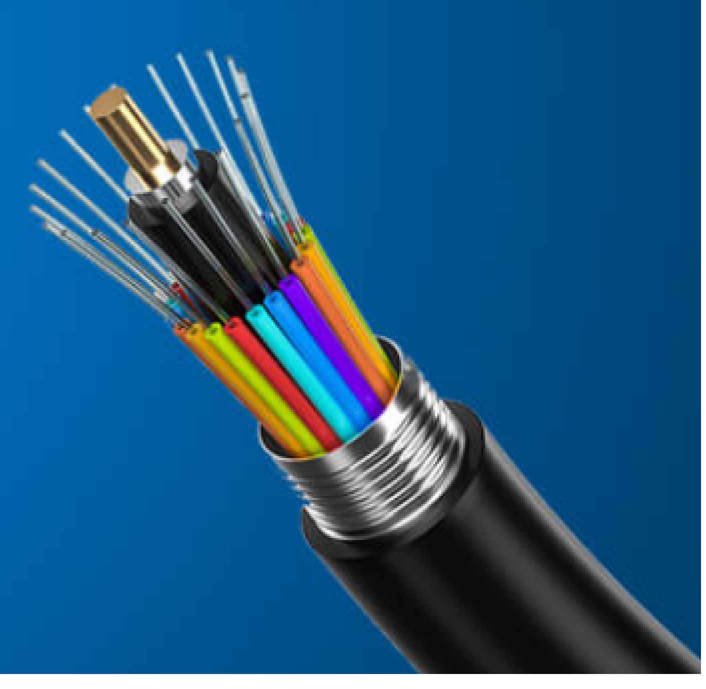
OM5 MULTIMODE FIBRE: DEVELOPMENTS AND PROSPECTS

The soaring growth of network data traffic has driven continual upgrading of multimode fibre standards and applications in recent years. Ethernet data rates have increased from 10GbE/40GbE/100GbE (Gigabit Ethernet) to 25GbE/50GbE/200GbE/400GbE, and will be further upgraded to 800GbE/1.6TbE in future. Fibre channel rates have increased from 8GFC/16GFC to serial 32GFC/64GFC (Gigabit Fibre Channel) and parallel 128GFC/256GFC, and will be further upgraded to serial 128GFC and parallel 512GFC in future. Meanwhile, multimode optical transceiver technology has gradually evolved from NRZ coding to PAM4 coding, and from single-wavelength light source to multi-wavelength multiplexing, such as BiDi (supporting two-wavelength multiplexing) SWDM (supporting four-wavelength multiplexing), and potentially eight-wavelength multiplexing in future. In addition to this, multimode fibres have potential for mode division multiplexing (MDM), which will increase their transmission capacity by taking advantage of the multiple available modes they offer.



01 CURRENT STATUS OF DATA CENTER CABLING APPLICATION

In recent years, data center networks' traffic demands have been continuing to grow. According to Cisco statistics and forecasts, from 2015 to 2020, a compound annual growth rate (CAGR) of total global data center traffic is 27%, with a CAGR of 30% for cloud data centers and steady annual growth of 9% for traditional local data centers.

At present, most data centers adopt a combination of copper, short-distance multimode optical devices and long-distance single-mode optical devices in their cabling schemes. Such cabling schemes are dominated by multimode SR4 and single-mode PSM4 solutions. Cost is a critical factor in cabling scheme selection for most data centers, and often the least costly solutions are the most advantageous. Thus Short Reach (SR) optical fibres are used for transmission ranges of hundreds of meters, while Long Reach (LR) fibres are used for ranges exceeding 2 kilometers. Alibaba's current network uses 100GBASE-SR4 multimode fibre connections, a cabling scheme which has proven more cost-effective than those based on single-mode fibres and PSM4 or CWDM4. The scale, architecture, network capacity and storage need of enterprise local data centers all suggest that multimode fibre and VCSEL will remain the primary solution in this important market.

02 OM5 FIBRE MANUFACTURERS AND THE SWDM ALLIANCE

OM5 fibre extends the bandwidth performance at 850 nm of the traditional OM4 fibre to 850 nm - 953 nm and supports the four-wavelength shortwave wavelength division multiplexing (SWDM4) technology, allowing four wavelengths to be transmitted simultaneously over a single multimode fibre, increasing its transmission capacity four-fold while maintaining complete downward compatibility.

A novel technique capable of greatly increasing the transmission capacity and range of multimode fibres, SWDM is of great significance to data center deployment, and to optical fibre, device and equipment manufacturers. Present SWDM Alliance members include optical fibre and cabling suppliers (such as YOFC, Corning, OFS, Prysmian and CommScope), equipment suppliers (such as Dell, Huawei, H3C and Juniper) and optical component makers (such as Finisar and Lumentum). The SWDM Alliance released the Multi-Source Agreement (MSA) in March 2017, defining the application requirements of 40GE SWDM4 and 100GE SWDM4, and had plans for further incorporating 400 Gbit/s applications into the MSA in future.

03 UPDATE ON OM5 FIBRE STANDARDS

OM5 fibre is based on OM3/OM4 fibre, extending its performance to support multiple wavelengths, and offering a path for the continued future development of multimode fibre systems. Since 2015, major international standard organizations have established specifications for OM5 fibre and its applications.

3.1 TIA and IEC

In June 2016, the Telecommunications Industry Association (TIA) officially released the TIA-492AAAE Standard which defined wideband multimode fibre (WBMMF) with support for wavelength division multiplexing (WDM) in the 850 nm - 950 nm range. In October 2016, TIA released ANSI/TIA-568.3-D "Optical Fibre Cabling Components", a structured cabling standard approving the use of TIA-492AAAE fibre for cabling operations.

The International Electrotechnical Commission (IEC) officially issued IEC 60793-2-10 ed. 6 in August 2017, categorizing WBMMF as Type A1a.4 optical fibre, and receiving ISO/IEC support for the 11801. ed. 3 request for liaison. Then, in November 2017, IEC officially issued the ISO/IEC 11801-1 generic cabling standard, awarding such cabling the OM5 designation.

3.2 IEEE 802.3

The IEEE 802.3bs standard was drafted in September 2016 and officially released in December 2017. This defines media access control parameters, physical layer and management parameters for 200 Gbit/s and 400 Gbit/s Ethernet. It also officially designates wideband multimode fibre cabling as "OM5", and specifies the shortest link distances to be supported by OM3/OM4/OM5 fibres under the 400GBASE-SR16 system (See Table 1).

PMD type	Required operating range [a]
400GBASE-SR16	0.5 m to 70 m for OM3
	0.5 m to 100 m for OM4
	0.5 m to 100 m for OM5

Table 1 Shortest Link Distances Supported by OM3/OM4/OM5 Fibres under the 400GBASE-SR16 System

The IEEE 802.3cd standard was drafted in November 2016 and released in December 2018. This defines media access control parameters, physical layer and management parameters for 50 Gbit/s, 100 Gbit/s and 200 Gbit/s Ethernet. It also stipulates that OM5 fibre must support 50GBASE-SR, 100GBASE-SR2 and 200GBASE-SR4 for ranges above 100 meters.

In November 2017, IEEE 802.3 established a special study group, the "NGMMF Study Group" engaged in researching the physical layer of next-generation 200 Gbit/s and 400 Gbit/s multimode fibre, with the aim of achieving 200 Gbit/s and 400 Gbit/s data transmission with fewer multimode fibres than existing Ethernet technology. In January 2018, at the first formal meeting of this study group, 400GBASE-SR8 or 400GBASE-SR4.2 was proposed as a substitute for 400GBASE-SR16, capable of supporting 400 Gbit/s Ethernet with a minimum 100 meter transmission range. The 400GBASE-SR8 scheme adopts eight pairs of optical fibres, and takes full advantage of existing techniques (using the more PAM4-friendly VCSEL technology), with a target wavelength of 850 nm. Currently, 400GBASE-SR8 has been encapsulated into optical transceivers including QSFP-DD, OSFP and COBO 8-Lane. The 400GBASE-SR4.2 scheme adopts four pairs of optical fibres deployed according to the existing 100GBASE-SR4 scheme's cabling pattern. Each optical fibre transmits two wavelengths and adopts PAM4 modulation, with an 850 nm target wavelength and a longer-wavelength light source. The 400GBASE-SR4.2 scheme is more suitable for using OM5 fibres that supports multiple wavelengths. The relevant IEEE 802.3cm standard was released in January 2020.

OM5 MULTIMODE FIBRE

04 APPLICATIONS OF OM5 FIBRE AND THE FUTURE

OM5 fibre was originally designed to meet the needs of WDM in a multimode transmission system, and its most valuable application is in the field of short-wavelength WDM. At present, most multi-wavelength optical transceivers, with 50 Gbit/s per wavelength, for multimode fibres remain in the R&D stage, and are only available from a limited number of optical transceiver suppliers in small quantities, as samples for internal experimental use. PAM4 modulation can achieve a single-wavelength rate of 50 Gbit/s using present 25 Gbit/s VCSEL. The two-wavelength bidirectional (BiDi) and SWDM4 techniques reduce fibre usage by half and three quarters, respectively, for high-speed Ethernet links above 100 Gbit/s.

Investigators have discovered that a fluorine-doped fibre core layer reduces the dependence of the optimal alpha values on various wavelengths, thus increasing the bandwidth of "ultra-wideband multimode fibre" across the entire 850 nm - 1,050 nm range, and proving that "ultra-wideband multimode fibre" is capable of supporting eight WDM channels at 30-nm intervals within the 850 nm - 1,050 nm window.

Over the past three years, experimental results for data transmission using OM5 fibre and "ultra-wideband multimode fibre", under the application of PAM4 modulation and WDM, have been reported by various optical fibre suppliers and optical transceiver suppliers. As indicated in these experimental results, reported in Table 2, OM5 fibre is sufficient to support 100 Gbit/s, 200 Gbit/s and 400 Gbit/s multi-wavelength transmission systems with ranges in excess of 150 meters.

Apart from this, after design optimizations, 50μm core diameter multimode fibre can achieve lower differential mode group delay (DMGD) compared with few-mode fibre in the 1,550 nm window, and can thus increase fibre capacity several-fold when applied in multi-input multi-output (MIMO) MDM system ,demonstrating the future potential of multimode fibre in MDM.

	FIT			Finisar		OFS		Prysmian		Panduit			YOFC	
	0M3	0M4	0M5	0M4	0M5	0M4	0M5	0M4	0M5	0M3	0M4	0M5	0M4	0M5
100GB/s-BiDi (850nm、910nm)	70m	100m	150m			200m	400m			70m	100m		200m	300m
200GB/s-SWDM4 (850nm、880nm 910nm、940nm)				100m	300m		300m	100m	300m					
50GB/s @980nm					300m		300m		200m			200m		
50GB/s @1060nm					200m		200m							

Table 2 Results of Latest PAM4 Transmission Experiments

05 SUMMARY

Multimode optical fibre has always been regarded as an efficient, flexible transmission medium, and its potential applications to higher network transmission speeds have been continuously explored. The scheme with multimode fibre and VCSEL has advantages in terms of link cost, power consumption and availability, making it the most cost-effective data center solution for most enterprise customers. With the continuous steady growth of traffic demands in both cloud and enterprise local data centers,the cost-effective multimode fibre solutions have a broad potential market. The OM5 fibre solutions defined by new industry standards are optimized for multi-wavelength SWDM and BiDi transceivers, and provide longer transmission link distances and network upgrade margins for high-speed transmission networks exceeding 100 Gbit/s.