIA) issued a standard of a new type of multimode fiber named wideband, which targets an operational window between 850 nm and 950 nm with VCSELs to support 4 wavelengths SWDM in TIA-492AAAE. Other standard organizations, such as ISO/IEC, are also actively developing detailed standards for wideband multimode fiber. The wideband multimode fibers (WB MMF) are required to have high effective modal bandwidth (EMB) performance over a wide range of wavelengths from 850 nm to 950 nm. Besides, strict macro-bending performance requirements ensure the cabling flexibility.

In this paper, 100 Gbps SWDM4 transmission tests over novel bend-insensitive wideband multimode fibers and conventional OM4 fibers were carried out. Macro-bending performance of wideband multimode cables was tested with 2 turns at bending radius of 7.5 mm.

2. Requirements for WB MMF

The wideband multimode fiber is specified in TIA-492AAAE, taking the both Excel link models for IEEE 100GBASE-SR4 [2] and Fibre Channel 32GFC [3] into account, that the EMB minimum values are 4700 MHz•km at 850 nm and 2470 MHz•km at 953 nm. With these bandwidth requirements fulfilled, the Wideband MMF is able to support four SWDM channels between 850 nm and 950 nm at speeds of over 25 Gb/s to realize a 150 meters transmission link at least.

Besides, the Wideband MMF is required to have a small macro-bending loss, less than 0.2 dB at 850 nm and 0.5 dB at 1300 nm with 2 turns at bending radius of 7.5 mm.

3. WB MMF characterization

The WB MMF were designed and fabricated as reported before [4]. The EMB performance was measured using a high resolution DMD bench with a tunable Titanium-Sapphire laser at various wavelengths. Figure 1 shows the EMB performance of the fabricated WB MMF and conventional OM4 fiber over wavelengths from 850 nm to 950 nm. The sharp decline of EMB performance at longer wavelengths hinders the OM4 fiber to apply in the SWDM4 system.

In order to compare the transmission performance of WB MMF and conventional OM4 fiber, we set up a 4*25 Gbps SWDM transmission experiment platform using a Finisar 100GE SWDM4 optical module. Figure 2 is a schematic of the Finisar 100GE SWDM4 optical module function. The transceivers transmit four streams of 25 Gbps data at the wavelengths of around 850, 880, 910 and 940 nm.

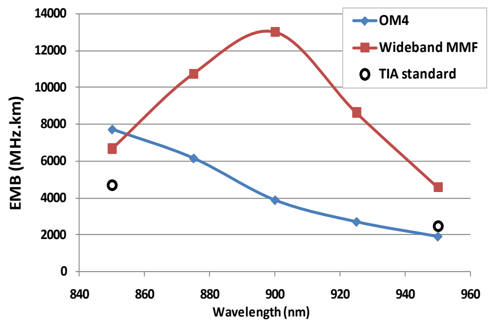

Fig. 1. Tested EMB of WB MMF and conventional OM4 fiber versus wavelength

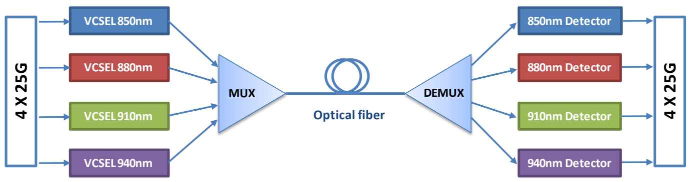

Fig. 2. Schematic of the 100G SWDM4 transmission

The overall experimental setup is shown in Figure 3. Signals generated by a pulse pattern generator (PPG) were processed by the Finisar 100GE SWDM4 optical module, then transmitted by the multimode fiber samples, finally received by a bit error rate tester (BERT) and an oscilloscope (OSC) to observe the electrical eye diagrams. A clock recovery was used before bit error rate testing. It should be noted that the optical eye diagrams were obtained at the fibers output directly, not through the Rx of the SWDM4 optical module.

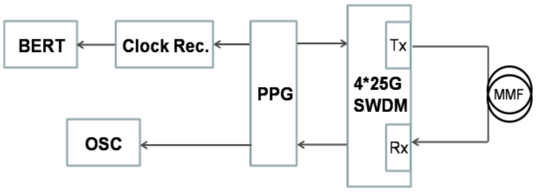

Fig. 3. Overview of the transmission experiment setup

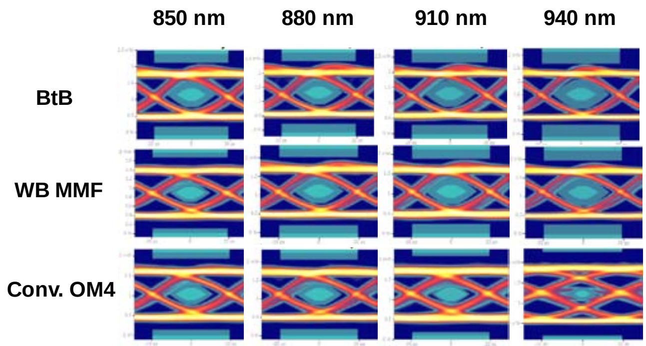

Fig. 4. Optical eyes of the 100G SWDM4 transmission over 300 m wideband multimode fiber and conventional OM4 fiber

It is found that, without forward error correction (FEC) technology, both the WB MMF and OM4 fiber can achieve error free operation (BER < 1E-12) at the length below 340 meters at 850 nm. However, at 940 nm, BER of the OM4 fiber increases rapidly with length, while the WB MMF still maintains a low BER below 340 meters. Optical eyes of the 100 Gbps SWDM4 transmission over 300 meters WB MMF and OM4 fibers are displayed in Figure 4. At 940 nm, the WB MMF has zero BER at the length of 300 meters, while the OM4 fiber has much bigger BER at 300 meters with almost closed eye. The WB MMF can support a distance of over 300 meters in 100 Gbps transmission, which is far exceeding the standard requirements of 150 meters.

4. Macro-bending test over wideband multimode cable

The wideband multimode fibers were made into a 24-core GJFH wideband multimode cable, with a length of 100 meters and outer diameter of 5 millimeters. The macro-bending test link consisted of the 100 meters trunk pre-termination cable (iCONEC-F-MTP/F-MTP/F-LSZH), two MPO-LC module boxes (iCONEC-24-MTP-

DLC/UPC), two 2.5 meters LC jumpers (iCONEC-DLC/U-DLC/U-LSZH) and two LC couplers. Firstly, the total link loss at 850 nm was recorded (link loss A). Secondly, wrapped the wideband multimode cable around a 15 millimeters round bar, and tested the total link loss at 850 nm (link loss B). Then the link loss variation should be the macro-bending loss of lane 1. Finally, 24 lanes were tested one by one. The detailed test results are listed in Table 1. The wideband multimode cable shows negligible macro-bending loss with 2 turns at bending radius of 7.5 mm at 850 nm.

Table 1. Detailed macro-bending test results of wideband multimode cable with 2 turns at bending radius of 7.5 mm at 850 nm

Lane	Link loss A (dB)	Link loss B (dB)	Macro-bending loss (dB)	Lane	Link loss A (dB)	Link loss B (dB)	Macro-bending loss (dB)
1	1.60	1.59	-0.01	13	0.52	0.54	0.02
2	0.74	0.73	-0.01	14	0.62	0.68	0.06
3	0.67	0.68	0.01	15	0.74	0.74	0
4	0.81	0.82	0.01	16	0.63	0.65	0.02
5	0.90	0.91	0.01	17	1.26	1.26	0
6	0.74	0.75	0.01	18	0.71	0.72	0.01
7	0.81	0.82	0.01	19	0.99	1.00	0.01
8	0.67	0.66	-0.01	20	0.81	0.82	0.01
9	0.57	0.58	0.01	21	1.05	1.05	0
10	0.69	0.71	0.02	22	0.74	0.74	0
11	0.61	0.61	0	23	1.07	1.07	0
12	0.63	0.64	0.01	24	0.73	0.74	0.01

5. Conclusions

The fabricated Wideband multimode fibers can support a distance of over 300 meters using 4x25 Gbps SWDM4 technology at wavelengths between 850 nm to 950 nm. The wideband multimode cable shows negligible macro-bending loss with 2 turns at bending radius of 7.5 mm. This novel WB MMF has got a great potential application in the high speed data centers.

6. Acknowledgements

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7. References

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