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W h i t e P a p e r

**Smart Data Center Tech Refreshes:
24-Fiber Systems for 40G and 100G Network Upgrades**

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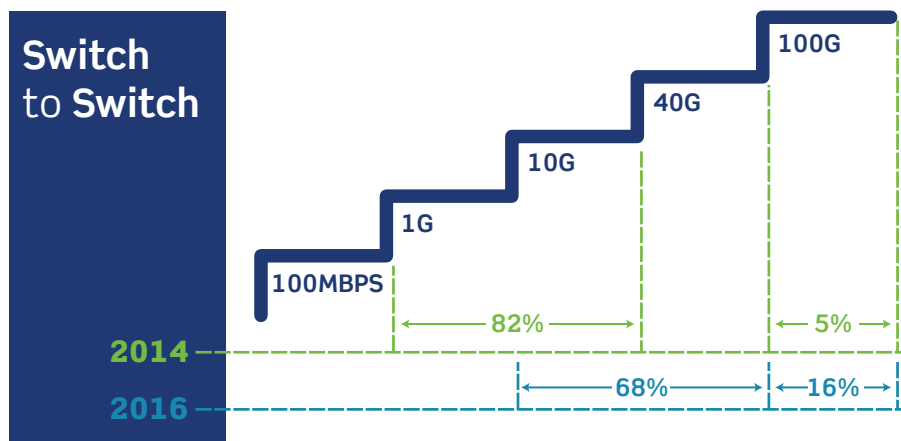
The Continuous Push for More Bandwidth

Global IP traffic has increased more than fivefold in the past five years, and will increase another threefold over the next five years, according to the 2014 Cisco Visual Networking Index. Cisco also projects that there will be 2.7 networked devices per person in 2018, up from 1.7 per capita in 2013.

Data centers everywhere are moving quickly to manage these ever-increasing bandwidth demands. And the emergence of cloud computing has acted as catalyst for driving even faster adoption of new network technology and higher bandwidth. While switch-to-switch connections of 40G and 100G accounted for 8 percent of data center infrastructure speeds in 2014, those combined speeds are expected to rise 26 percent by the end of 2016, according to research organization BSRIA.

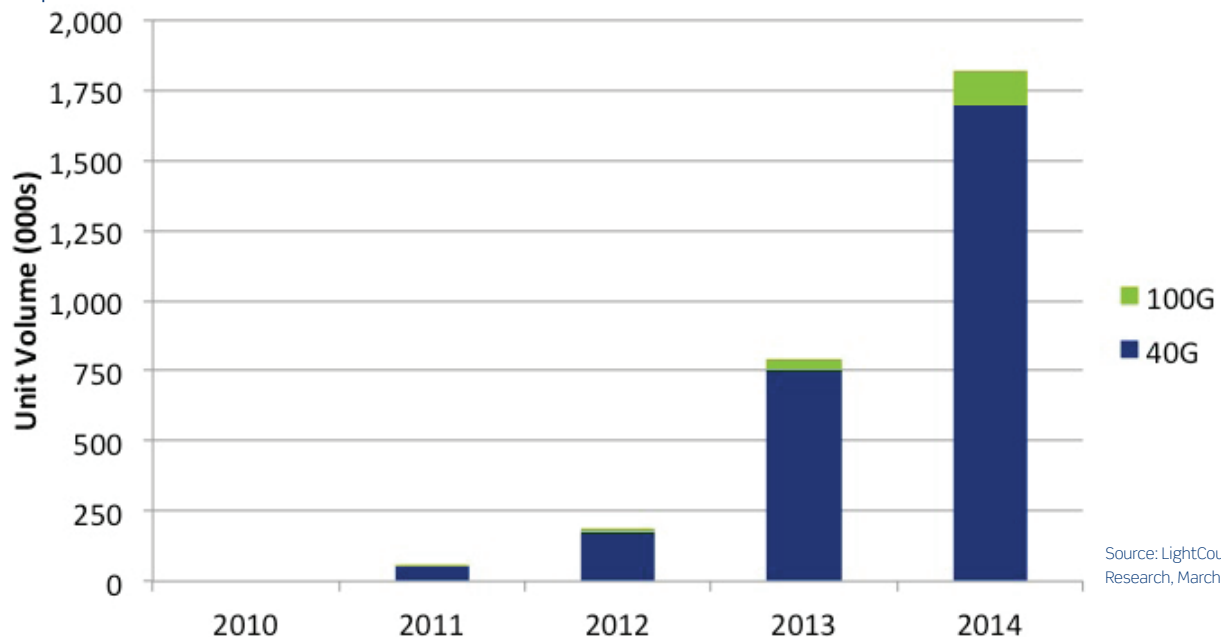
This growth is currently due to 40G network adoption: 40G transceiver shipments saw a whopping 126 percent increase last year, according to LightCounting Market Research. However, 100G transceiver sales is increasing and expected to make up more than 50 percent of data center optical transceiver capacity by 2019, according to market-research firm IHS Infonetics.

Data Center Speeds: 2014 vs Expected 2016



Source: BSRIA

Shipments of 40G and 100G Transceivers



Source: LightCounting Market Research, March 25, 2015

40G/100G Equipment On The Market

In 2010, when the IEEE 802.3ba standard for 40G and 100G was published, few active equipment options were available to support the new standard. But today there is a wide and ever-growing selection of switches and servers to deliver 40G/100G. Arista, Cisco, Juniper, and other manufacturers are introducing transceivers that address demands for higher bandwidth, as well as greater density, farther reach, and improved cost. Many of these new options have already outpaced the specifications in existing IEEE standards.

40G Transceivers

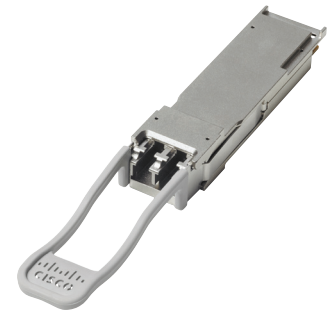
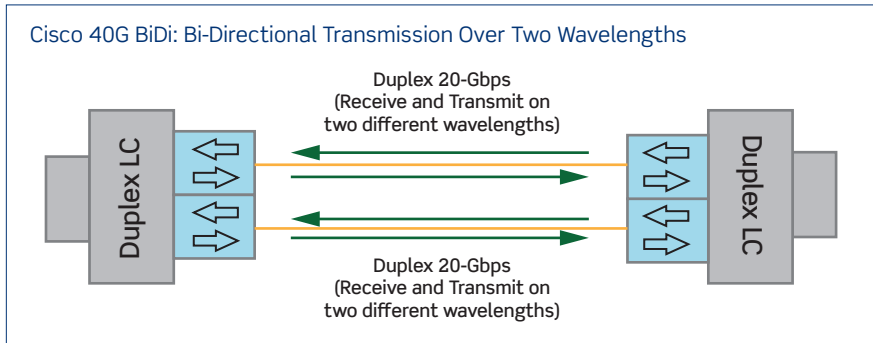
There are at least nine different 40G optical transceiver options now available on the market. All of these use the QSFP+ form factor, with the **40GBASE-SR4** transceiver currently the most popular option on the market. Arista recently introduced a **40GBASE-xSR4** transceiver that extends reach out to 400 meters, well beyond the 40GBASE-SR4 150-meter maximum specified distance. This gives larger data centers reach they need while taking advantage of more cost-effective multimode fiber, as opposed to single-mode fiber.



QSFP+ 40GBASE-SR4

40G Transceivers (QSFP+ Form Factor)						
	Transceiver	IEEE Standards Compliant	Fiber Type	Distance	# of Fibers	Connector
1	40G-SR4	Yes	OM3 / OM4	100 m / 150 m	8	12F MTP
2	40G-XSR4	No	OM3 / OM4	300 m / 400 m	8	12F MTP
3	40G-LRL4	Yes	OS2	1 km / 2 km	2	LC
4	40G-LR4	No	OS2	10 km	2	LC
5	40G-PLR4 / 4x10-IR (Arista/Juniper)	No	OS2	1 km	8	12F MTP
6	40G-PLR4	No	OS2	10 km	8	12F MTP
7	40G-SR-BD (Cisco only thru 2015)	No	OM3 / OM4	100 m / 150 m	2	LC
8	40G-LX4 (Juniper)	No	OM3 / OM4	100 m / 150 m	2	LC
9	40G-UNIV (Arista)	No	OM3 / OM4 / OS 2	150 m / 150 m / 500 m	2	LC

The new Cisco QSFP 40G Bidirectional (BiDi) Transceiver, **QSFP-40G-SR-BD**, has a duplex LC connector interface using multimode fiber. Each BiDi transceiver consists of two 20G transmit and receive channels, enabling an aggregated 40G link over a two-strand multimode fiber connection using two wavelengths. This allows customers to reuse their existing 10G infrastructure for migration to 40G connectivity. Cisco has exclusivity to this technology until 2016.



Cisco 40G BiDi (QSFP-40G-SR-BD)

Other proprietary 40G transceivers have been released that offer similar solutions to the Cisco BiDi transceiver. Both the Arista **QSFP-40G Universal** and Juniper **40GBASE-LX4** transceivers also support 40G over two multimode fibers with a LC duplex interface. However, unlike the Cisco BiDi, these transceivers deliver 40G over four 10G channels, with simultaneous transmission over four wavelengths.

100G Transceivers

There are even more transceiver options for 100G, with a range of form factors. These include the **QSFP28**, which has the same form factor as QSFP+, but increases individual lane speeds from 10G to 25G.

The compact form-factor pluggable (CFP) transceiver for 100G has received upgrades in performance and density, found in the **CFP2** model. CFP4 is the next generation in the CFP family, and many manufacturers are ramping up production now.

Introduced in 2013, Cisco's proprietary CPAK transceiver is a smaller, lower power alternative to the CFP2 form factor. Cisco offers CPAK transceivers for 100G multimode and single-mode, available on their Nexus 7000 and 7700 Series Switches. The transceivers are exclusive to Cisco until 2016.



CFP2 100GBASE-SR10

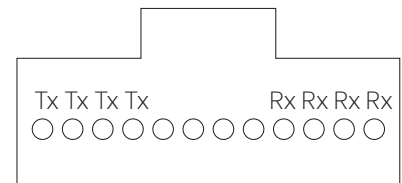


Cisco CPAK 100GBASE-SR10

100G Transceivers							
	Transceiver	Form Factor	IEEE Standards Compliant	Fiber Type	Distance	# of Fibers	Connector
1	100G-SR10 MXP (Arista)	Embedded optics	No	OM3 / OM4	100 m / 150 m	24	24F MTP
2	100G-SR10	CFP2	Yes	OM3 / OM4	100 m / 150 m	20	24F MTP
3	100G-SR4 - NEW	QSFP28	Yes	OM3 / OM4	70 m / 100m	8	12F MTP
4	100G-xSR4 (tbd) Est. Q1 2016	QSFP28	No	OM3 / OM4	300 m (tbd)	8	12F MTP
5	100G-LR4	CFP2	Yes	OS2	10 km	2	LC/SC
6	100G-LR4 - NEW	QSFP28	Yes	OS2	10 km	2	LC
7	100G-LR4	CPAK	Yes	OS2	10 km	2	SC
8	100G-LRL4 - NEW	QSFP28	Yes	OS2	2 km	2	LC
9	10x10-LR - (Cisco) NEW	CPAK	No	OS2	1 km	20	24F MTP
10	100G-PSM4 - NEW	QSFP28	No	OS2	500 m	8	12F MTP
11	100G-CWDM4 Est. Q4 2015	QSFP28	No	OS2	2 km	2	LC

As you can see in the chart above, the number of transceiver types available for 100G keeps growing, with new options introduced seemingly by the month.

For example, the 100GBASE-SR4 standard was just approved in February 2015, and became available in late April. This standard, created by the IEEE 802.3bm Task Force, reduces the lane count for 100GbE from 10 lanes at 10GbE to four lanes at 25GbE. This greatly reduces the amount of fiber required for delivering 100GbE from the core to top-of-rack switching. A separate standard to define 25GbE to the server is currently under development by the 802.3by Task Force, and expected to be ratified by late 2016.



100GBASE-SR4 Lane Assignment

When designing new networks or upgrading an existing network to 100GBASE-SR4, it's important to be aware of the difference in channel loss and reach requirements between 802.3bm and previous 802.3ba standards. As detailed in the chart below, the loss budgets are different and the maximum reach is lower for both OM3 and OM4.

IEEE802.ba vs IEEE802.3bm

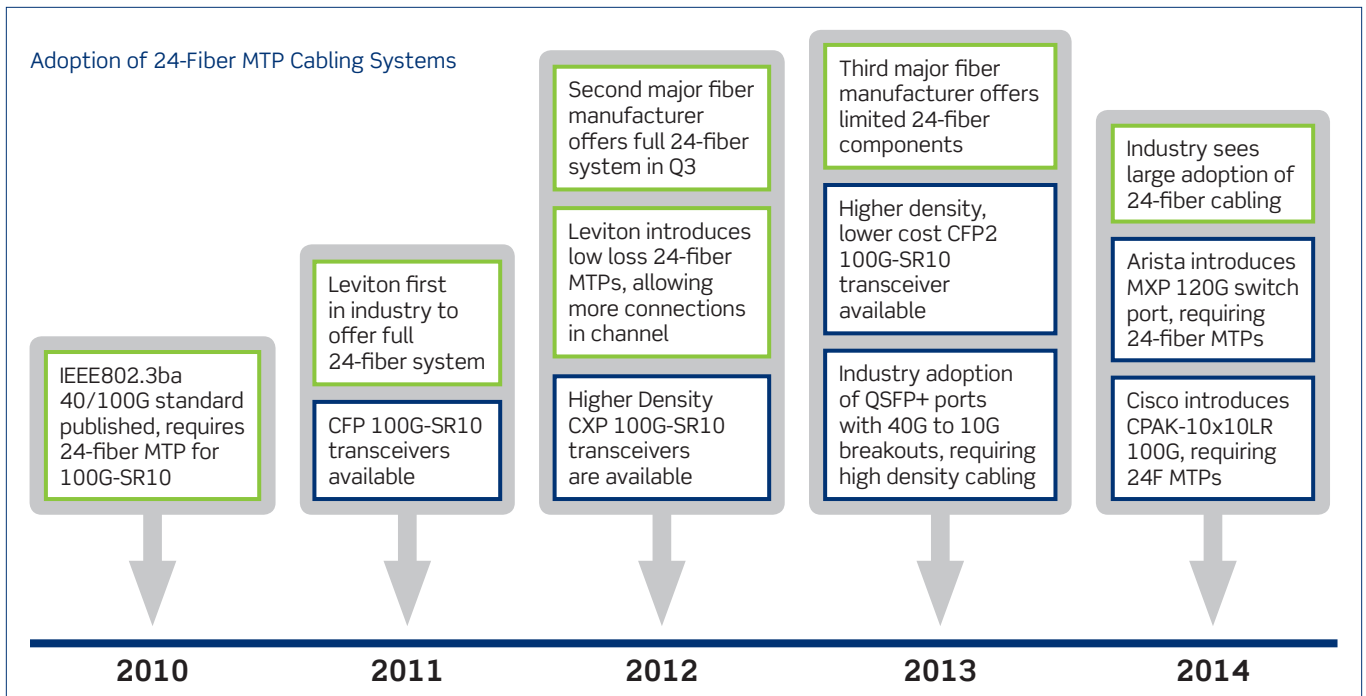
Application	IEEE Standard	OM3		OM4	
		Max Channel Insertion Loss	Reach	Max Channel Insertion Loss	Reach
40G-SR4	802.3ba	1.9	100 m	1.5	150 m
100G-SR10	802.3ba	1.9	100 m	1.5	150 m
100G-SR4	802.3bm	1.8	70 M	1.9	100 M

When looking at the emerging transceiver options in the preceding 40G and 100G transceiver charts, it becomes apparent that many of these new options are not compliant with IEEE standards. For some data center managers, it is a best practice to follow existing industry standards. But with data center demands changing so rapidly, the latest technology will often reach the market well ahead of new standards where they can be addressed. As part of next generation tech refreshes, many data centers have requirements for distance, cost, or custom solutions that simply don't fit into standard specifications. For example, data centers using 40GBASE-xSR4 transceivers exceed 802.3ba 40G maximum distance requirements, as it transmits to 300 meters over OM3 fiber and 400 meters over OM4 — well beyond IEEE standards.

Choose An Infrastructure That Can Adapt

With so many port types and form factors available, it is important for data center infrastructure managers to develop a cabling design that can be flexible to handle this rapidly changing landscape. In many cases, network engineers will decide on the type of transceiver and active equipment, and it is then up to the infrastructure manager to react quickly to ensure the physical layer is designed and connected in the most efficient way, while anticipating future tech refreshes.

Regardless of the switch or port type for 40G or 100G fiber, a 24-fiber MPO/MTP[®] cabling system is the most flexible and scalable solution to support this rapidly changing landscape. In 2010, when IEEE 802.3ba was ratified, it required 24-fiber MTP connections for 100GBASE-SR10. Within months, Leviton became the first manufacturer to offer an end-to-end 24-fiber MTP system. In the following years, more manufacturers followed suit, and in 2012 Leviton introduced lower loss 24-fiber MTP solutions, allowing more connections in a 40G/100G channel. Today we have reached the point where the latest active equipment for 100G requires a 24-fiber interface.



Installing a high-performance 24-fiber 40/100G MTP system provides several key benefits when the network is upgraded:

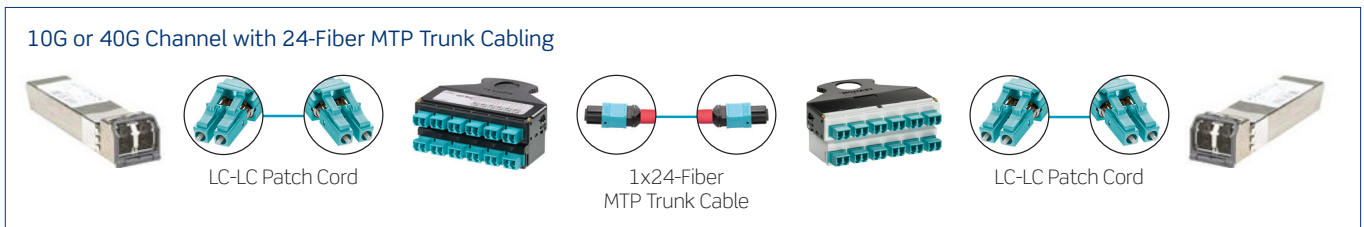
- Fewer connectivity components to be replaced or added simplifies migration and reduces costs for both components and installation
- Better fiber utilization in the channel, improving return on investment and total cost of ownership
- Higher density connectivity leaves more rack space for active equipment, and fewer trunks reduce cable congestion throughout the data center

Let's take a closer look at these key benefits.

Simpler Network Migration

With fewer connectivity components to be replaced or added when upgrading, a 24-fiber system simplifies migration and reduces costs for both components and installation. For example, when a 24-fiber backbone trunk cable is installed in a 10G network, that backbone stays in place when upgrading to 40G and 100G networks. A single 24-fiber cable can support a 1G, 10G, 40G, or 100G channel and will simplify network upgrades immensely. When equipment is upgraded, only cassettes and patch cords are exchanged for the appropriate new MTP® components.

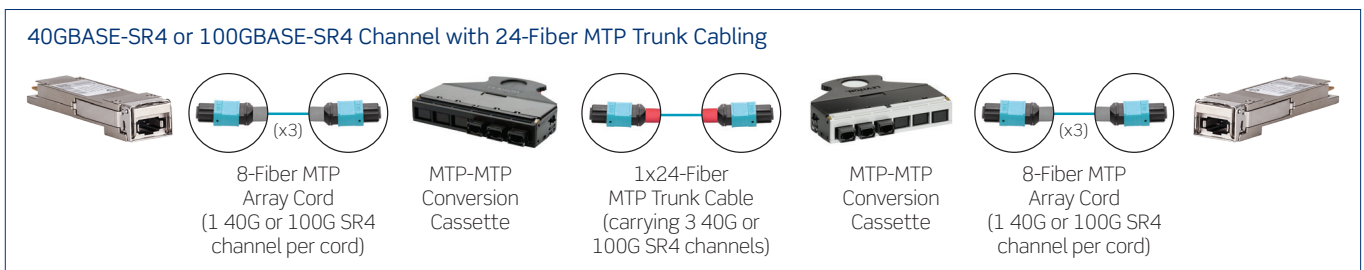
The example below shows a 10G channel using a 24-fiber MTP backbone trunk and MTP to LC connections. This exact configuration can also support a 40G channel using the new Cisco BiDi or Arista Universal transceivers. When upgrading from 10G to another 40G channel option, users can simply swap out the MTP-LC cassettes with MTP-MTP cassettes.



This strategy represents a non-disruptive methodology, with no changes required in the initial backbone trunking. All work is completed quickly within the cabinets. Less disruption means improved business continuity and less downtime.

Better Fiber Utilization

24-fiber MPO/MTP connectivity is more efficient than 12-fiber solutions when it comes to taking advantage of existing and emerging applications. For example, say you want to support twelve 100G channels using the recently ratified 100GBASE-SR4 standard, which defines 4 lanes of multimode fiber at 25G per lane. This 4x25 solution would only require 8 fibers (4 transmit, 4 receive), so a 12-fiber connector could support a single 100G channel. But with 12-fiber MPO/MTP systems you would need to install 12 connectors, or 144 fibers total, with 33% of the fiber wasted. However, when supporting 12 channels with a 24-fiber MTP system, only 4 backbone trunks would be required, using 96 fibers total at 100% fiber utilization.



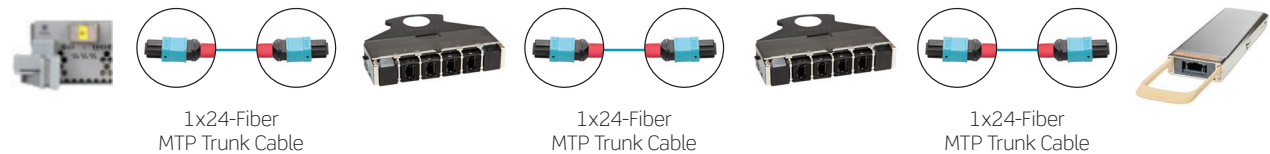
The 24-fiber MPO/MTP channel solution allows the use of the existing 100GBASE-SR10 (10x10) 20-fiber technology today, while at the same time maximizing the installed infrastructure investment in the event of the 4x25G upgrade in the future. Choosing a 12-fiber connector strategy simply does not accomplish this: it drives down return on investment and subsequently increases the total cost of ownership. This is the exact opposite of the design intent of a data center infrastructure system.

Higher Density and Space Savings

Since fewer cables are required as a result of 100 percent fiber utilization, and 24-fiber reduces the number of cables by half over 12-fiber cable, infrastructure managers can greatly reduce cable congestion in pathways and create more rack space for active equipment in racks and cabinets.

The example below shows a 24-fiber channel that provides parallel connections at the active equipment, which support 100GBASE-SR10 using CFP2 and CPAK transceiver form factors, as well as Arista MXP 120G embedded optics ports.

20- or 24-Fiber Connections at Equipment for 100GBASE-SR10 in CFP2/CPAK Form Factors or Arista MXP 120G Embedded Optics Ports



Leviton 24-fiber MTP trunk cables use Berk-Tek MDP cable in its trunks, which offers the smallest outside diameter available on the market. This in-turn creates even greater capacity and space savings in cabling pathways.

Leviton 24-Fiber MTP Systems: Flexibility for Multi-Generational Upgrades

A 24-fiber MTP system will support multi-generational changes, lower the cost of ownership, and maximize your return on infrastructure investment. However, some fiber optic assembly manufacturers only offer a 12-fiber system due to more stringent manufacturing requirements of the 24-fiber MTP connector and its end-face geometry. Leviton has made a significant investment and commitment to a higher level of manufacturing and testing to allow us to offer the advantages above.

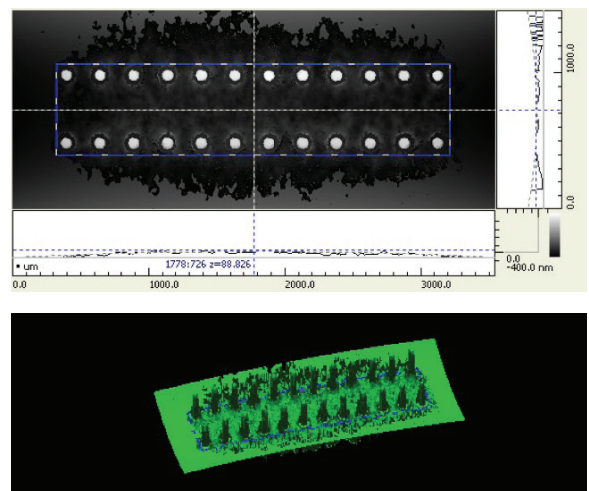
For example, Leviton uses an interferometer — a very precise microscope — to measure several important attributes of the 24-fiber connectors. The images below show interferometer measurements of the flatness of the polish (top), as well as the protrusion, or height, of each fiber (bottom). Leviton connectors typically see 1.5 to 2 microns of protrusion, well below the recommended maximum of 3.5 microns.

Insertion loss numbers for both OM3 and OM4 Leviton 24-fiber assemblies have a maximum of .35 dB, the same as a premium/low-loss 12-fiber MTP assembly. This performance has been independently tested in six different channel configurations and verified by independent laboratory Intertek/ETL. Testing verified that Leviton's performance meets IEEE 802.3ba specifications and exceeds the insertion loss rating of the connector to support additional connections in the channel and extended link distances.

It is critical to understand the impact of new technology and standards, and build flexibility into your network when migrating to 40G, 100G, and beyond. It is also important to get assistance from experts who understand the evolution of the data center environment and the latest network technology. Leviton works closely with many leading equipment manufacturers, is active in all next-generation standard developments, and can advise customers on their best possible migration strategy.

Learn more about our 24-fiber systems and data center design services at Leviton.com/datacenter.

Interferometer Testing of 24-Fiber Connector



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