White Paper

Non-Contact MPO Fiber Optic Connector

The traditional physical contact MPO fiber connector requires that all fiber end faces achieve physical contact at the same time. Otherwise, there will be an unintended air gap between the optical fiber end faces, resulting in multiple reflections between the fiber end faces and seriously degrading the optical signal transmission. To achieve simultaneous physical contact for all fiber end faces, first all fiber end faces must protrude significantly from the surrounding ferrule surface through polishing, and then large working pressure must be exerted on the MPO connector so that the fiber end faces deform to allow all fiber end faces to make physical contact simultaneously. Because of the design, there are numerous problems with traditional MPO connectors.

Figure 1. Non-contact MPO fiber connector (left) has an anti-reflective coating on the end face, compared to a conventional contact MPO connector (right)

Arrayed Fiberoptics Corporation's Non-Contact MPO (NC-MPO) fiber connectors are coated with an anti-reflection coating on the end faces of the fibers and the ferrule surface (Fig. 1). All fiber ends are recessed below the ferrule surface to avoid physical contact when mated (Fig. 2). When the connectors are mated, there is an intentional small air gap between the end faces of the fibers. Unlike traditional MPO connectors in which the unintended air gaps between fiber end faces cause grave harm to fiber connector's connection reliability due to multiple reflections, the NC-MPO fiber connector is minimally affected by the ubiquitous unintended small air gaps because anti-reflection coating prevents multiple reflections. Therefore, the NC-MPO fiber connector is becoming recognized as an ideal multi-fiber optical connector, and this fiber connector operating mechanism works equally well for both single-mode and multimode fibers.

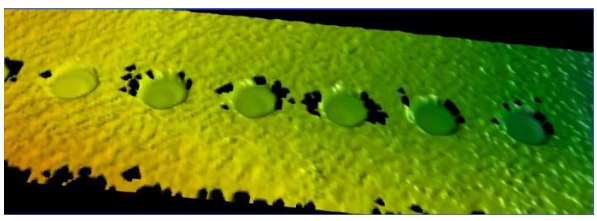


Figure 2. In a non-contact MPO fiber connector, the fiber end face is lower than the surrounding plastic ferrule surface (interferometer plot)

The insertion loss test and return loss test reported in this paper are performed using test

equipment model JGR-MS05B.

Experiment 1: SM NC-MPO connector mated to SM NC-MPO connector

Test Jumper:

A side: 12-core SM NC-MPO connector (8 degree, coating);

B side: 12-core SM MPO physical contact connector (8 degree, no coating).

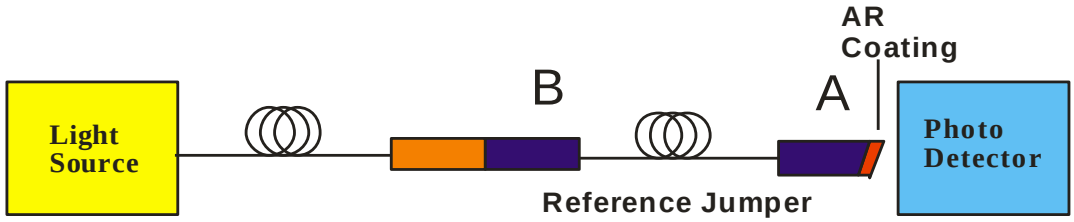
NC-MPO connector under test:

A side: 12-core SM NC-MPO connector (8 degree, coating);

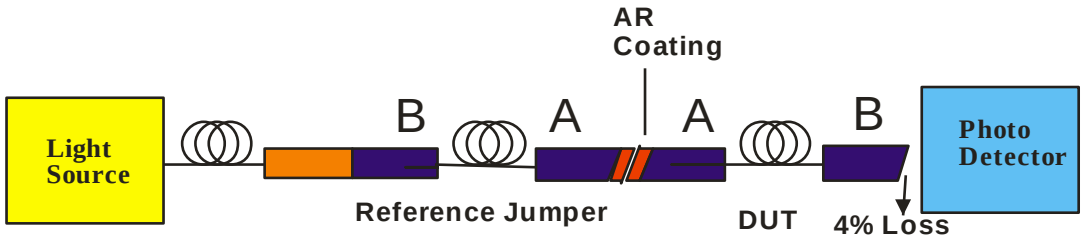
B-side: 12-core SM MPO physical contact connector (8 degree, no coating).

Test method is shown below where the red part denotes anti-reflection coating on the connector:

A) Reference measurement:



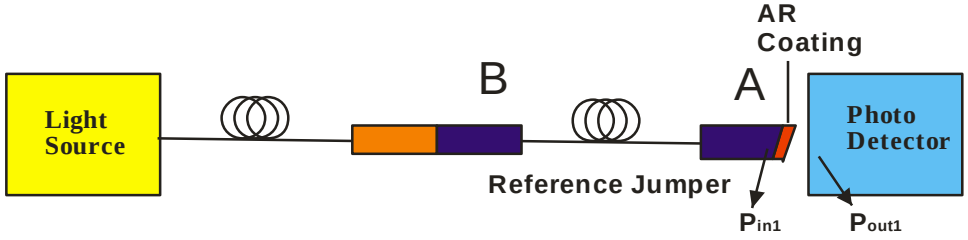
B) DUT measurement:



Due to the lack of reflection at the AR coated end face (see the next section), the insertion loss after mating needs to subtract 0.15 dB from the test value. Pout = Pin × (1-4%), Pout is the detection value of the photo detector, Pin is the actual insertion loss, loss of 4% is about 0.15dB.

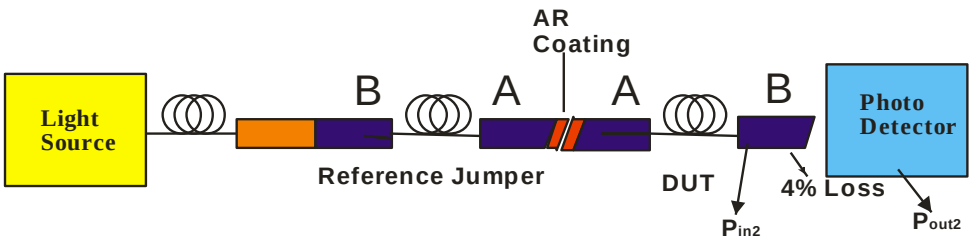
Test procedure for connectors with AR coating

At the reference measurement step, the A end of the reference jumper is an AR-coated connector. As a result of the AR coating, the A-side connector end face does not exhibit a 4% reflection loss. The photo detector receives power P_{out1} which is equal to the power P_{in1} at the output of the A-side connector.



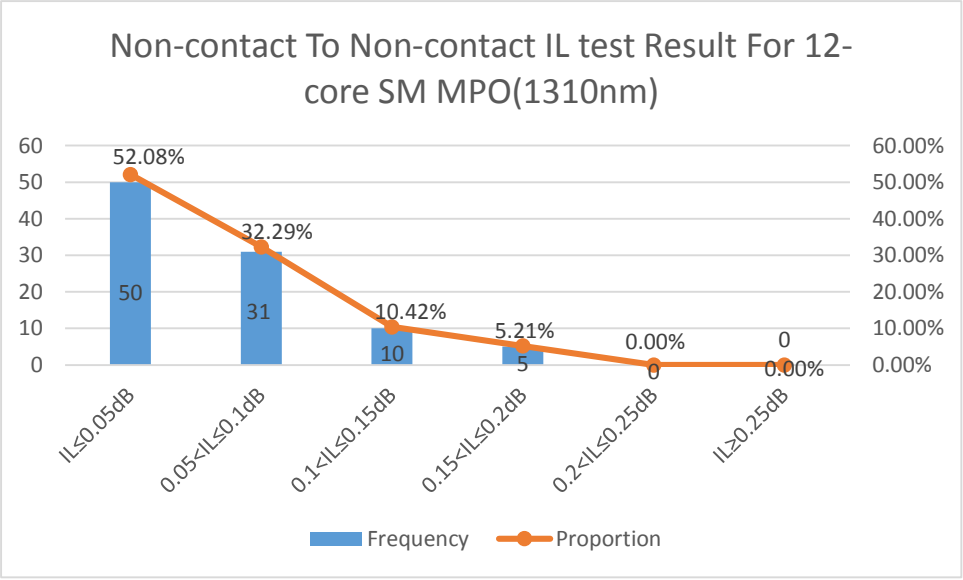
$P_{in1}=P_{out1}$

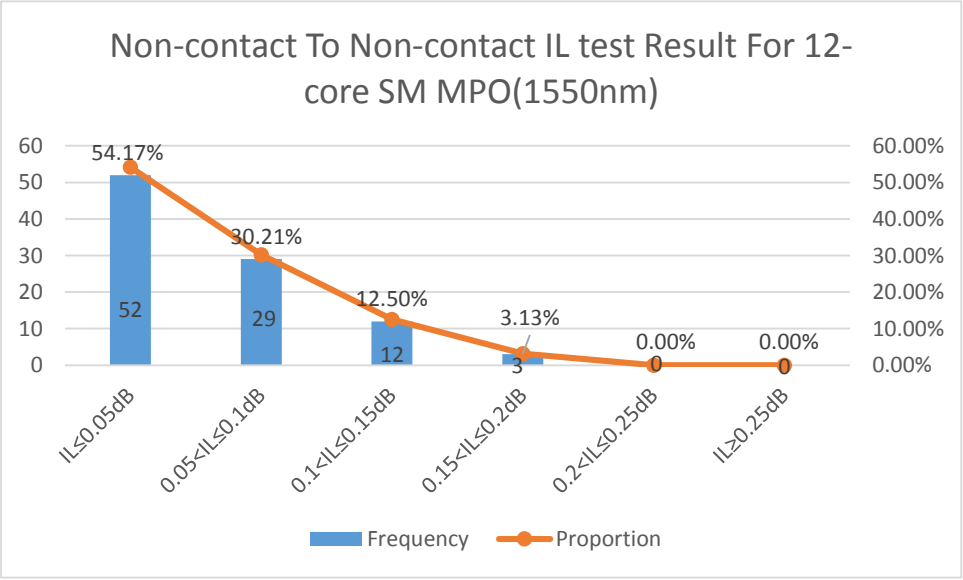
At DUT test step, because the DUT's B-side is a non-coated connector, the B-side connector end face will have 4% reflection loss. The power received by the photo detector is $P_{out2} = P_{in2} * (1-4\%)$.



The final test result P_{out2} includes an extra 4% return loss in addition to the actual insertion loss P_{in2} of the DUT. This 4% (or 0.15dB) needs to be subtracted from the measured insertion loss value.

Test Result:





Experiment 2: SM NC-MPO connector mated to Special SM Uncoated MPO connector

Test Jumper:

A side: 12-core SM NC-MPO connector (8 degree, coating);

B-side: 12-core SM MPO physical contact connector (8 degree, no coating).

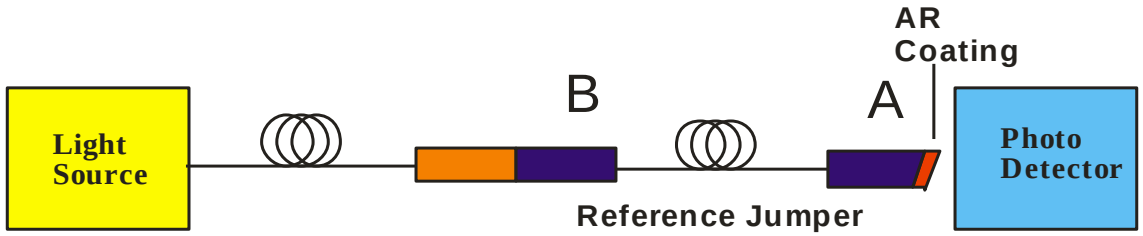
MPO connector under test:

A-side: Special 12-core SM MPO connector (8 degree, no coating): fiber end is recessed from the ferrule surface, no coating. In other words, the fiber is recessed from the ferrule surface and will not cause damage to the AR coating on the opposing connector.

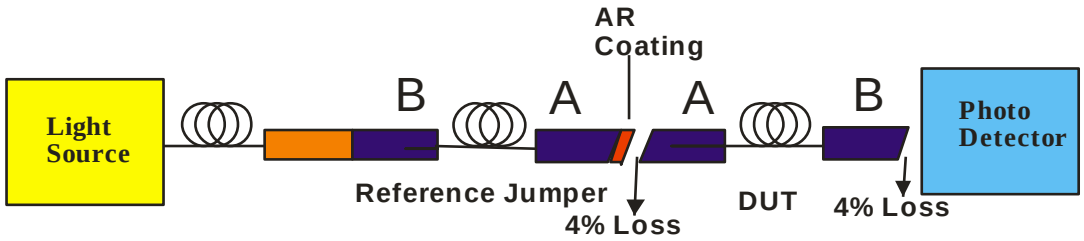
B-side: 12-core SM MPO physical contact connector (8 degree, no coating)

Test method is shown below where the red part denotes anti-reflection coating on the connector:

A) Reference measurement



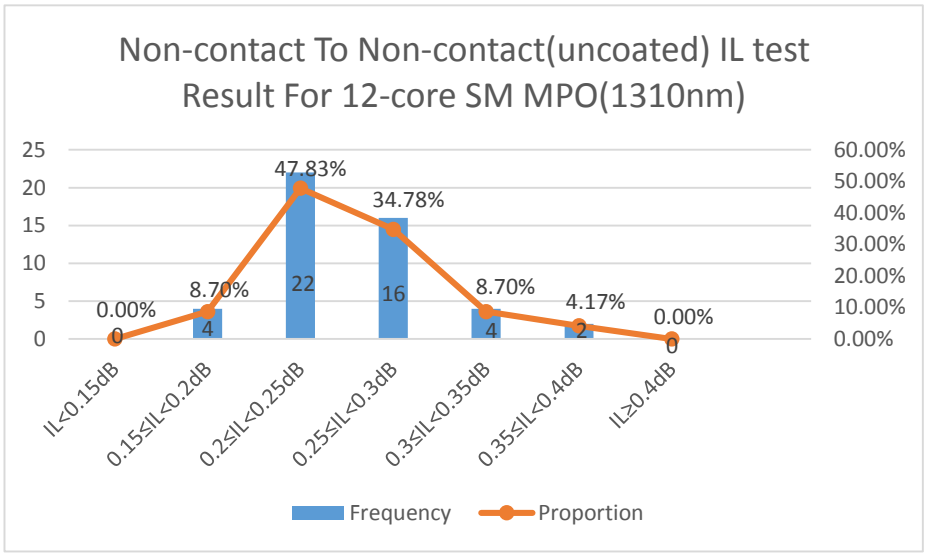
B) DUT measurement

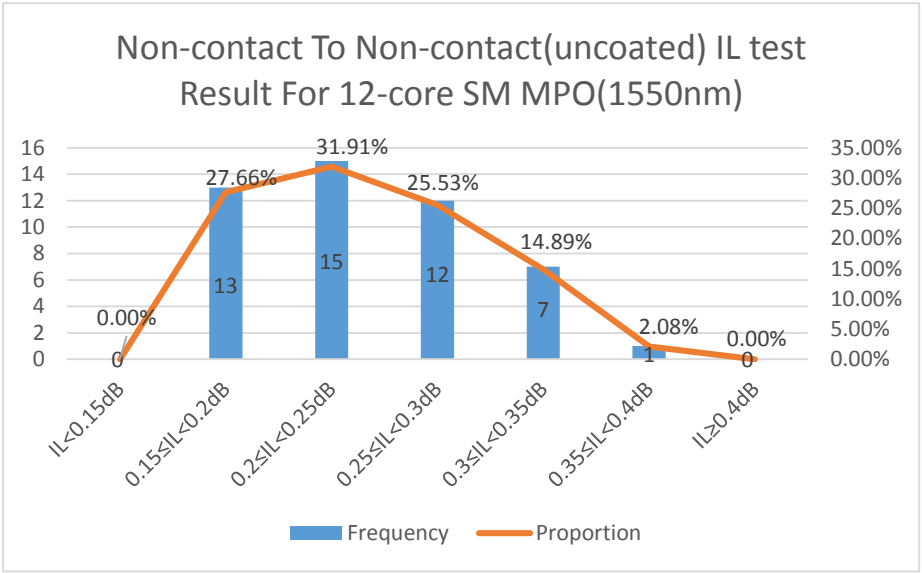


Pout = Pin × (1-4%), Pout is the photo detector value, Pin is the actual insertion loss, again 4% loss is equivalent to 0.15dB, which needs to be subtracted.

Since the A end of the DUT is a non-coated connector, a 4% loss is generated when the DUT A-side is mated with the A-side of the test jumper. Note this 4% loss is real. Therefore, the minimum loss in this case is 0.15 dB. The loss distribution can be clearly shown in the following figure.

Test Result:


Non-contact To Non-contact(uncoated) IL test Result For 12-core SM MPO(1310nm)
25
20
15
10
5
0
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
0.00%
8.70%
47.83%
34.78%
8.70%
4.17%
0.00%
0
4
22
16
4
2
0
IL<0.15dB
0.15≤IL<0.2dB
0.2≤IL<0.25dB
0.25≤IL<0.3dB
0.3≤IL<0.35dB
0.35≤IL<0.4dB
IL≥0.4dB
Frequency
Proportion


Non-contact To Non-contact(uncoated) IL test Result For 12-core SM MPO(1550nm)
16
14
12
10
8
6
4
2
0
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
0.00%
27.66%
31.91%
25.53%
14.89%
2.08%
0.00%
0
13
15
12
7
1
0
IL<0.15dB
0.15≤IL<0.2dB
0.2≤IL<0.25dB
0.25≤IL<0.3dB
0.3≤IL<0.35dB
0.35≤IL<0.4dB
IL≥0.4dB
Frequency
Proportion

12-core SM NC-MPO Performance Summary

12-core Singlemode NC-MPO Statistical results		Non-Contact 8° (AR coated mated to AR coated)		Non-Contact 8° (AR coated mated to uncoated)	
		1310nm	1550nm	1310nm	1550nm
Insertion Loss	Mean value	0.06dB	0.06dB	0.25dB	0.23dB
	Standard deviation	0.04	0.04	0.05	0.06
	97% distribution	0.16dB	0.15dB	0.35dB	0.35dB
	Repeatability	<0.01dB	<0.01dB	<0.01dB	<0.01dB
	Maximum value	0.2dB	0.19dB	0.39dB	0.39dB
	Minimum value	0.01dB	0.01dB	0.17dB	0.15dB
Return Loss	Mean value	77.92dB	80.12dB	75.07dB	75.44dB
	Standard deviation	4.89dB	3.28dB	6.23	5.12
	Maximum value	85.4dB	83.6dB	85.5dB	83.7dB
	Minimum value	69.9dB	73.4dB	65.1dB	66.1dB

Experiment 3: Multimode NC-MPO Connector mated to Multimode NC-MPO Connector: end face 0 degree

Test Jumper:

A-side: 12-core MM NC-MPO connector (0 degree, coating);

B-side: 12-core MM MPO physical contact connector (0 degree, no coating).

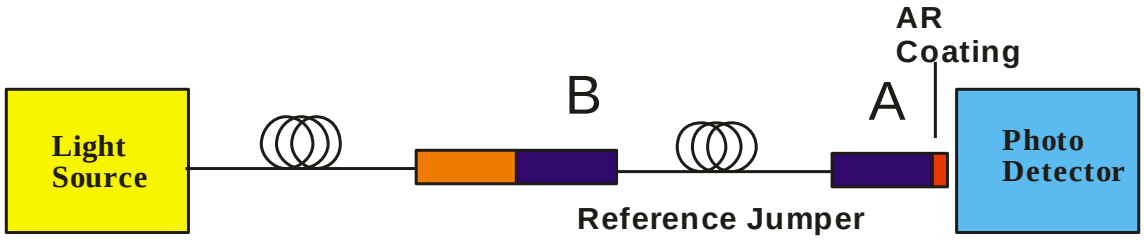
MPO connector under test:

A-side: 12-core MM NC-MPO connector (0 degree, coating);

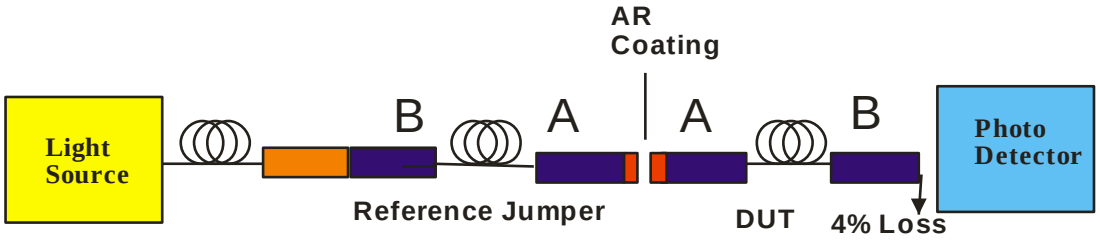
B-side: 12-core MM MPO physical contact connector (0 degree, no coating).

Test method is shown below where the red part denotes anti-reflection coating on the connector:

A) Reference measurement

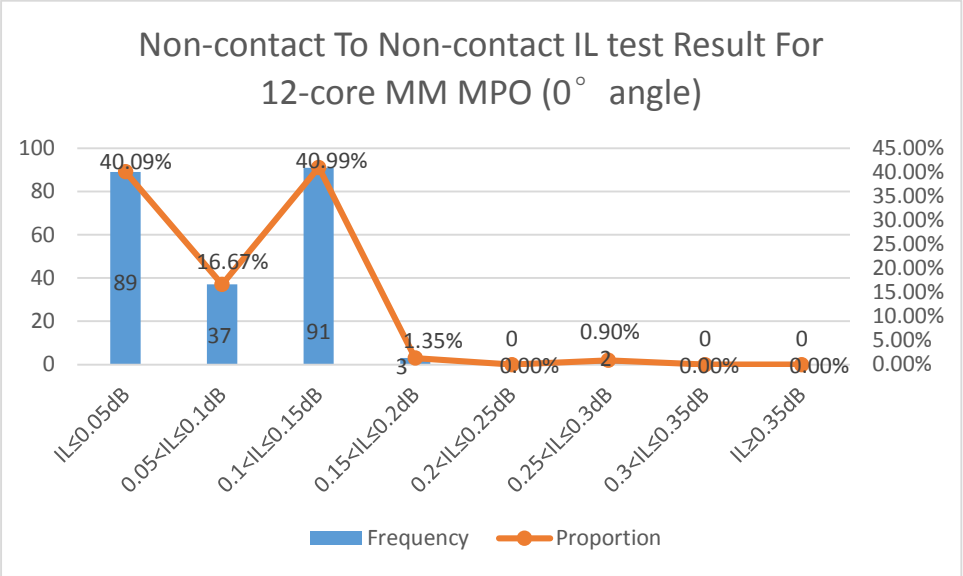


B) DUT measurement



Due to the lack of reflection at the AR coated end face, the insertion loss after mating needs to subtract 0.15 dB from the test value.

Test Result:



Experiment 4: Multimode NC-MPO Connector mated to Multimode NC-MPO Connector: end face 8 degree

Test Jumper:

A-side: 12-core MM NC-MPO connector (8 degree, coating);

B-side: 12-core MM MPO physical contact connector (8 degree, no coating)

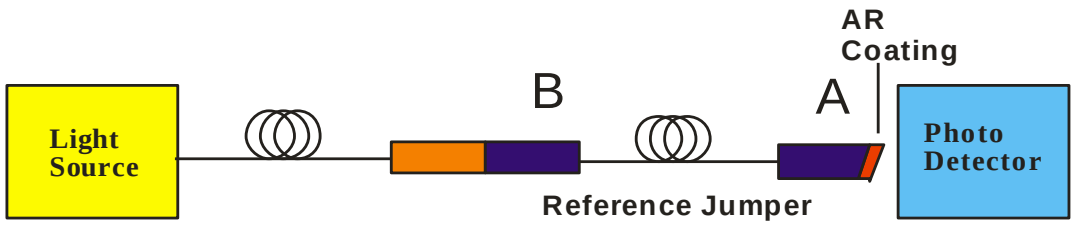
MPO connector under test:

A-side: 12-core MM NC-MPO connector (8 degree, coating)

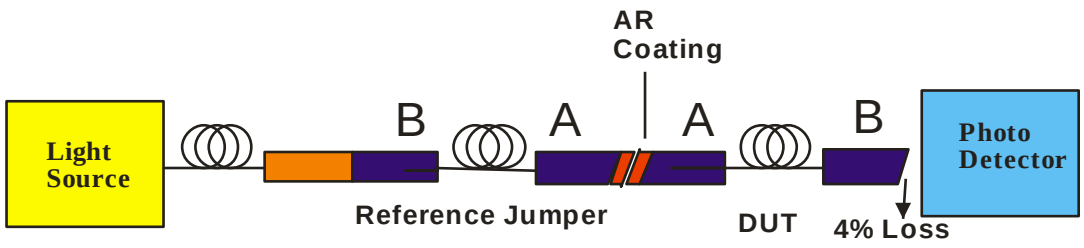
B-side: 12-core MM MPO physical contact connector (8 degree, no coating)

Test method is shown below where the red part denotes anti-reflection coating on the connector:

A) Reference measurement:

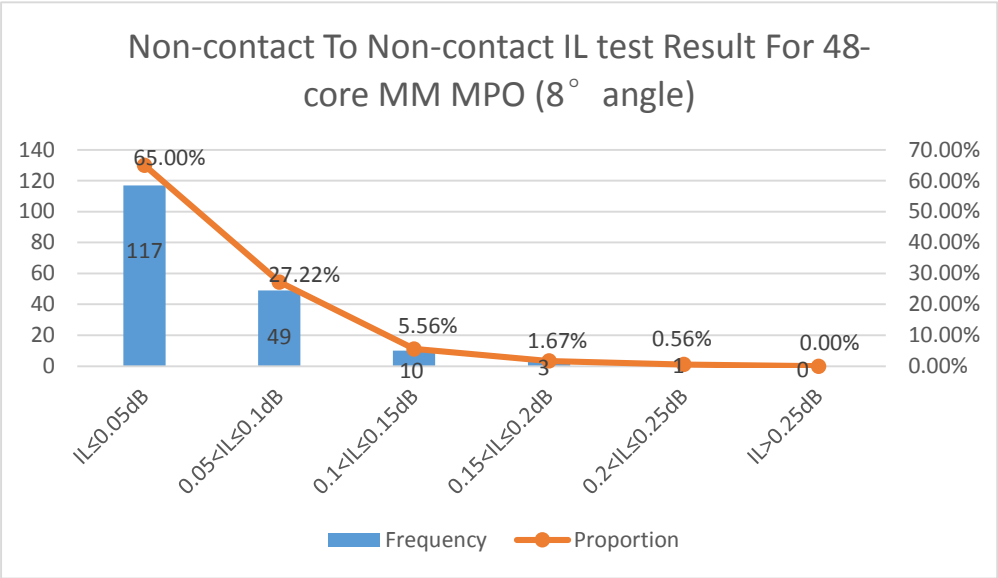


B) DUT measurement:



Due to the lack of reflection at the AR coated end face, the insertion loss after mating needs to subtract 0.15 dB from the test value.

Test Result:



12-core Multimode NC-MPO Performance Summary

12-core Multimode NC-MPO Statistical results		Non-Contact 0° (AR coated mated to AR coated)	Non-Contact 8° (AR coated mated to AR coated)
		Wavelength: 850nm	
Insertion Loss	Mean value	0.05dB	0.04dB
	Standard deviation	0.04	0.04
	97% distribution	0.15dB	0.15dB
	Repeatability	<0.01dB	<0.01dB
	Maximum value	0.28dB	0.22dB
	Minimum value	0.01dB	0.01dB
Return Loss	Mean value	18.68dB	Returned signal too small to detect.
	Standard deviation	2.3	
	Maximum value	25.4dB	
	Minimum value	16.9dB	

From the test results, it can be seen that 12-core MM 8 ° angle NC-MPO has better performance than 0 ° angle NC-MPO.

Experiment 5: 48-core multimode NC-MPO Connector mated to 48-core multimode NC-MPO connector: end face 0 degree

Test Jumper:

A side: 48-core MM NC-MPO connector (0 degree, coating);

B-side: 2 groups of 24-core MM MPO physical contact connector (0 degree, no coating).

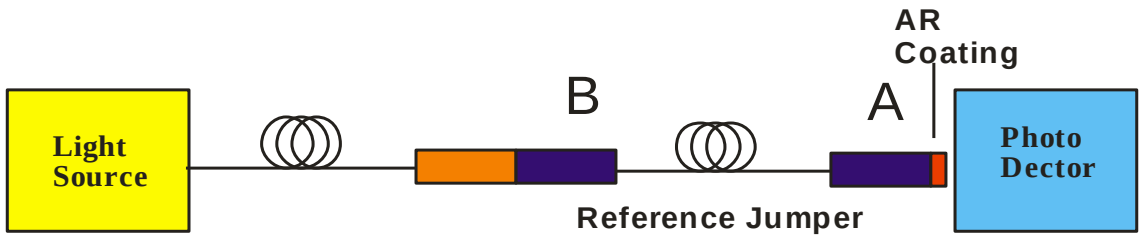
MPO connector under test:

A side: 48-core MM NC-MPO connector (0 degree, coating);

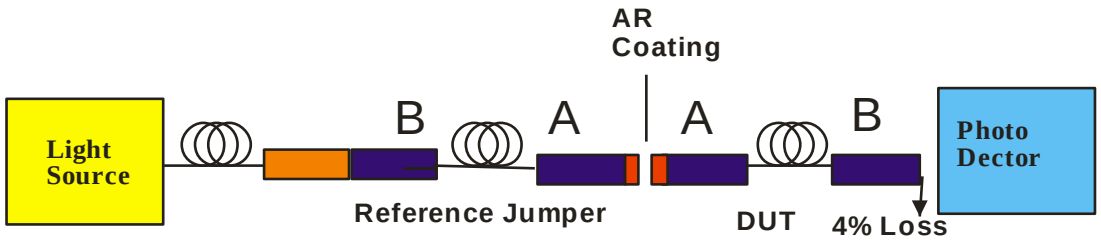
B-side: 2 groups of 24-core MM MPO physical contact connector (0 degree, no coating).

Test method is shown below where the red part denotes anti-reflection coating on the connector:

A) Reference measurement

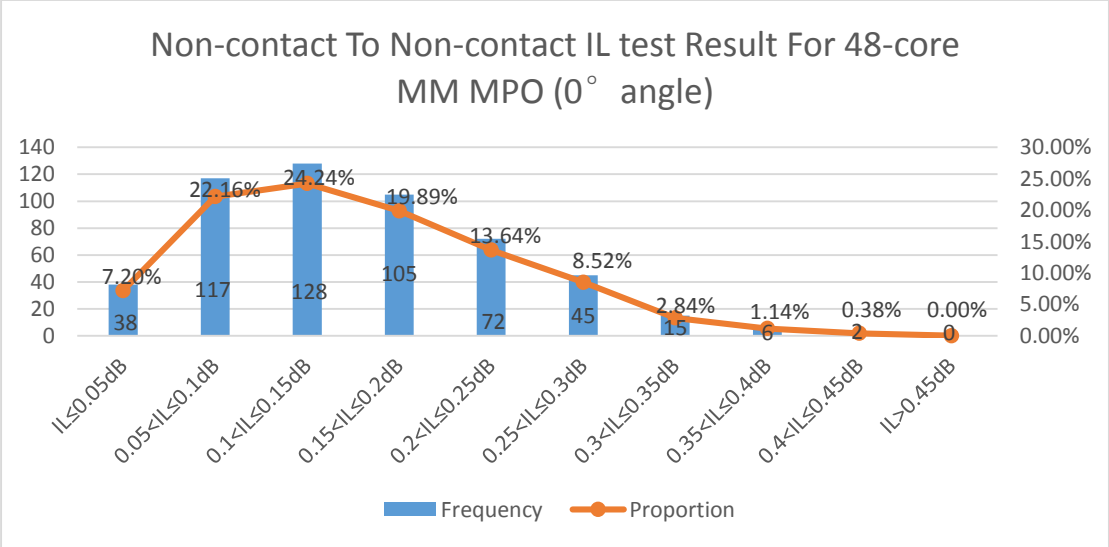


B) DUT measurement



Due to the lack of reflection at the AR coated end face, the insertion loss after mating needs to subtract 0.15 dB from the test value.

Test Result:



Experiment 6: 48-core Multimode NC-MPO connector mated to 48-core Multimode NC-MPO connector: end face 8 degree

Test Jumper:

A-side: 48-core MM NC-MPO connector (8 degree, coating);

B-side: 2 groups of 24-core MM MPO physical contact connector (0 degree, no coating).

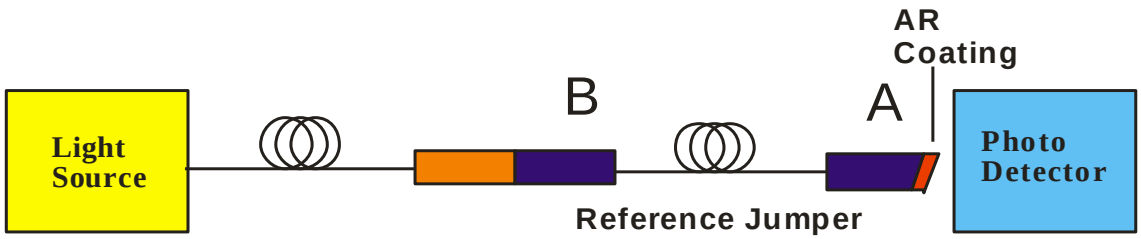
MPO connector under test:

A-side: 48-core MM NC-MPO connector (8 degree, coating);

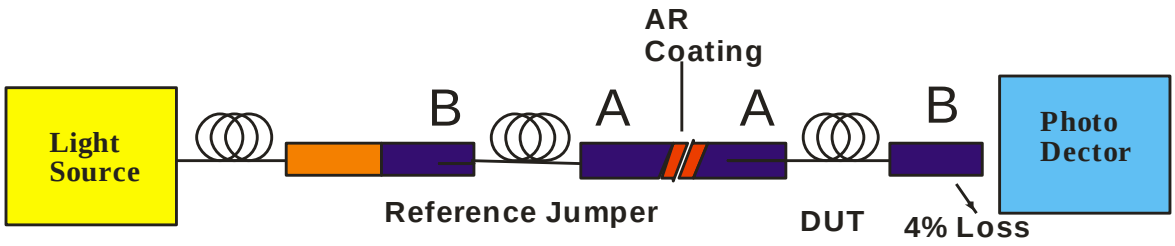
B-side: 2 groups of 24-core MM MPO physical contact connector (0 degree, no coating).

Test method is shown below where the red part denotes anti-reflection coating on the connector:

A) Reference measurement

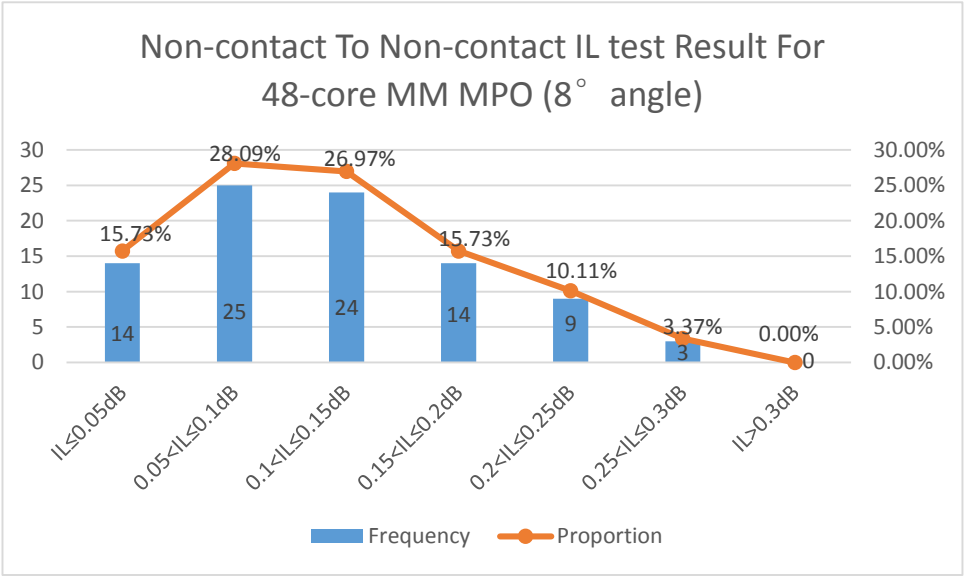


B) DUT measurement



Due to the lack of reflection at the AR coated end face, the insertion loss after mating needs to subtract 0.15 dB from the test value.

Test Result:



48-core Multimode NC-MPO Performance Summary:

48-core Multimode NC-MPO Statistical results		Non-Contact 0° (AR coated mated to AR coated)	Non-Contact 8° (AR coated mated to AR coated)
		Wavelength 850nm	
Insertion Loss	Mean value	0.16dB	0.13dB
	Standard deviation	0.079	0.065
	97% distribution	0.31dB	0.25dB
	Repeatability	<0.01dB	<0.01dB
	Maximum value	0.42dB	0.29dB
	Minimum value	0.01dB	0.02dB
Return Loss	Mean value	24.42dB	Returned signal too small to detect.
	Standard deviation	1.793	
	Maximum value	27.1dB	
	Minimum value	17.3dB	

From the test results, it can be seen that 48-core MM 8 ° angle NC-MPO has better performance than 0 ° angle NC-MPO.

Experiment 7: Repeatability testing for 12-core SM NC-MPO connectors.

Experiment 7 and 8 were performed by a customer and included here with the customer's consent. The goal of the two experiments was a head-to-head comparison of traditional MPO fiber connector against NC-MPO fiber connector. All test conditions were kept the same between the two sets of tests as much as possible.

Test Jumper:

A side: 12-core SM NC-MPO connector (8 degree, coating);

B side: 12-core SM MPO physical contact connector (8 degree, no coating).

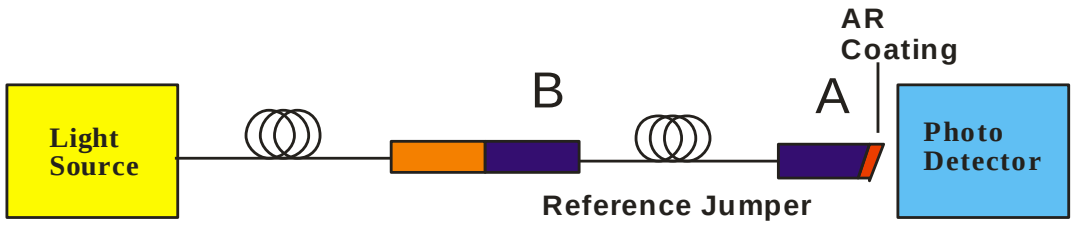
NC-MPO connector under test:

A side: 12-core SM NC-MPO connector (8 degree, coating);

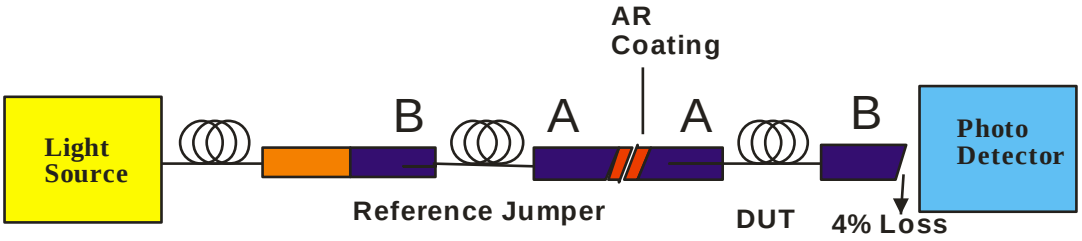
B-side: 12-core SM MPO physical contact connector (8 degree, no coating).

Test method is shown below where the red part denotes anti-reflection coating on the connector:

A) Reference measurement:



B) DUT measurement:

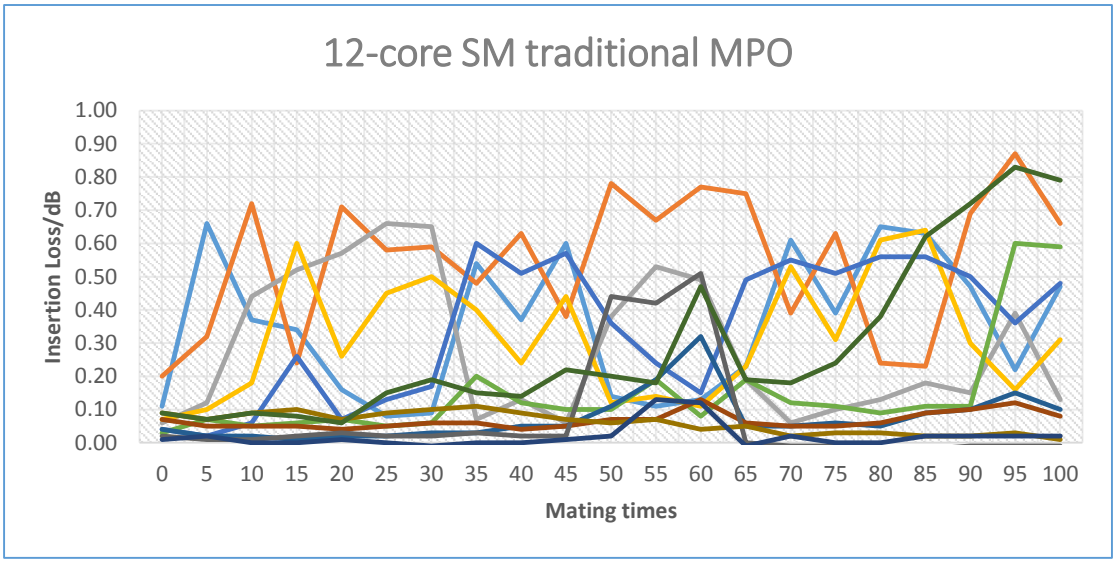


Repeatability testing method:

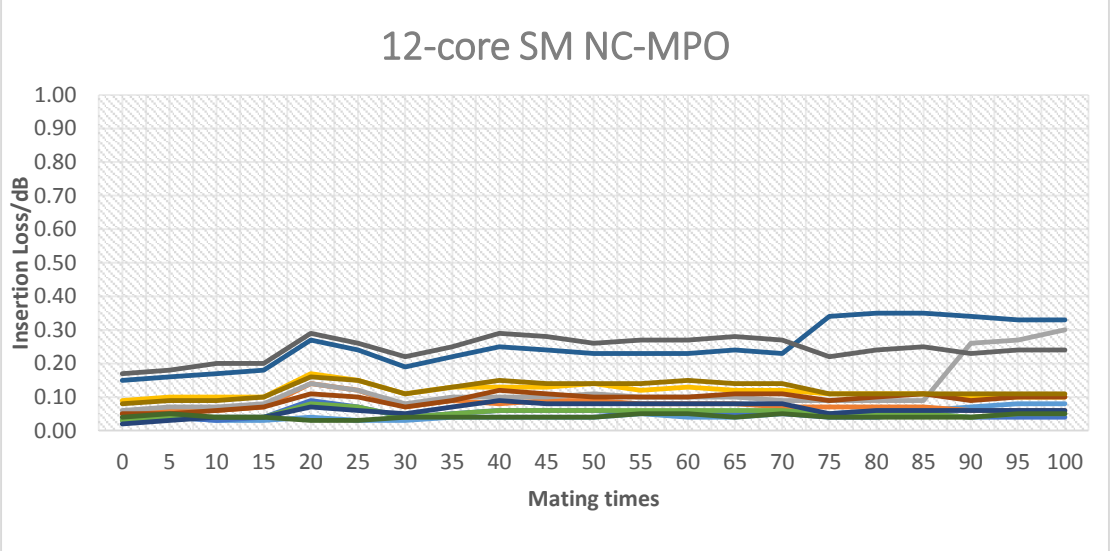
Connectors were all cleaned thoroughly, then mated for 100 times without cleaning in between. Data was taken after every 5 matings.

The result of 12-core SM NC-MPO is compared with 12-core SM traditional MPO.

A) 12-core SM traditional MPO connector repeatability result:



B) 12-core SM NC-MPO connector repeatability result:



From the results, it can be seen that the repeatability for 12-core SM NC-MPO connectors is

much better than 12-core SM traditional MPO connectors and it is much more insensitive to the dusts in the environment.

Experiment 8: Repeatability testing for 12-core MM NC-MPO: end face 8 degree

Experiment 8 again was performed by a customer and included here with the customer's consent. The goal of the experiment was a head-to-head comparison of traditional MPO fiber connector against NC-MPO fiber connector. All test conditions were kept the same between the two sets of tests as much as possible.

Test Jumper:

A-side: 12-core MM NC-MPO connector (8 degree, coating);

B-side: 12-core MM MPO physical contact connector (8 degree, no coating)

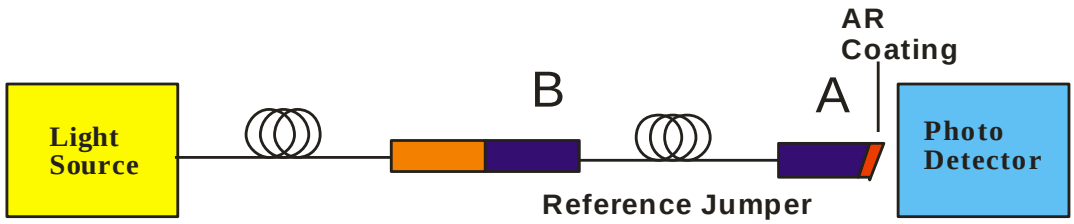
MPO connector under test:

A-side: 12-core MM NC-MPO connector (8 degree, coating)

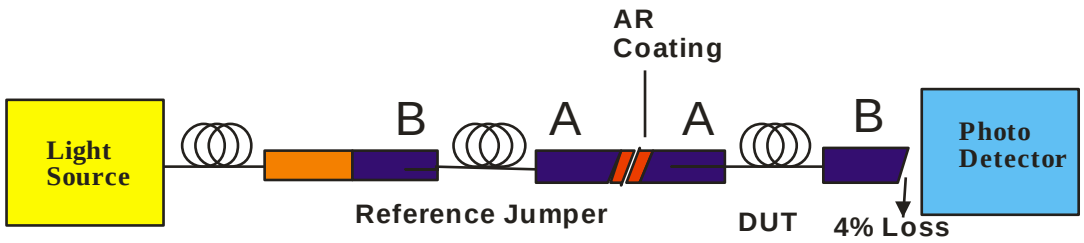
B-side: 12-core MM MPO physical contact connector (8 degree, no coating)

Test method is shown below where the red part denotes anti-reflection coating on the connector:

A) Reference measurement:



B) DUT measurement:



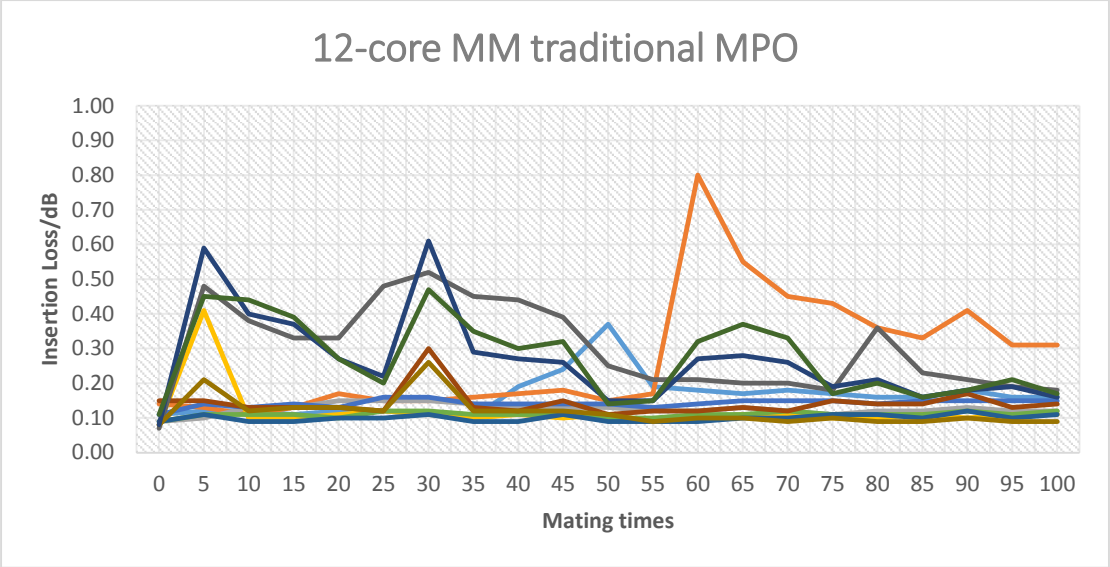
Repeatability testing method:

Connectors were all cleaned thoroughly, then mated for 100 times without cleaning in between. Data was taken after every 5 matings.

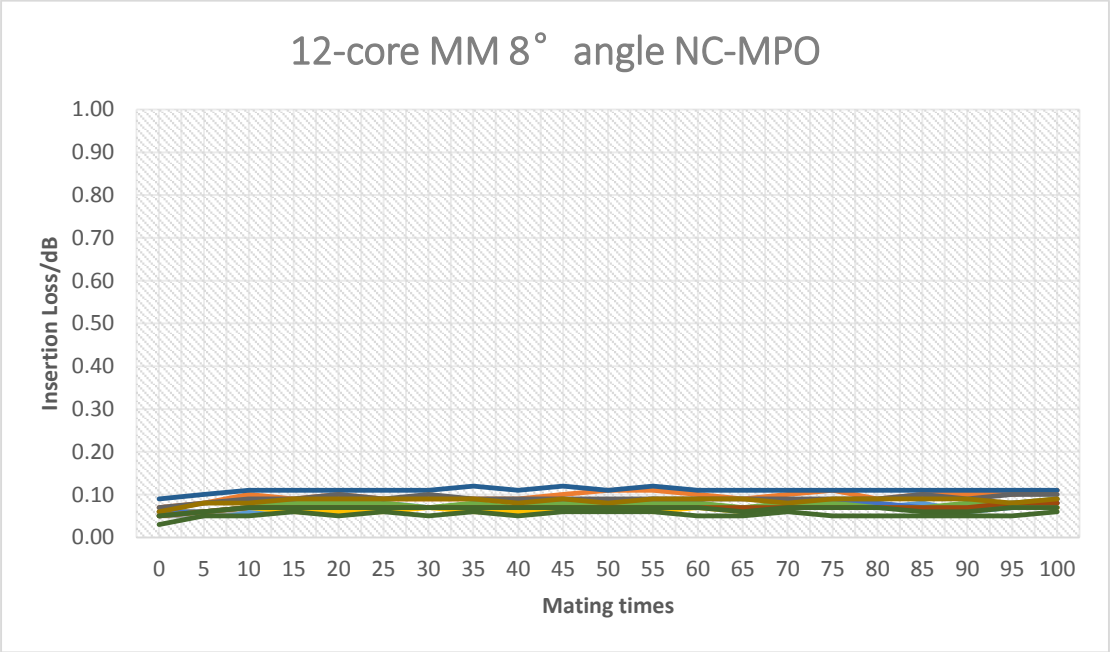
The result of 12-core MM NC-MPO is compared with 12-core MM traditional MPO.

Testing result for 12-core MM NC-MPO compared with 12-core MM traditional MPO.

A) 12-core MM traditional MPO connector repeatability result:



B) 12-core MM NC-MPO connector (8 degree end face) repeatability result:



From the test results, it can be seen that the repeatability of the 12-core MM NC-MPO connector (8 degree end face) is far better than 12-core MM traditional MPO connectors and it is much more insensitive to the dusts in the environment. The repeatability of the MM NC-MPO is even better than SM NC-MPO, probably because the much larger core diameter of MM fiber makes it much harder for dust particles to block the light path, compared to the SM NC-MPO.