

# **High Density Fiber Connection with Very Small Form Factor Connector for Over 51.2Tbps Co-Packaged Optics**

**Teruhiko Omori, Manager  
Optical Component Division  
Fujikura Ltd.**

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- 1. Demand of High Density Fiber Connection for CPO**
- 2. MDC and MMC – a Very Small Form Factor Connector**
- 3. Characteristics of MMC**
- 4. Applications - Reduced Cladding Fiber and MMC Jr.**
- 5. Summary**

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# Demand of High Density Fiber Connection for CPO

Decade of Switch Silicon, SerDes, + Parallel Optics

## Relentless Advancement – Switch Silicon Bandwidth

Represents a combination of multiple chip families and architectures to provide historical context and future projections



2010-2022:

- 80X Switch Silicon Bandwidth Increase
- 10X Optics Bandwidth Increase
- Result: 8X fiber (or  $\lambda$ ) increase per switch

Source: Cisco / SP360: Service Provider /Co-Packaged Optics and an Open Ecosystem; R. Chopra US Conec Ltd., /Optical Connectivity Considerations for Co-Packaged Optics; Tom Mitcheltree

# Demand of High Density Fiber Connection for CPO

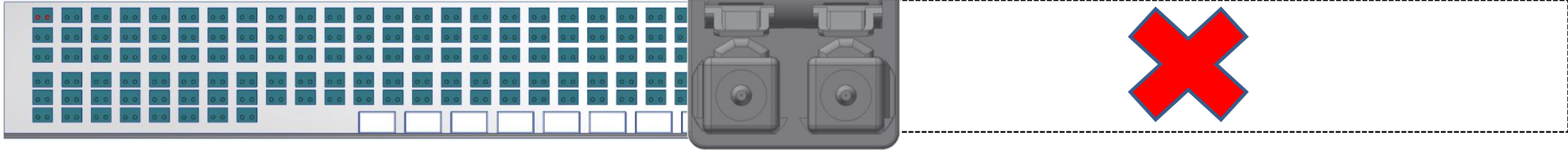
## Front Panel Density Considerations: 1<sup>st</sup> Gen - 51.2TB CPO

FR 256f

DR 1024f

128 Duplex LC's → 2RU

512 Duplex LC's → 8RU??



16 MPO-16's → 1RU

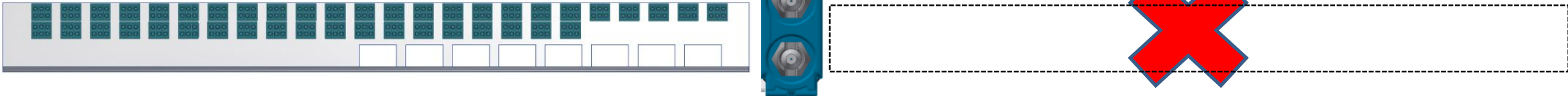
64 MPO-16's → 1RU



not enough utility area.

128 MDC's → 1RU

512 MDC's → 2-3RU??



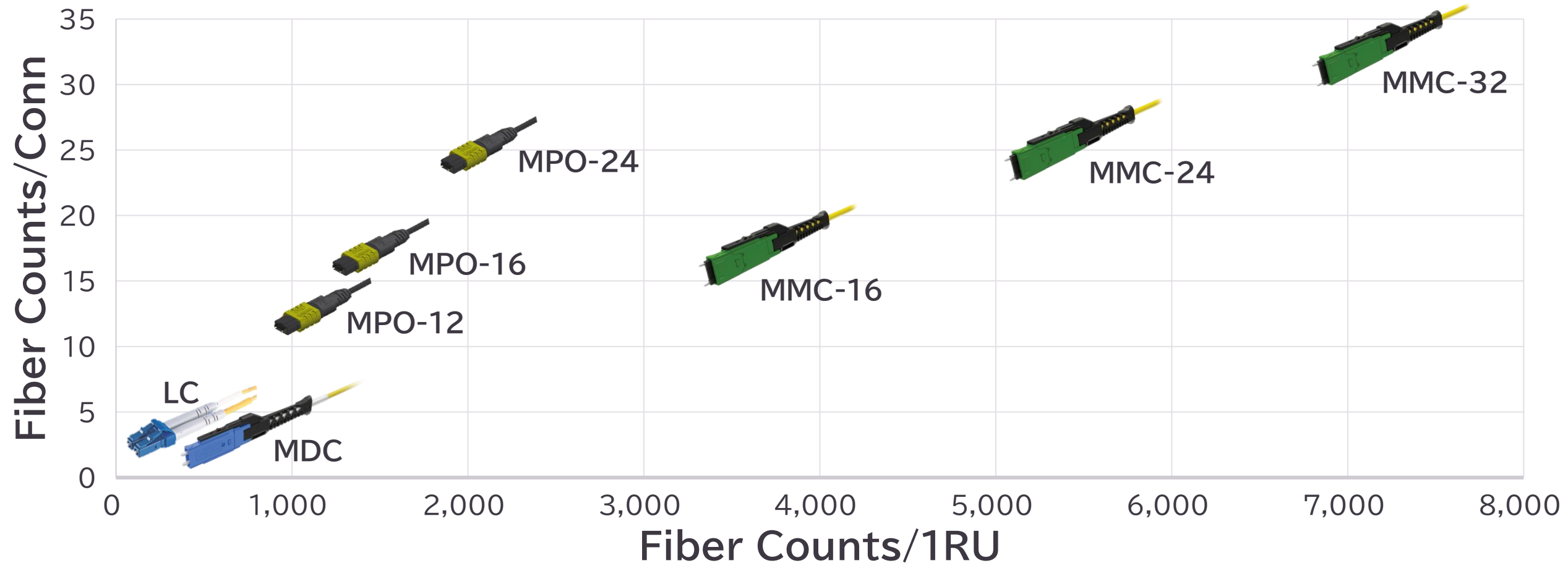
16 MMC-16's → 1RU

64 MMC-16's → 1RU



# Demand of High Density Fiber Connection for CPO

Connector Type	DxLC	MDC	MPO-12	MPO-16	MPO-24	MMC-16	MMC-24	MMC-32
Fiber Counts/Conn	2	2	12	16	24	16	24	32
Fiber Counts/1RU	144	432	960	1,280	2,560	3,456	5,184	6,912



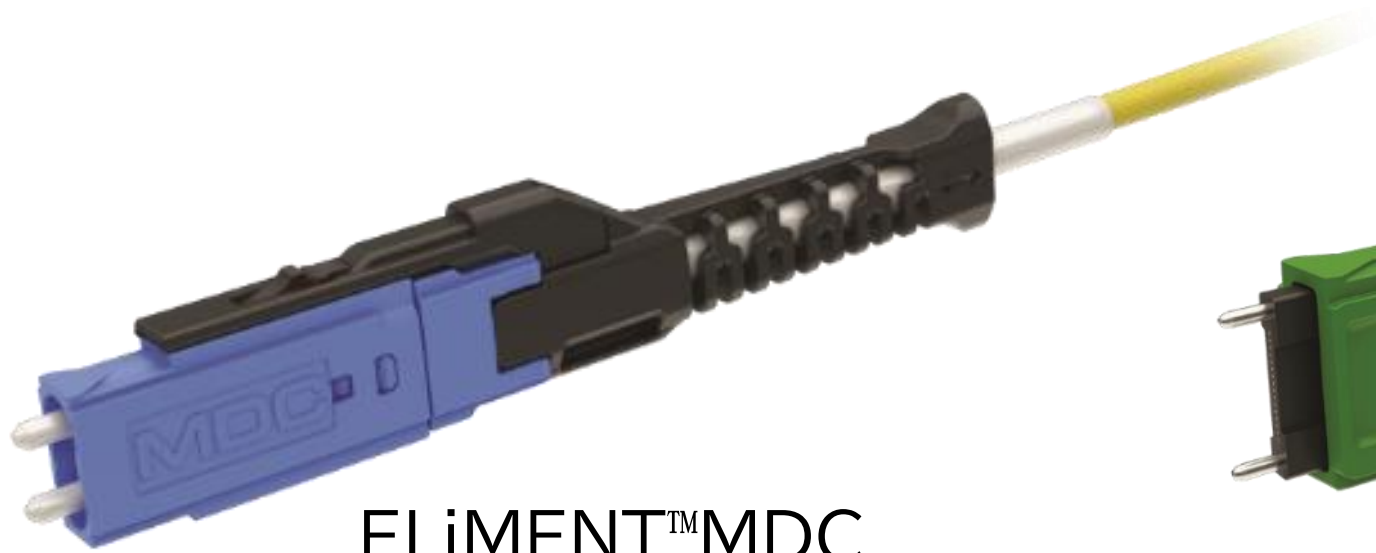
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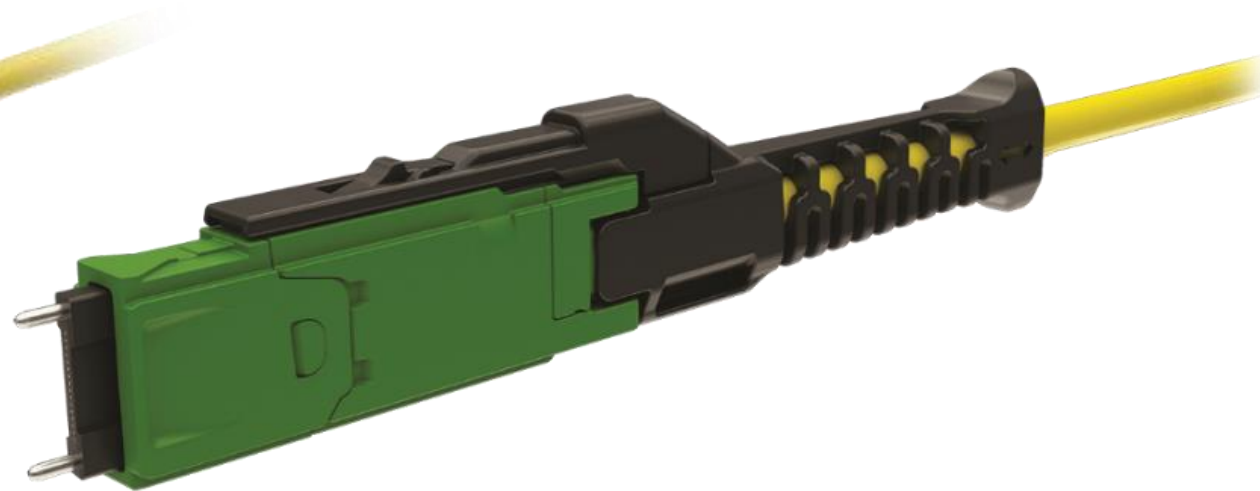
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# Very Small Form Factor Connector

- ✓ USConec and Fujikura collaborate to develop next generation miniature optical connector (MMC/MDC) solutions



ELiMENT™ MDC



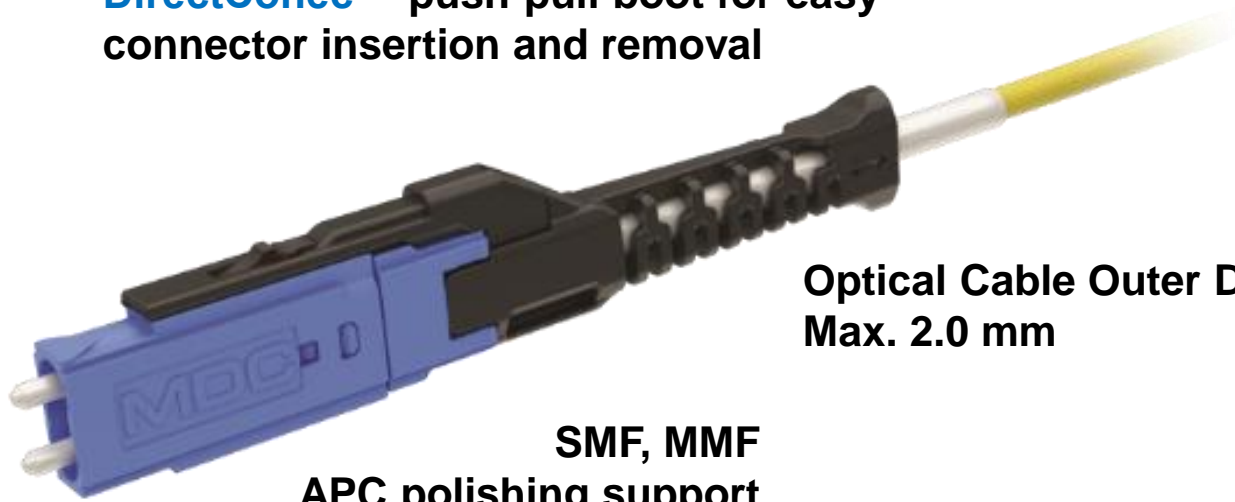
Mini-Multi-Connector

[ELiMENT™, a trademark of US Conec Ltd.](#)



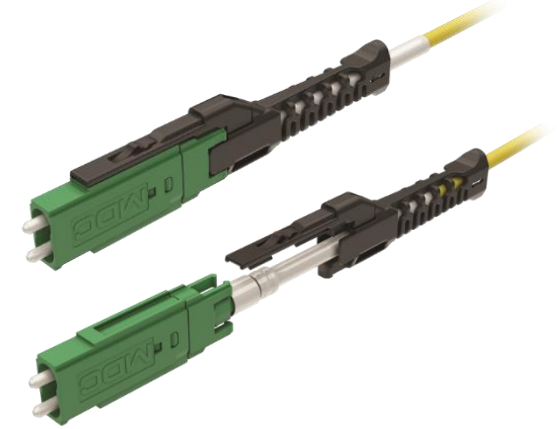
# Very Small Form Factor Connector

**DirectConec™** push-pull boot for easy connector insertion and removal



Optical Cable Outer Diameter  
Max. 2.0 mm

SMF, MMF  
APC polishing support



No exposed optical fiber  
Easy polarity conversion

- **QSFP-DD/SFP-DD/OSFP MSA specified optical interface**
- **Complies with IEC standard insertion loss class B (max. value 0.25 dB @  $\geq 97\%$ )**
- **Compliant with Telcordia GR-326 and TIA-568**
- **One-Click® for MDC/IBC™ Optical connector cleaner**

[ELiMENT™, a trademark of US Conec Ltd.](#)



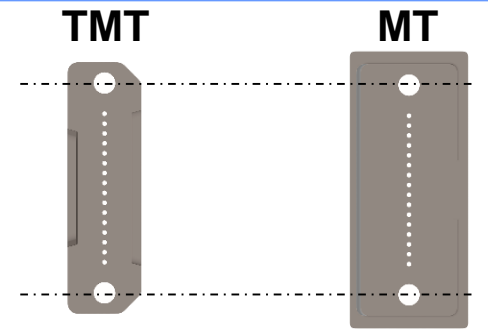
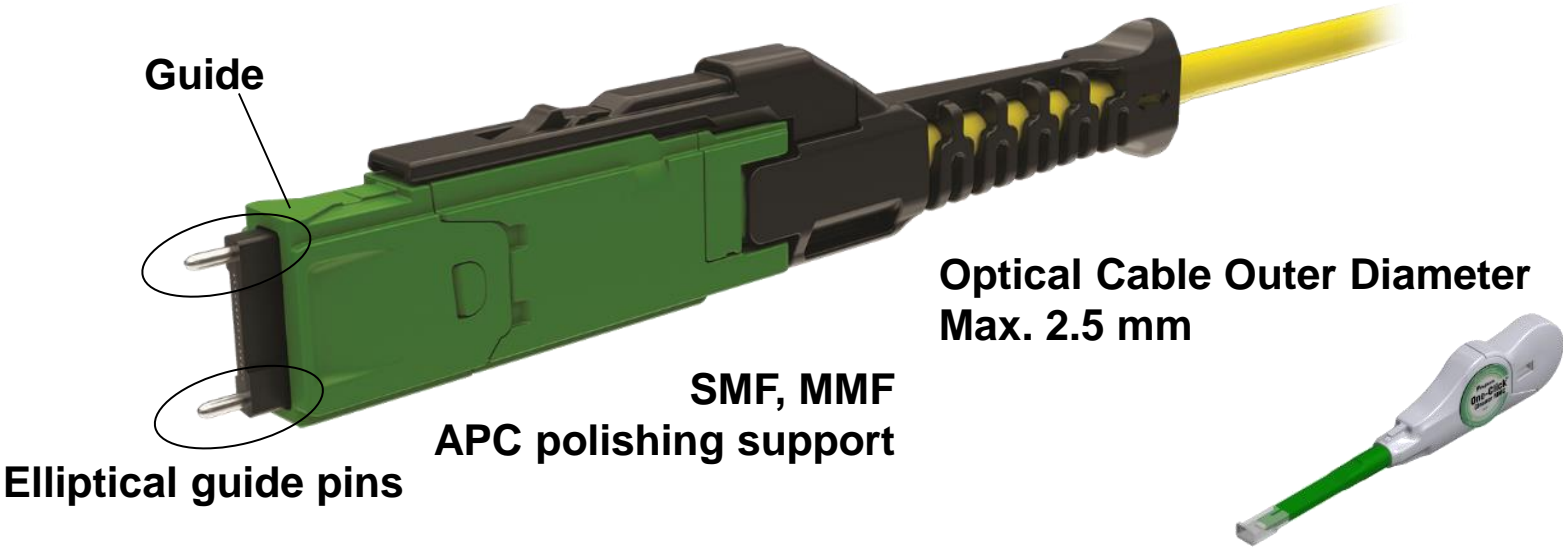
ELiMent™ MDC

Duplex LC

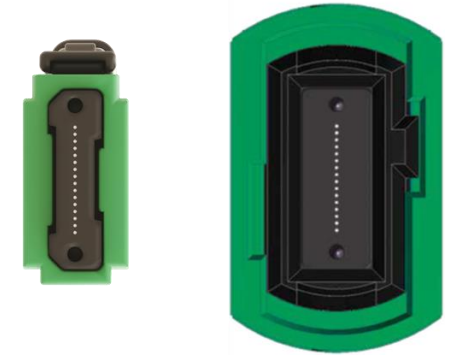
**3x cabling port density over the Duplex LC connector**

# Very Small Form Factor Connector

**DirectConec™** push-pull boot for easy connector insertion and removal



- Proven conventional MT mechanical and fiber alignment structure
- Compatible with standard 250 micron OD and pitch optical fibers

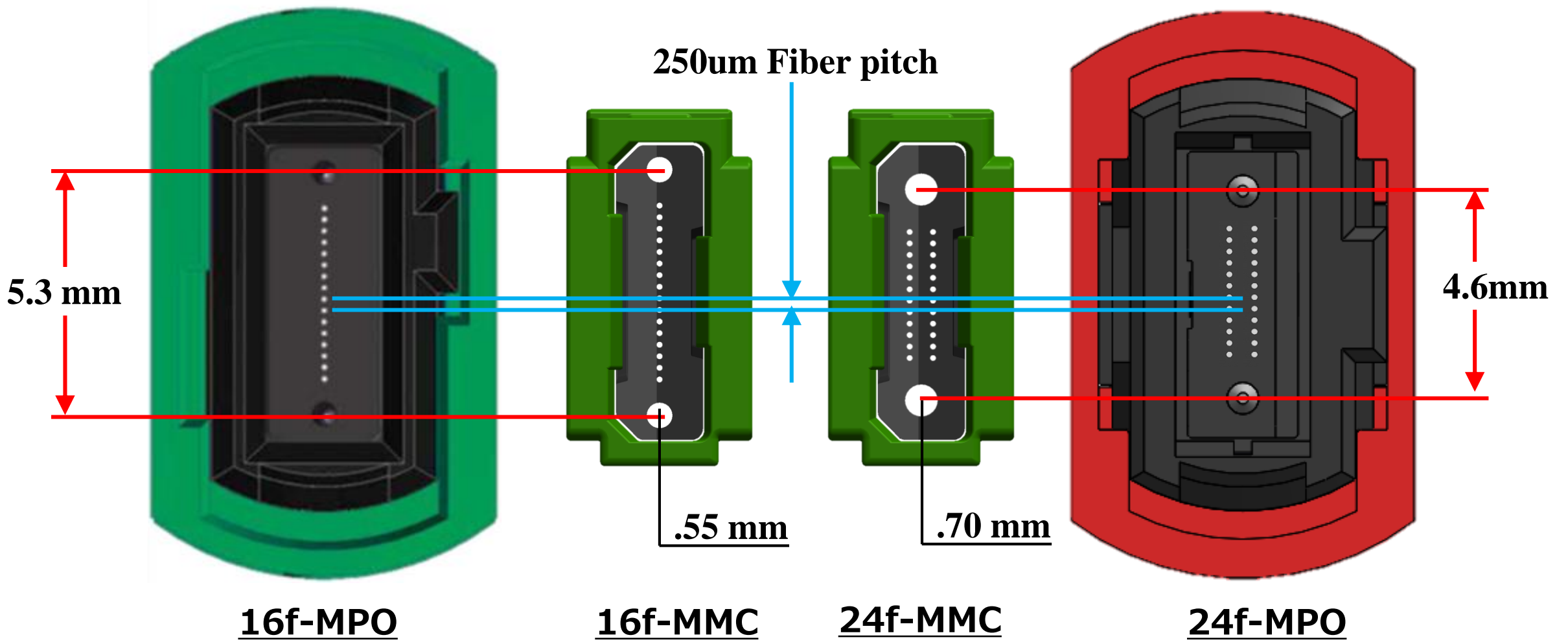


MMC MPO  
**3x cabling port density over the MPO format**

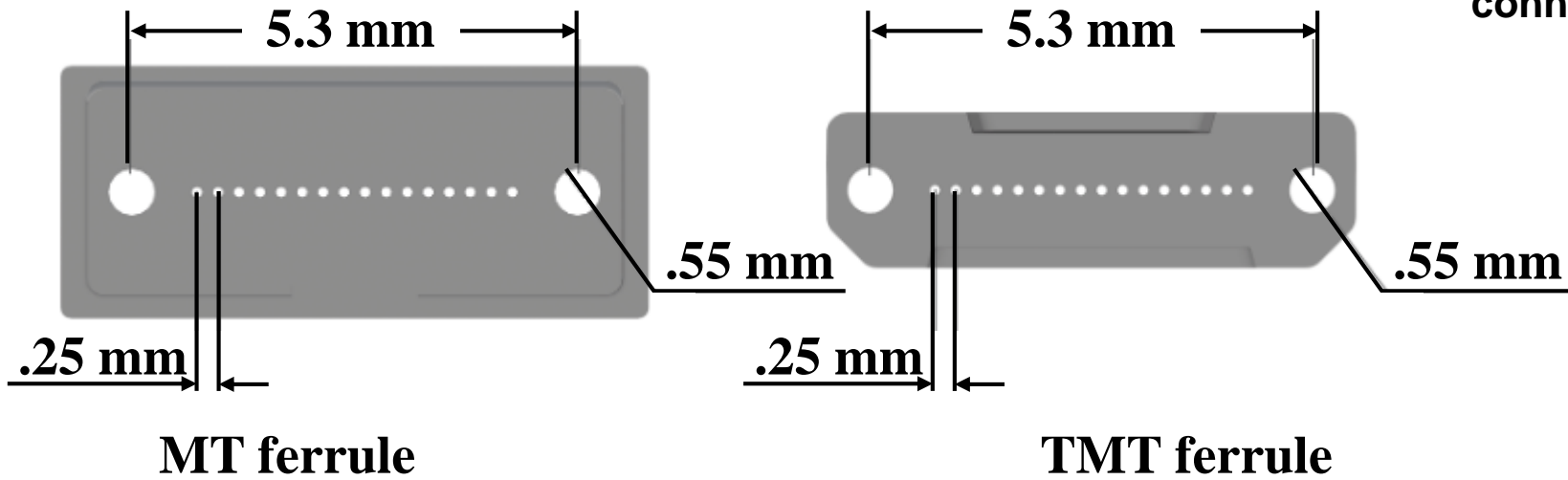
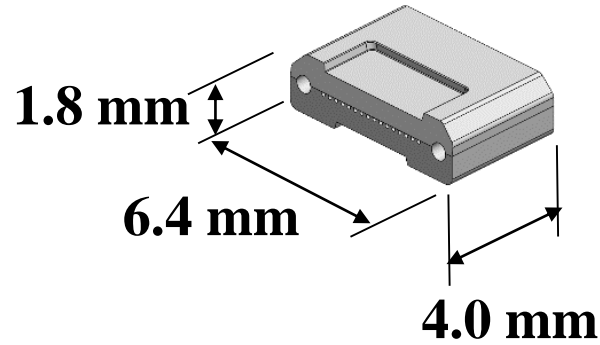
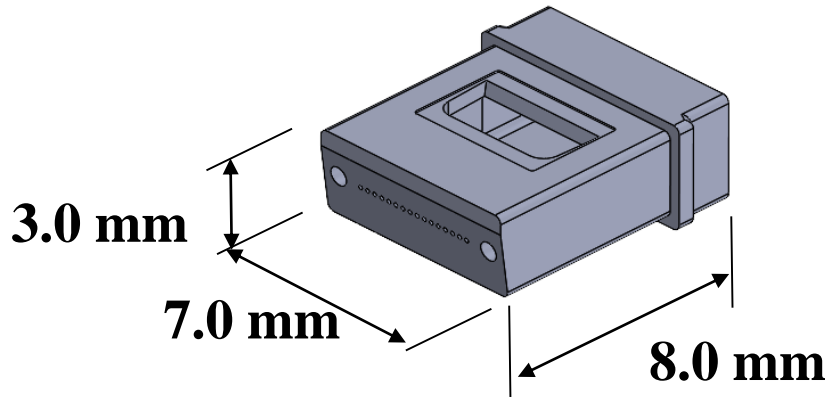
- Low-loss, IEC Grade B insertion loss performance
- Compliant with Telcordia GR-1435 (expected)
- Standard cabling industry infrastructure support including IBC™/One-Click™ **cleaners, polishers, interferometers, and optical testing equipment**

# Very Small Form Factor Connector

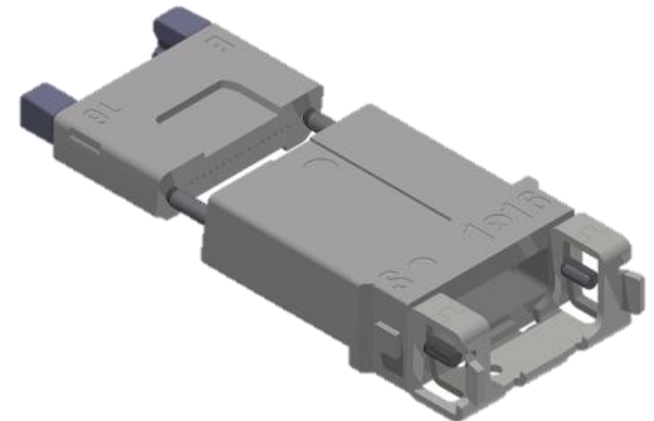
➤ MMC was designed to be fully compatible pin and fiber alignment with MPO format



# Very Small Form Factor Connector



- Proven alignment structure of MT-16 and Intermateable with MT-16 technology
- 16 fibers at 250 micron pitch.
- Compatible with 250, 200, and 165 micron fibers.
- Ideal for on-board fiber management, as well as transceivers and hardened connector embodiments.

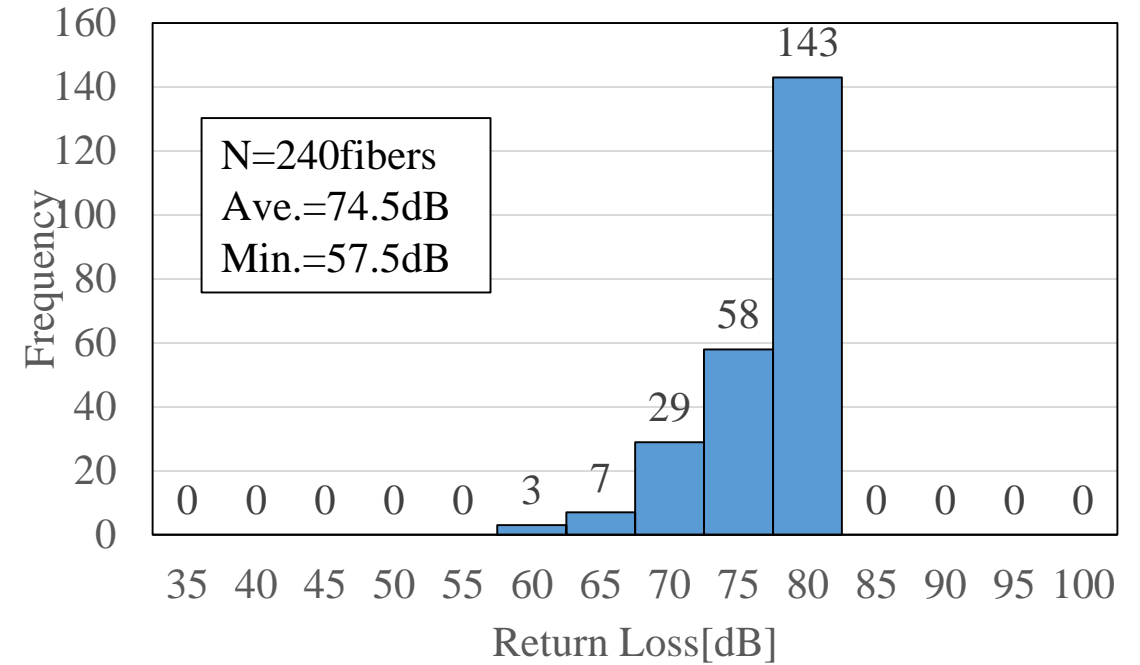
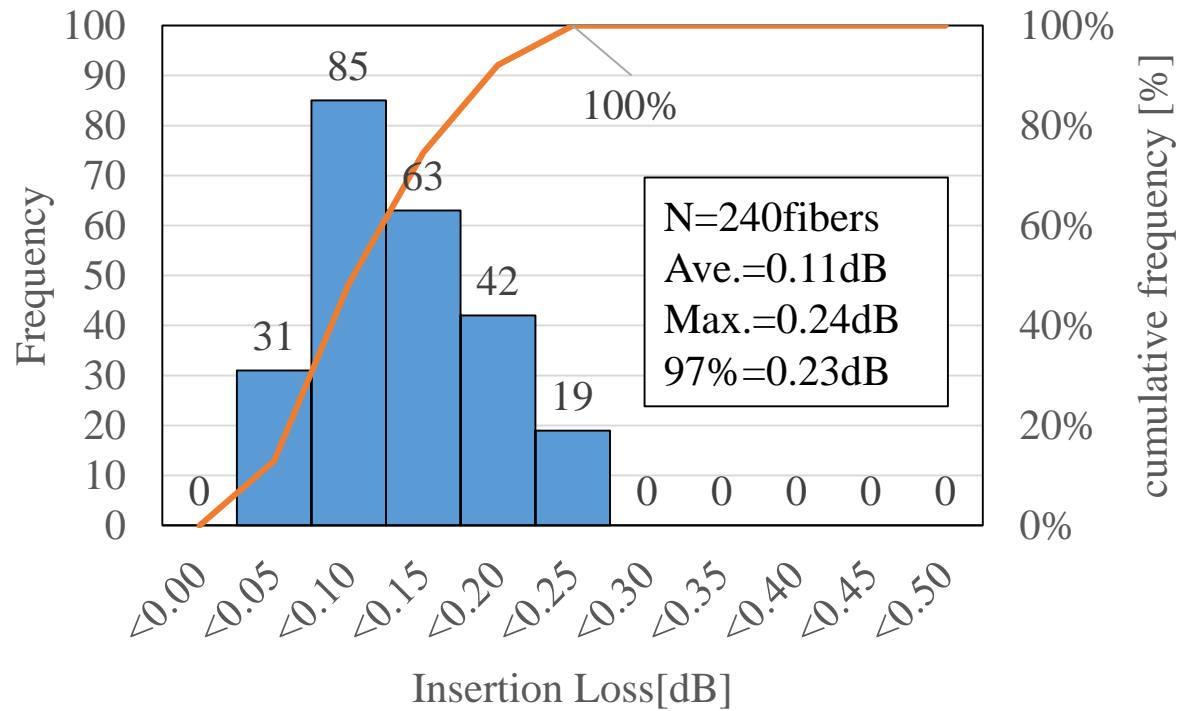


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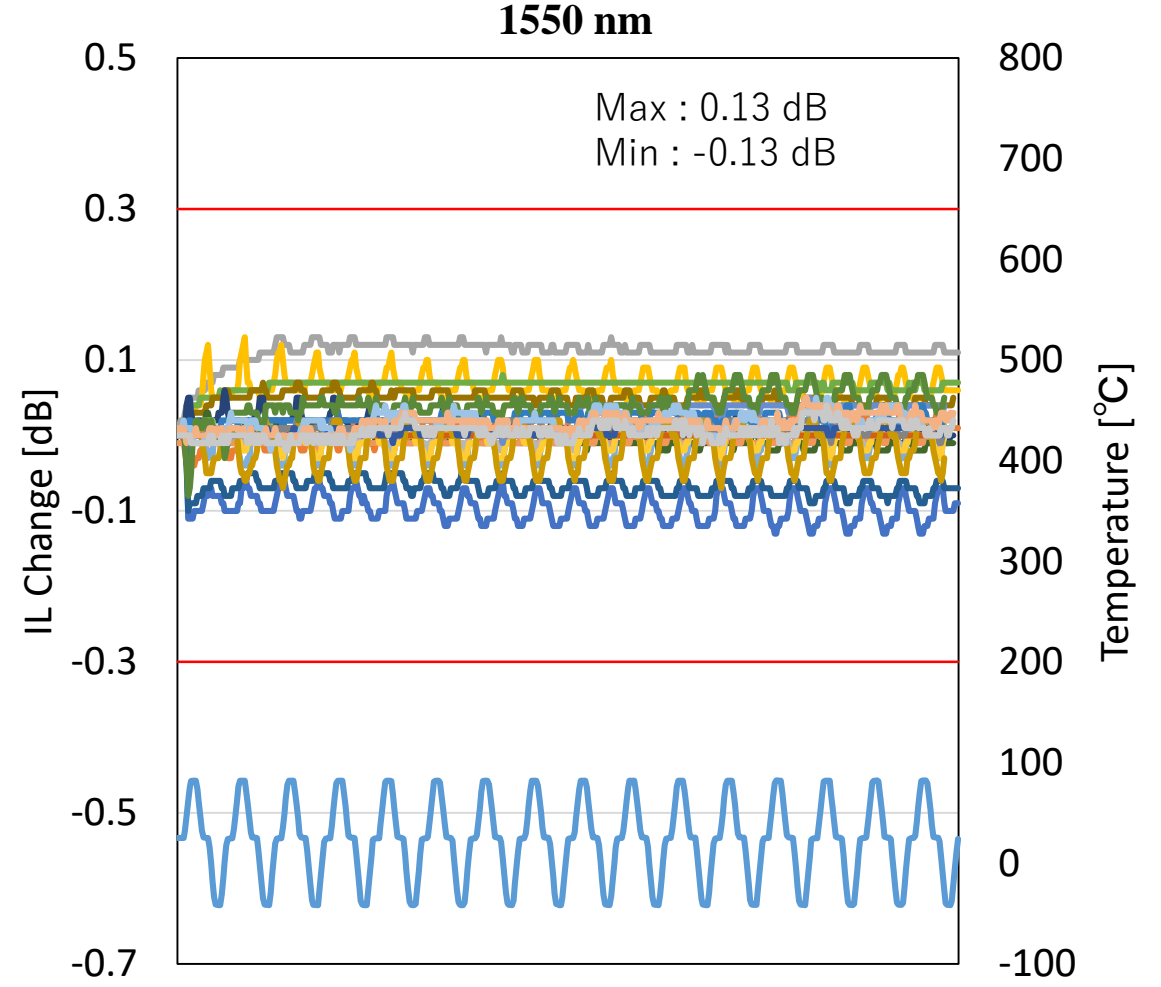
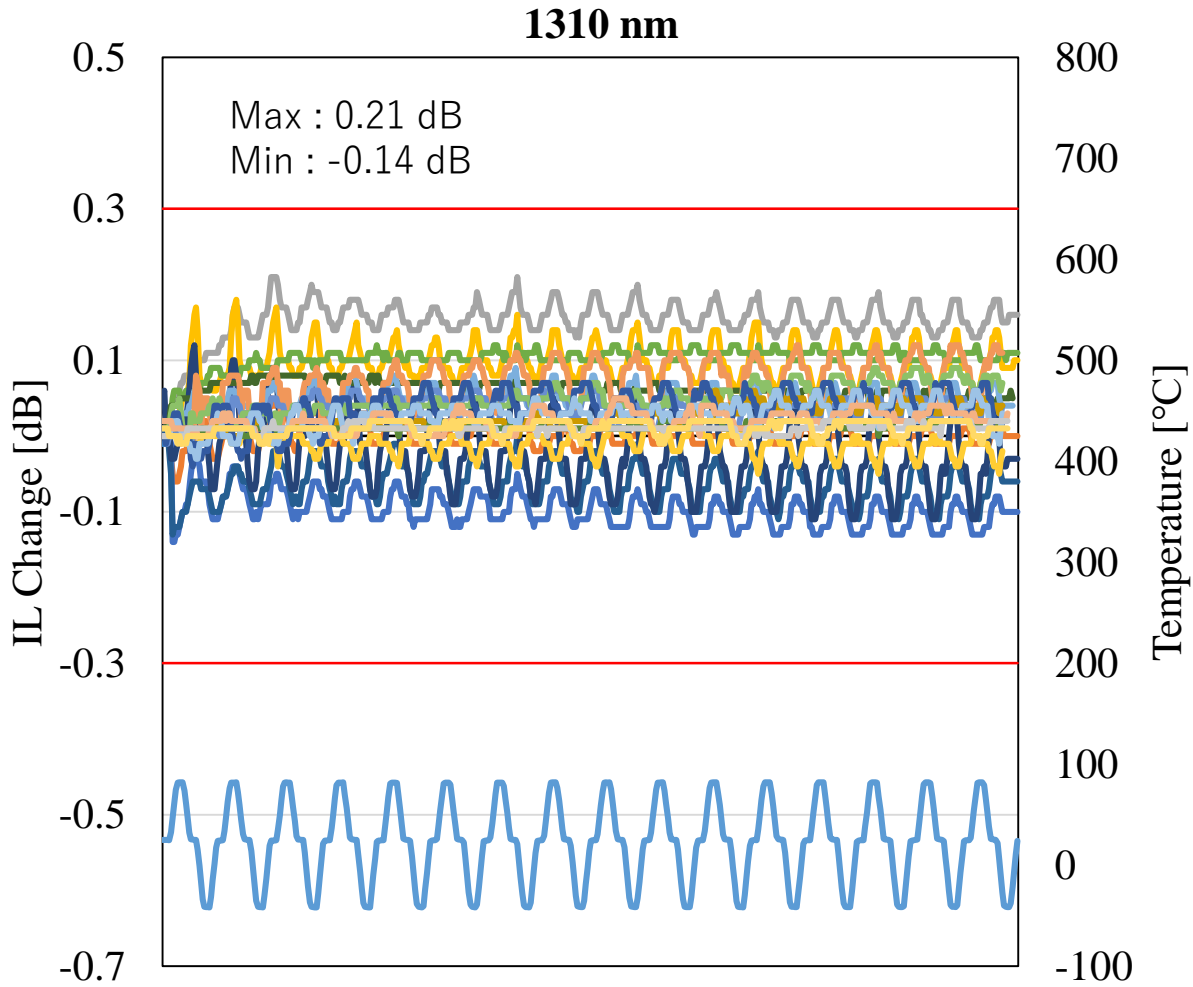
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# Optical performance 1x16 MMC, 1310nm



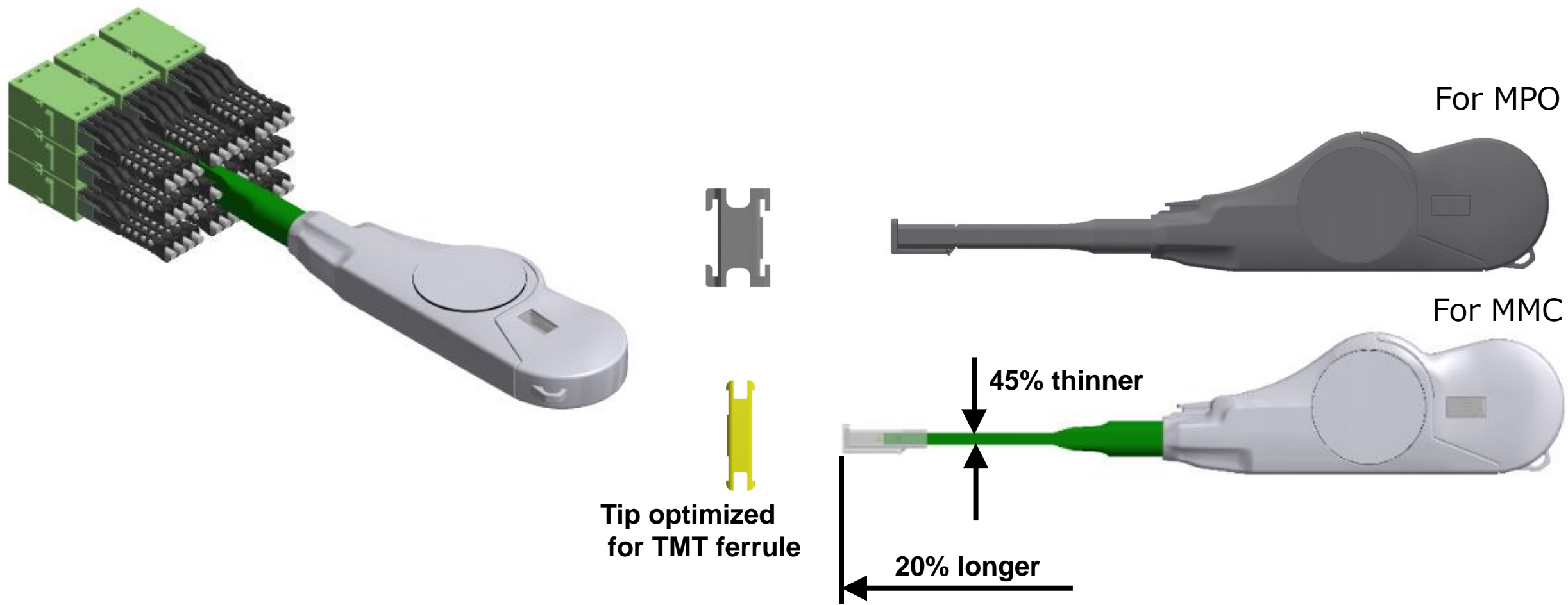
- N ...Sample size of fibers
- Ave. ...Average of all IL and RL measurements
- Max. ...Maximum value of all IL measurements
- <97%. ... Value that ranks 97% in the IL measurement data sorted from the smallest to the largest
- Min. ...Minimum value of all RL measurements

# Environmental Testing



# Structure and Design : MMC Cleaner

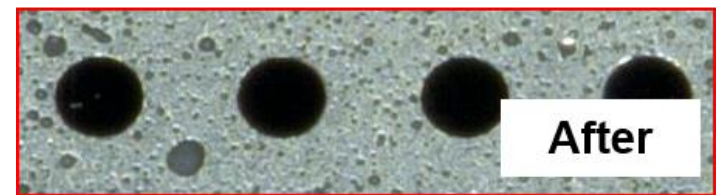
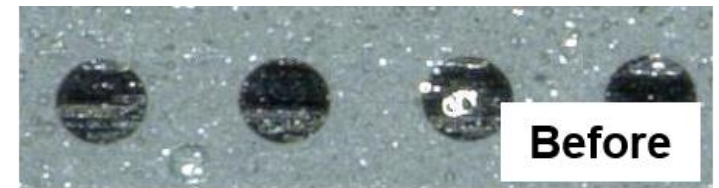
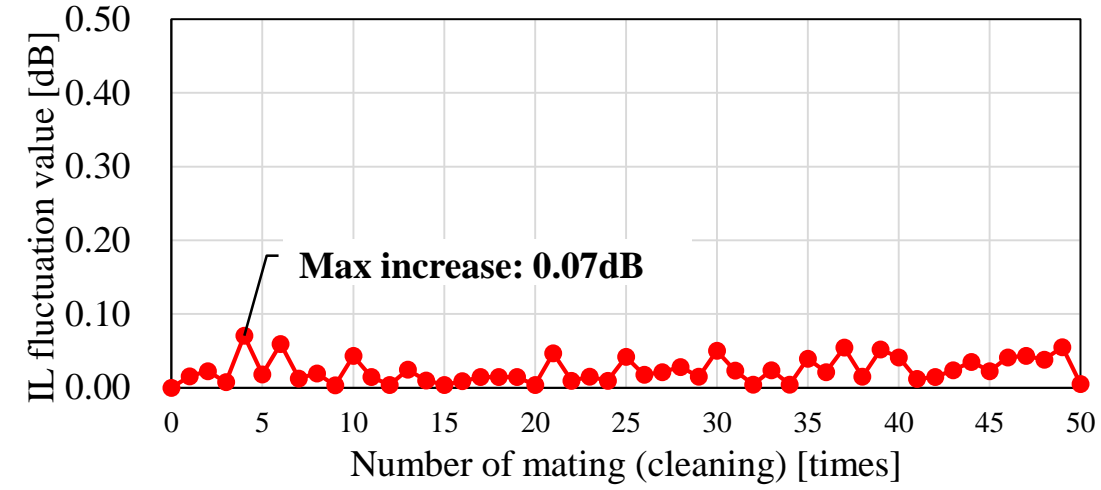
➤ The MMC Cleaner is designed to clean high-density connectors one port



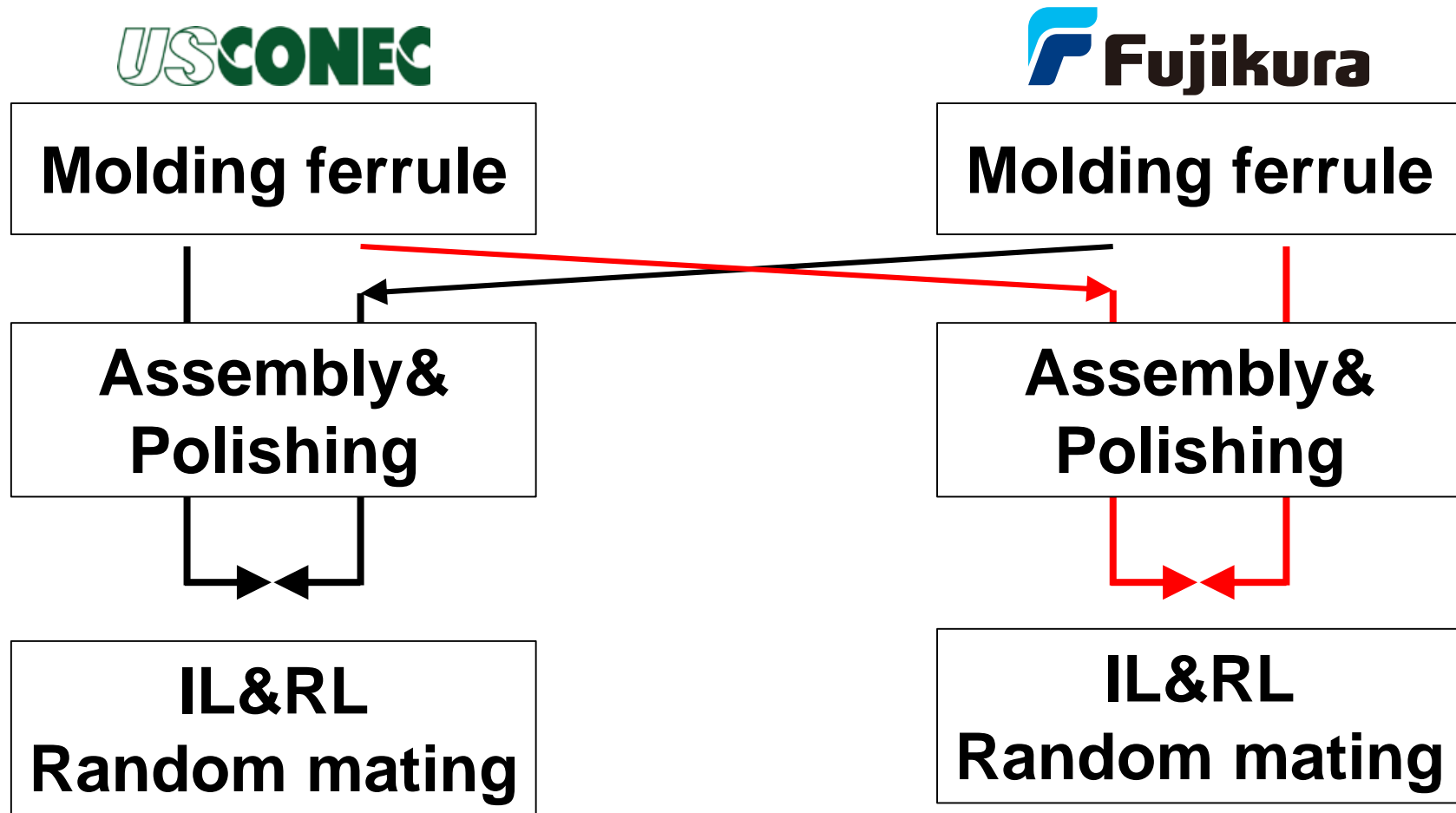


# Mechanical Testing

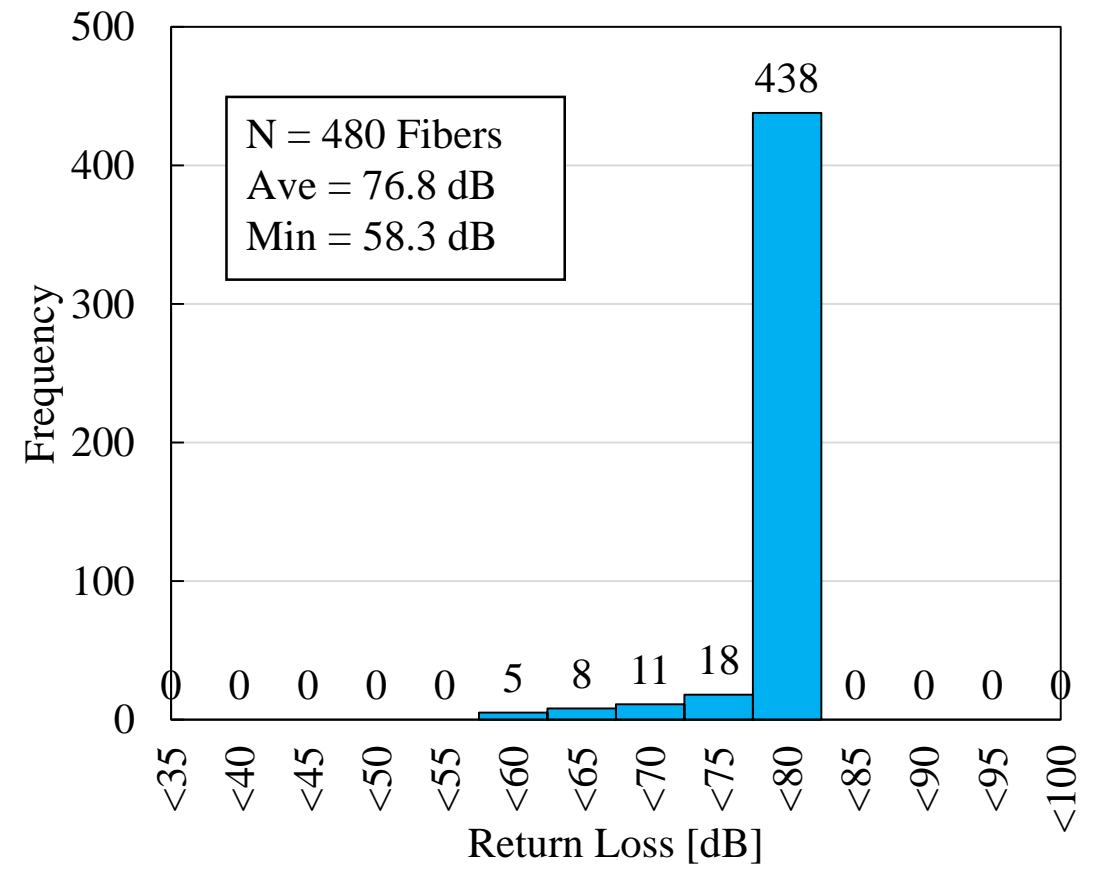
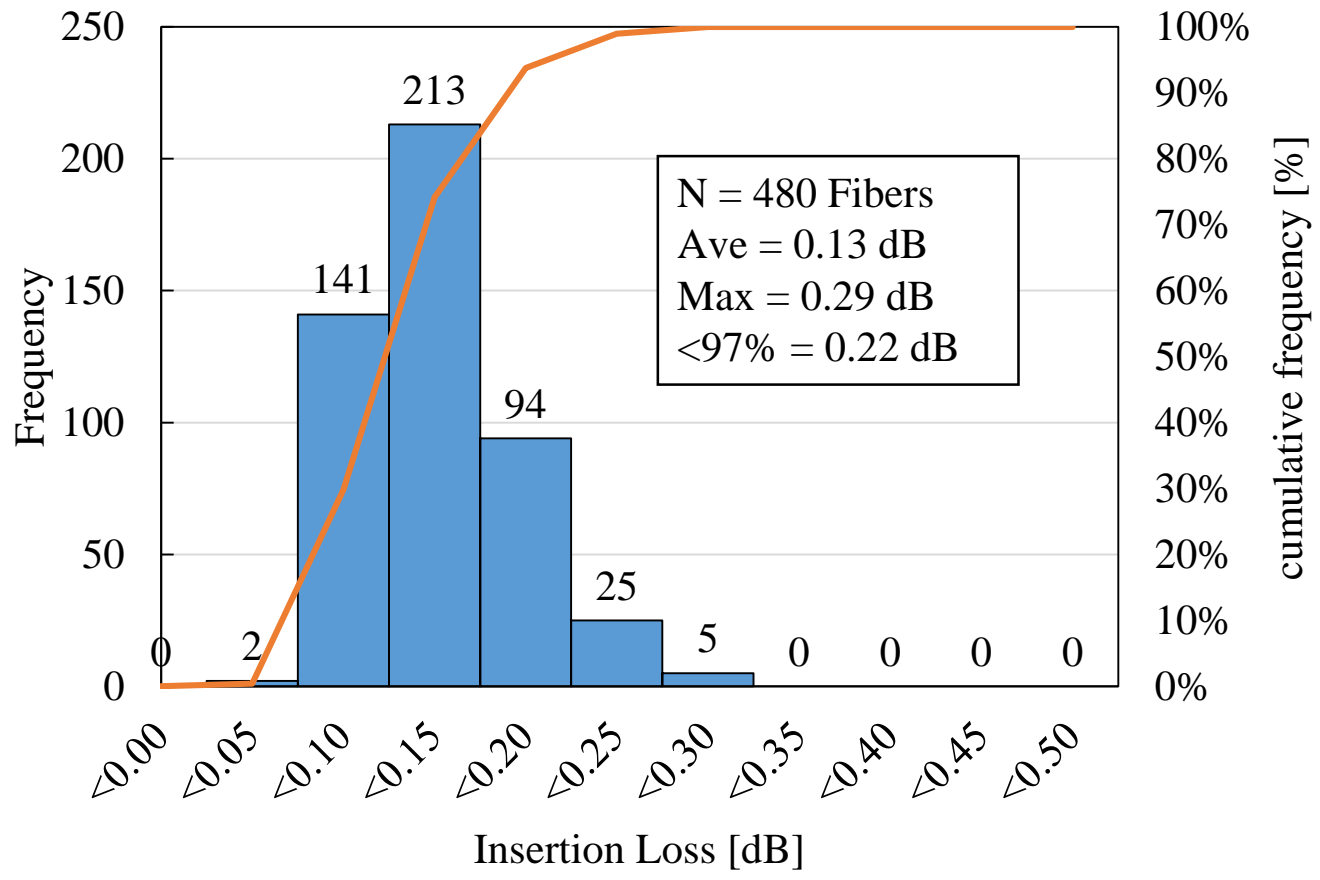
Test		Criteria	Results
Vibration		IL $\leq$ 0.8 dB, IL change $\leq$ 0.3dB RL $\geq$ 50dB	IL $\leq$ 0.35 dB IL change $\leq$ 0.25 dB RL $\geq$ 55.3 dB
Flex		IL $\leq$ 0.8 dB IL change $\leq$ 0.3dB RL $\geq$ 50dB	IL $\leq$ 0.51 dB IL change $\leq$ 0.16 dB RL $\geq$ 56.4 dB
Twist		IL $\leq$ 0.8 dB IL change $\leq$ 0.3dB RL $\geq$ 50dB	IL $\leq$ 0.50 dB IL change $\leq$ 0.01 dB RL $\geq$ 56.3 dB
Transmission with Applied Load	Measure w/Load (0deg)	<ul style="list-style-type: none"> <li>After test IL <math>\leq</math> 0.8 dB IL change <math>\leq</math> 0.3dB RL <math>\geq</math> 50dB</li> <li>During Applied Load IL change <math>\leq</math> 0.5dB RL <math>\geq</math> 50dB</li> </ul>	<ul style="list-style-type: none"> <li>After test IL <math>\leq</math> 0.50 dB IL change <math>\leq</math> 0.08 dB RL <math>\geq</math> 66.3 dB</li> <li>During Applied Load IL change <math>\leq</math> 0.09 dB RL <math>\geq</math> 66.4 dB</li> </ul>
	Measure w/Load (90deg)	<ul style="list-style-type: none"> <li>After test IL <math>\leq</math> 0.8 dB IL change <math>\leq</math> 0.3dB RL <math>\geq</math> 50dB</li> <li>During Applied Load IL change <math>\leq</math> 0.5dB RL <math>\geq</math> 50dB</li> </ul>	<ul style="list-style-type: none"> <li>After test IL <math>\leq</math> 0.59 dB IL change <math>\leq</math> 0.09 dB RL <math>\geq</math> 66.6 dB</li> <li>During Applied Load IL change <math>\leq</math> 0.04 dB RL <math>\geq</math> 66.2 dB</li> </ul>
Impact		IL $\leq$ 0.8 dB IL change $\leq$ 0.3dB RL $\geq$ 50dB	IL $\leq$ 0.58 dB IL change $\leq$ 0.16 dB RL $\geq$ 62.1
Durability		IL $\leq$ 0.8 dB IL change $\leq$ 0.3dB RL $\geq$ 50dB	IL $\leq$ 0.18 dB IL change $\leq$ 0.07dB RL $\geq$ 68.1



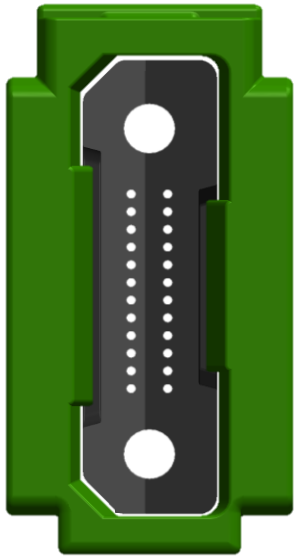
# Intermateability - condition



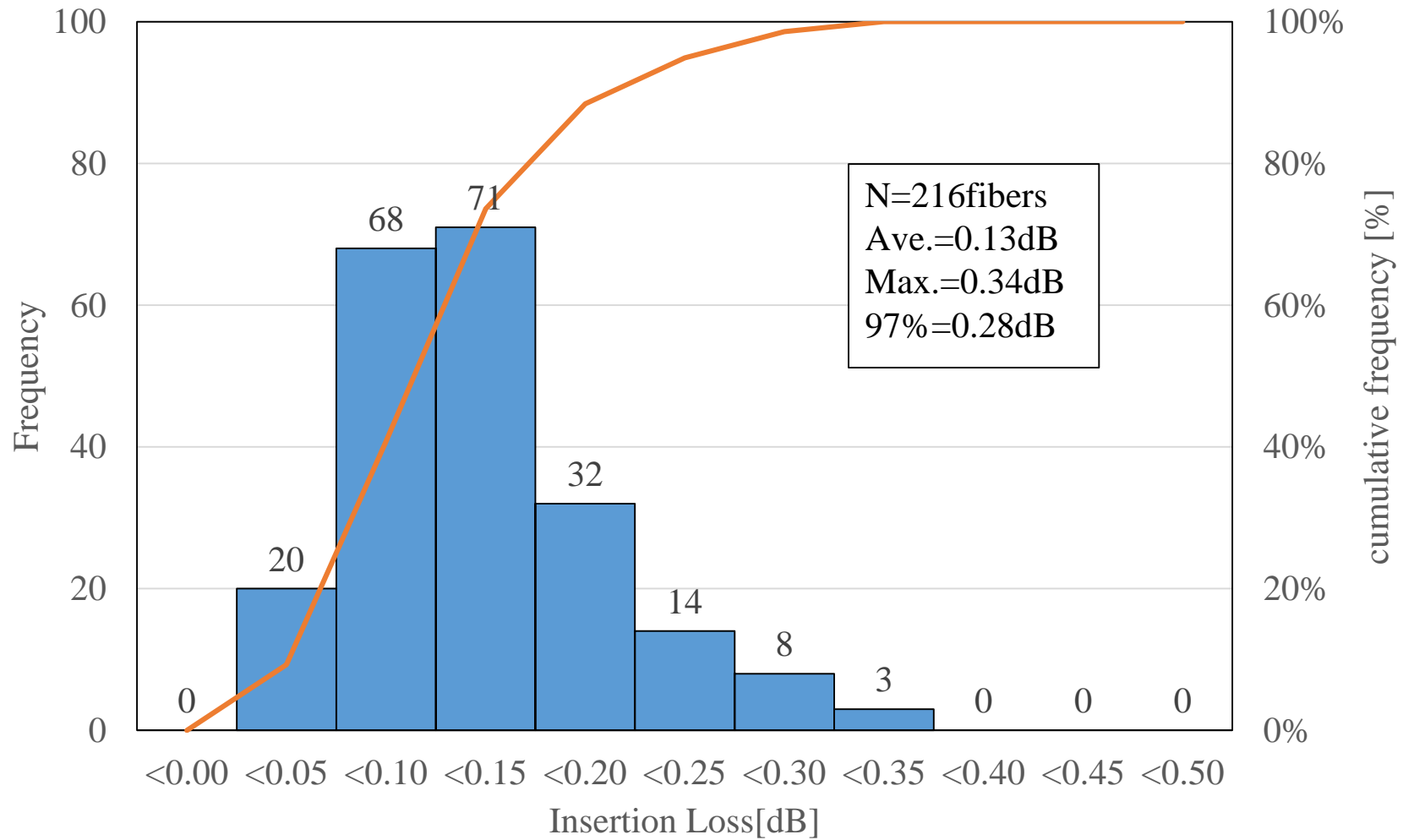
# Intermateability - Results



# Preliminary 2-row MMC results



**24f-MMC**



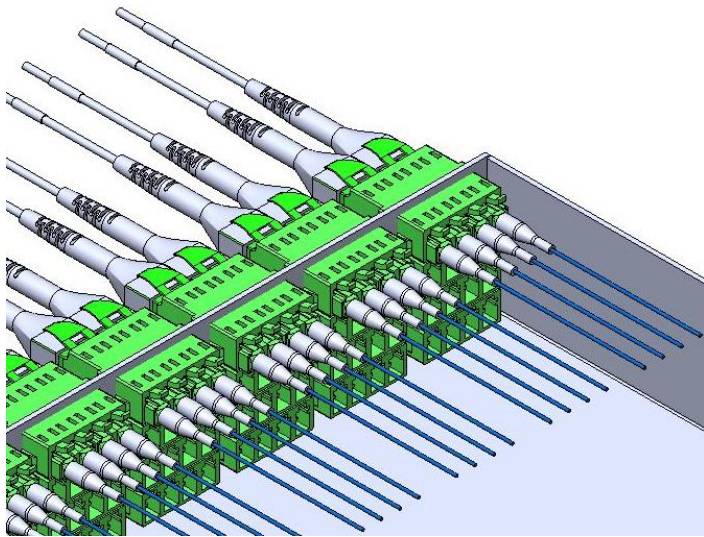
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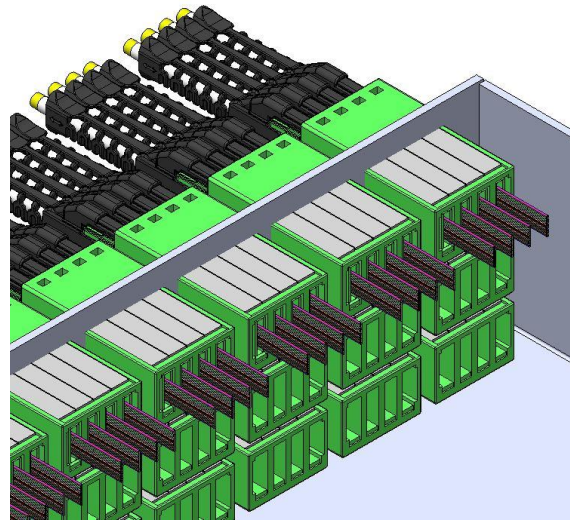
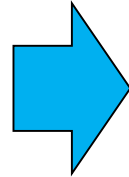
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# MMC Jr. (Inside Box) and Bundled Connector (Patch)

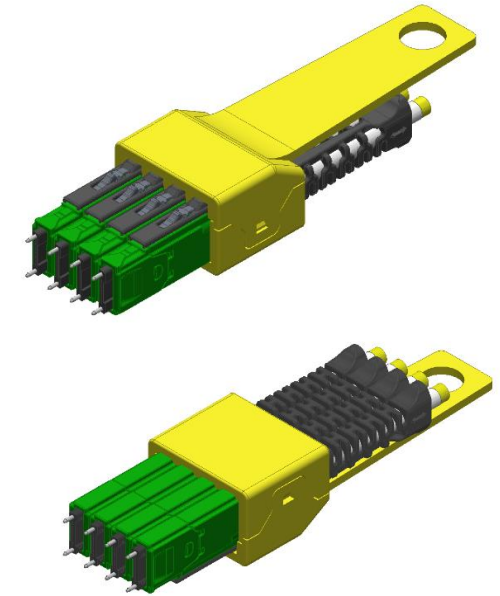
- ✓ Much more fiber density inside box application compare with LCs or MPOs
- ✓ More room to manage fibers inside box
- ✓ Bundled MMC connector for easy to operate outside box patching



Conventional LC



MMC Jr.

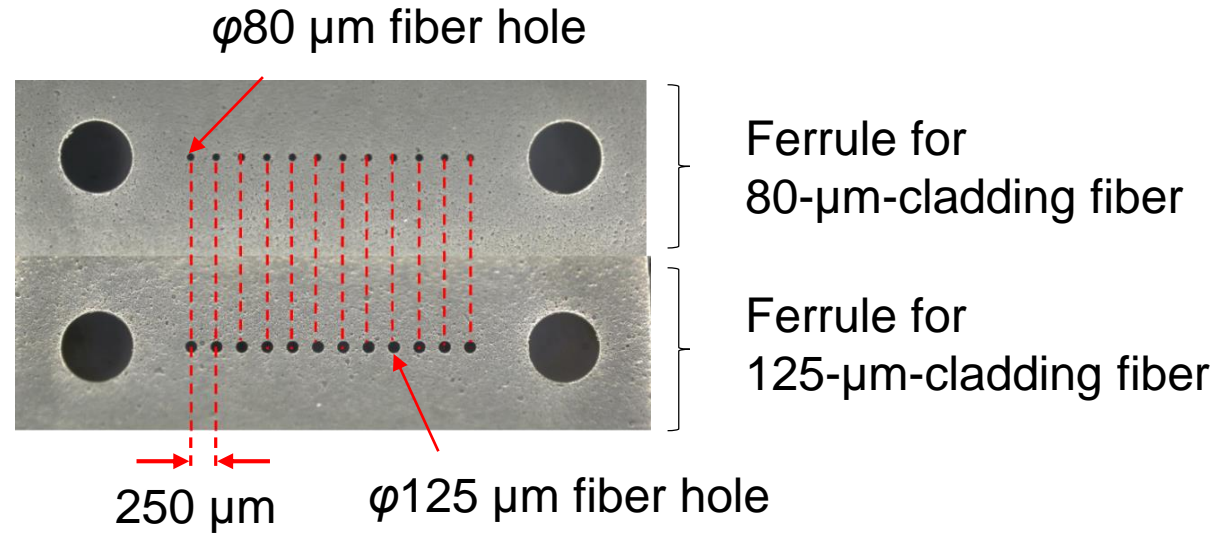
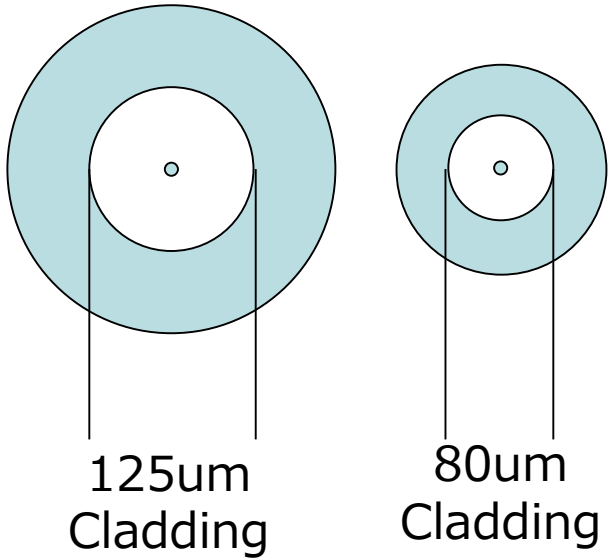


Bundled MMC Connector

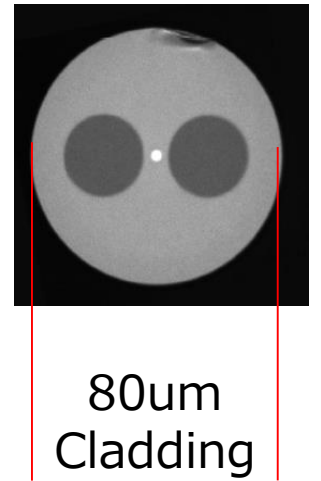
Much more room to manage fibers inside box

# Reduced Cladding Fibers Support

- ✓ MT ferrule base connector interface compatibility between conventional 125um cladding/250um pitch and 80um/250um pitch
- ✓ 80um PM fiber available with multiple MFD design for external light source



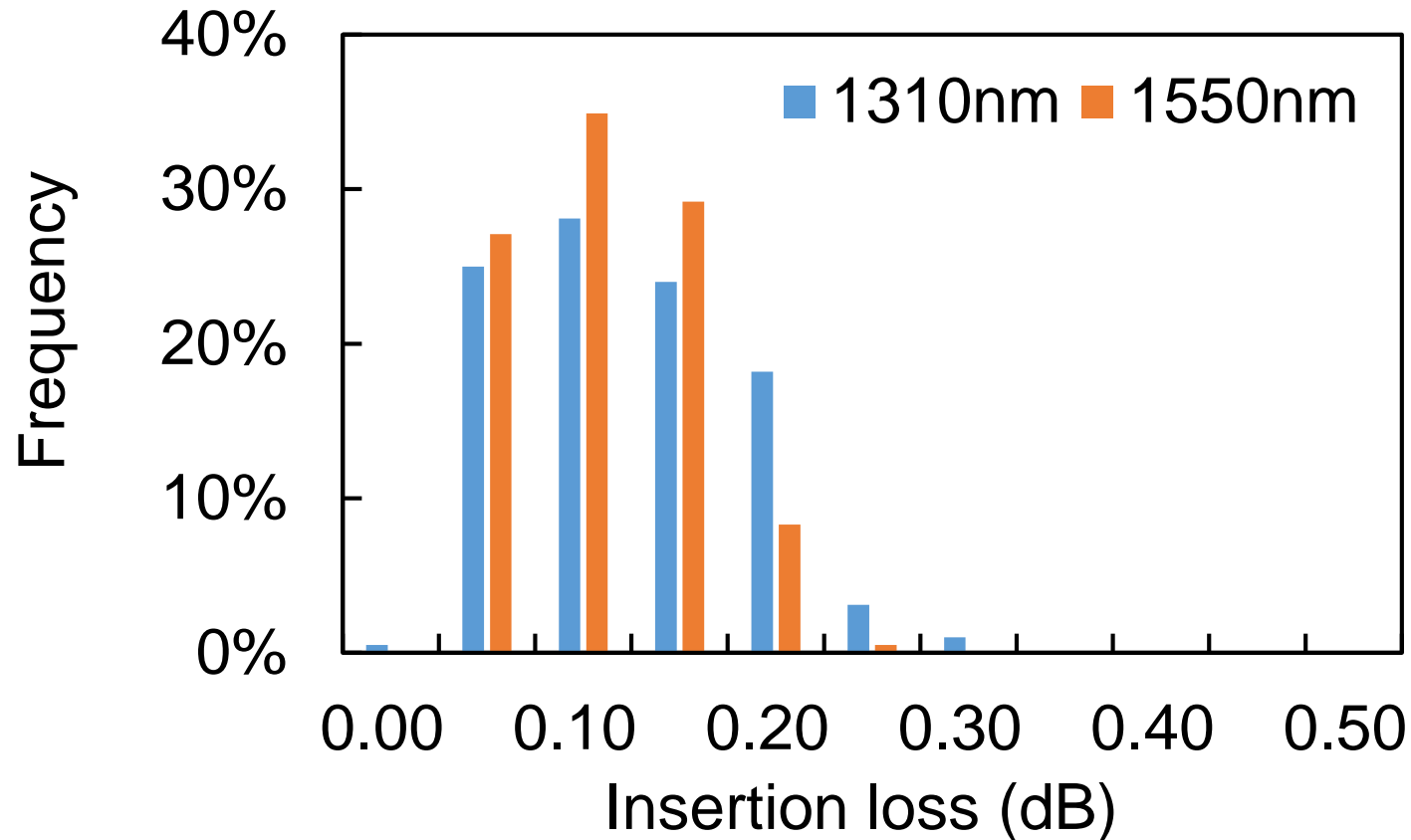
Endface Microscopic Image,  
Conventional size MT,  
80um cladding (top), 125um cladding(bottom)



PM Fiber Endface  
80um Cladding

# Reduced Cladding Fibers Support

Intermateability, 125um fiber to 80um SM fiber connection, conventional 12MT

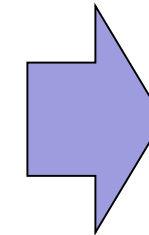




# Reduced Cladding Fibers Support with MMC

- ✓ Benefit of reduced cladding fiber MMC connector as CPO interface:  
Supporting near future higher densities Si-Photonics interface  
Supporting external laser light source by reduced cladding PM fiber

	Conventional 125um Cladding, 250um pitch	Reduced 80um Cladding, 250um pitch
1x16f		
2x12f		
2x16f		



<250um pitch for single  
raw 24f  
or future higher  
densities  
e.g. 2x24f

# Summary

- 1. Very small form factor connector like as MMC will be suitable for 102.4Tbps or above optical switch box interface**
- 2. Reduced cladding (i.e. 80um diameter) fiber supports future high density Si-Photonics chip**
- 3. Fiber system from 80um to 125um can be seamlessly designed not only with SM signal fiber, but also with PM light source fiber with 250um fiber pitch**

Shaping the future with “tsunagu” technology.



Optical Component Division



<http://www.opticalcomponent.fujikura.com/>