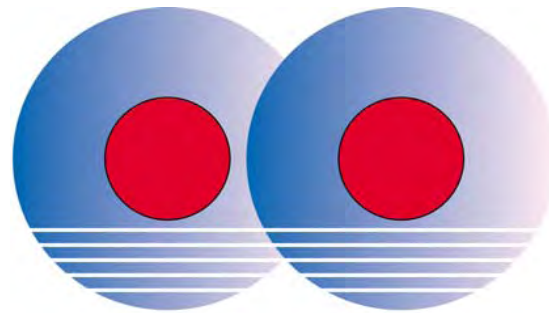


Ultra-High Reliability Fused Fiber Products For Optical Amplifier Applications



COMCORE

A Leader of Fused Fiber Technologies in the World



Comcore Technologies Properties
<http://www.comcore.com>

Ultra-High Reliability Fused Fiber Products

For Optical Amplifier Applications

- KEY ISSUES FOR FFPs
- SUPERFUSION TECHNOLOGIES
- MAIN FFPs in EDFAs
- PRODUCT RELIABILITY
- CAPABILITY AND CAPACITY

Ultra-High Reliability Fused Fiber Products

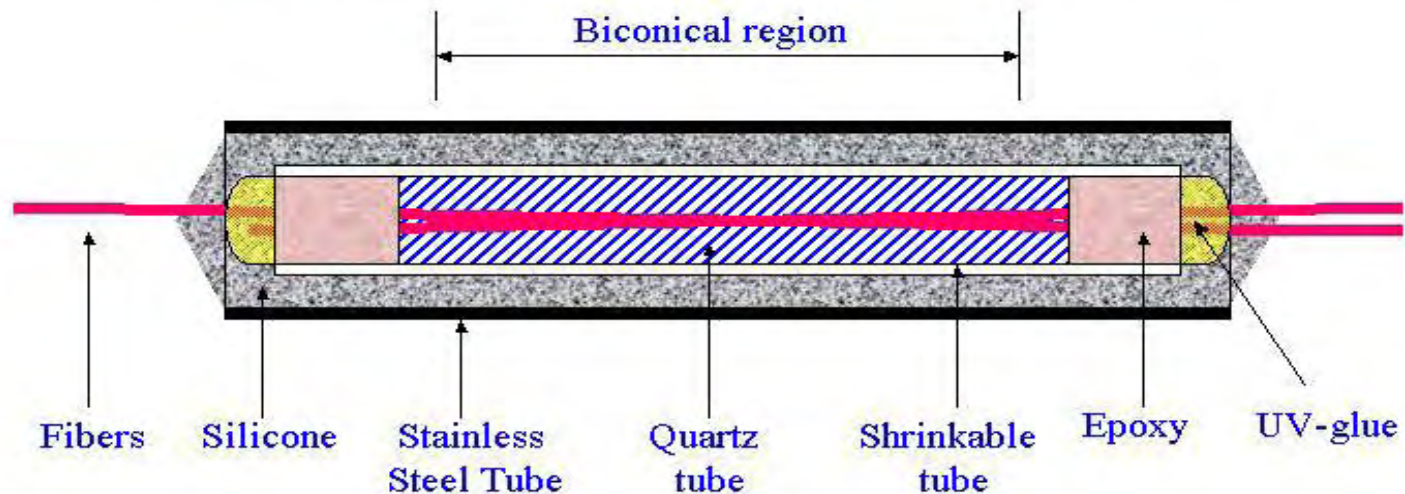
For Optical Amplifier Applications

- **KEY ISSUES FOR FFPs**
- **SUPERFUSION TECHNOLOGIES**
- **MAIN FFPs in EDFAs**
- **PRODUCT RELIABILITY**
- **CAPABILITY AND CAPACITY**

KEY ISSUES FOR FFPs

1. Basic Structure of FFPs

Longitude Cross-Sectional Structure



Prepared by Yong Huang

3

KEY ISSUES FOR FFPs

2. Two most important issues:

- **To avoid specifications shifting outside the given values at any time during lifetime of system.**
- **To avoid fiber breakage inside stainless steel tube**

KEY ISSUES FOR FFPs

3. Designing Proposal of Reliability:

Method1: Enhancing the stability of package for environment.

- a. Hermetically sealed using special glass tube
- b. Glass solder process.

Method2: Enhancing the stability of coupling region of fused device for environment.

- a. **Strong Fusion and Stress Release**

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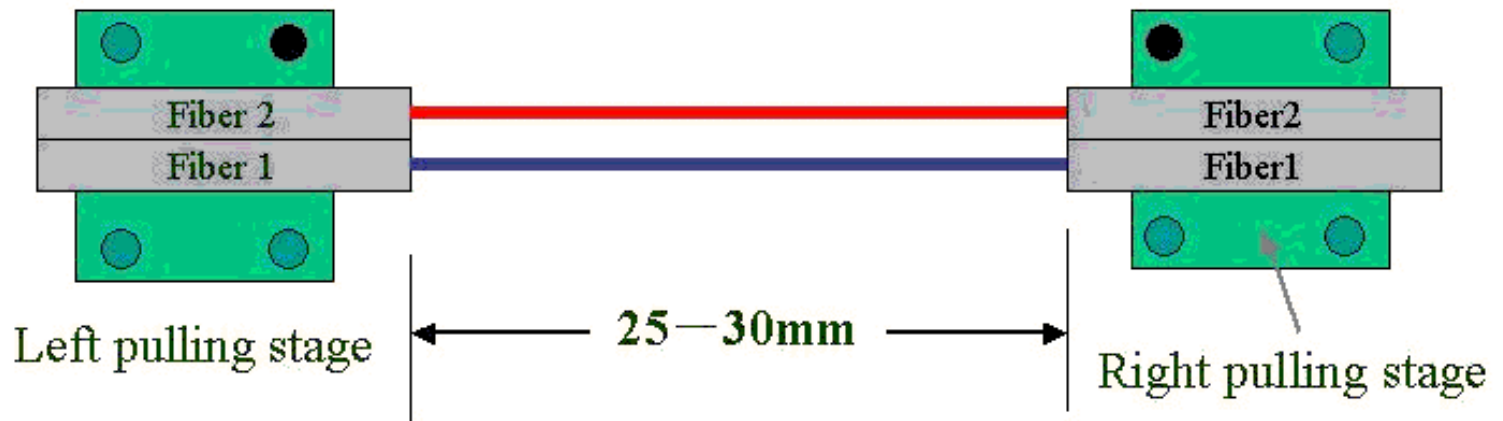
SUPERFUSION TECHNOLOGIES

1. Process Highlight

NO DUMBBELL SHAPE

SUPERFUSION TECHNOLOGIES

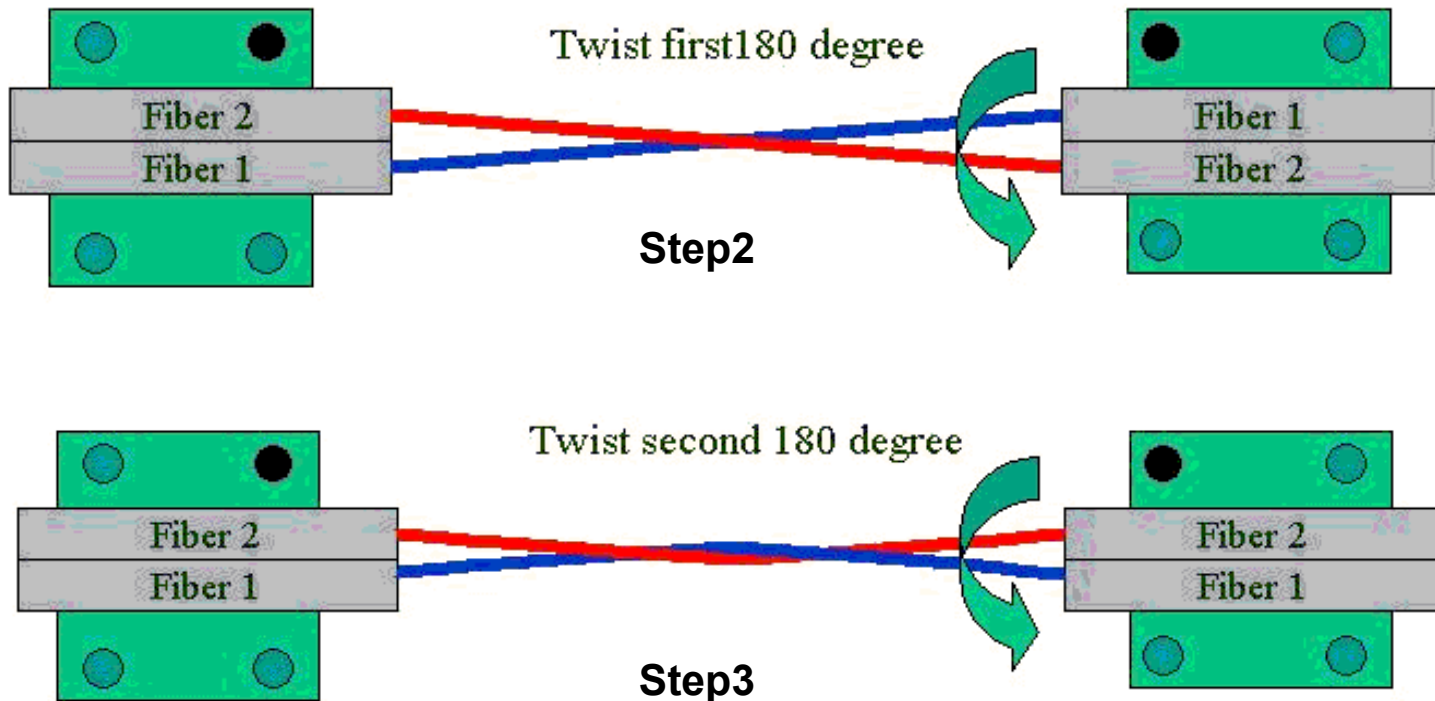
2.Manufacturing Process



Step1

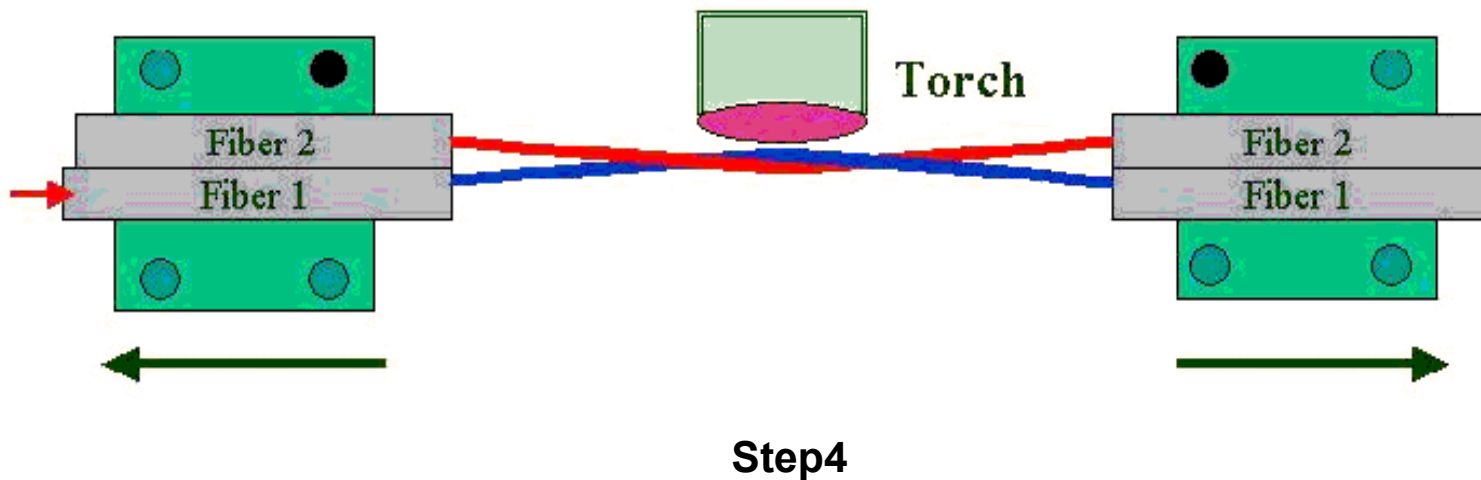
SUPERFUSION TECHNOLOGIES

2.Manufacturing Process



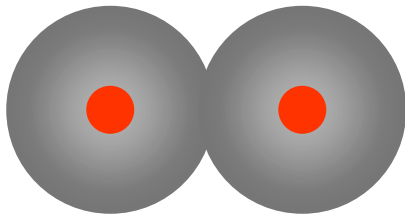
SUPERFUSION TECHNOLOGIES

2.Manufacturing Process

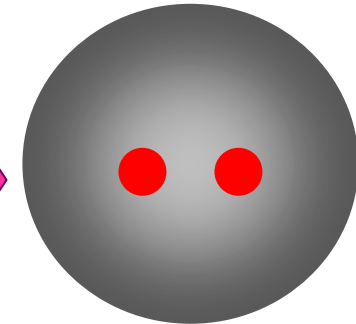
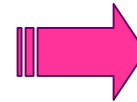
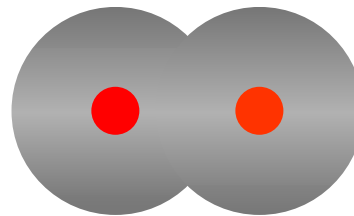


SUPERFUSION TECHNOLOGIES

3. Different Cross-sectional Shapes in Different Process



Normal Process
(stick)
1000°C

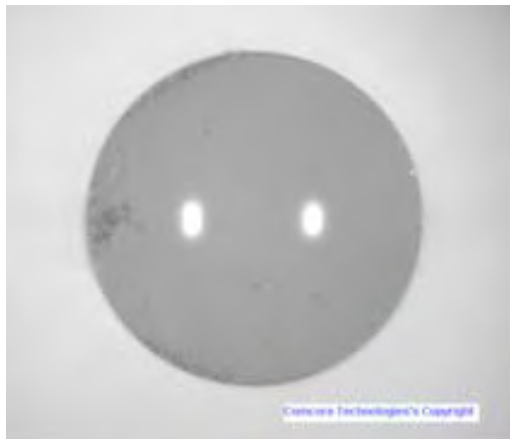


Comcore's Process
(Melting Process)
1700C

SUPERFUSION TECHNOLOGIES

4. Real Cross-sectional Shape for Different FFPs

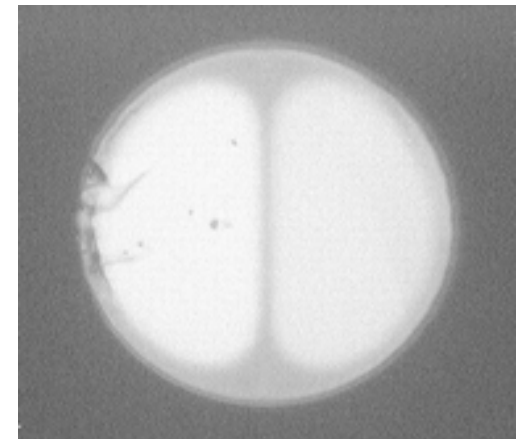
Single Mode Fiber



125/62.5um MM Fiber

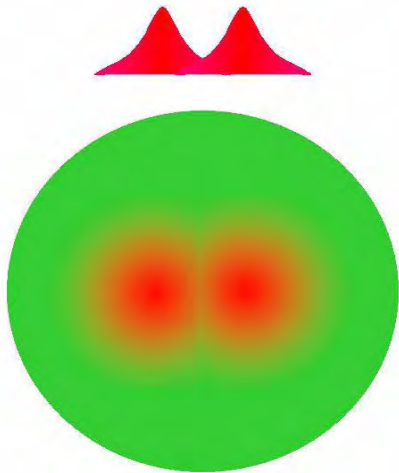


125/105um MM Fiber

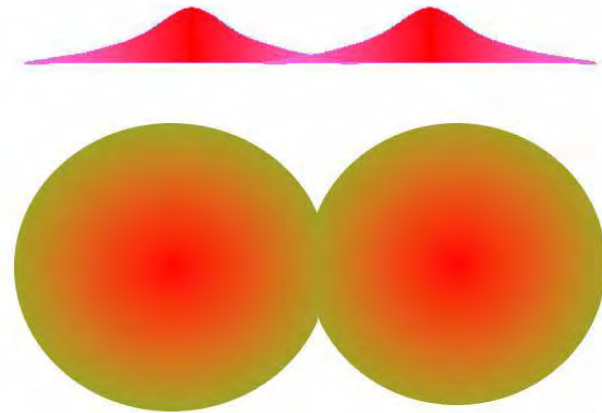


SUPERFUSION TECHNOLOGIES

5. Modal Field Distribution in Coupling Region



In Superfusion Process



In Stick Process

SUPERFUSION TECHNOLOGIES

6.Comparison Between Different Processes

Process \ Characteristics	Stick Process	Superfusion Process
Heating temperature	Around 1000°C	Around 1700°C
Fiber contact form	Stick together	Melting together
Shape of cross section	Visible Pre-fiber Shape	Invisible pre-fiber
Micro-cracks on surface of fibers	Not eliminated	Fully Eliminated

SUPERFUSION TECHNOLOGIES

7. Features of FFPs by using Superfusion process:

- (1) The structure of coupling region is very strong, the cross-sectional shape looks like a twin core fiber.
- (2) Optical characteristics of devices are , relatively speaking, insensitive to surrounding environment.
- (3) Very small twisted effect due to almost circularly symmetric structure of cross-section.
- (4) Eliminate micro-cracks on the surface of fibers included in non-coupling and coupling region of FFP to protect the moisture enters these micro-cracks and proliferates them, causing FFP degradation and ultimate failure.
- (5) Improve polarization dependent loss and wavelength isolation for WDMs.

Ultra-High Reliability Fused Fiber Products

For Optical Amplifier Applications

- KEY ISSUES FOR FFPs
- SUPERFUSION TECHNOLOGIES
- **MAIN FFPs in EDFAs**
- PRODUCT RELIABILITY
- CAPABILITY AND CAPACITY

MAIN FFPs in EDFAs

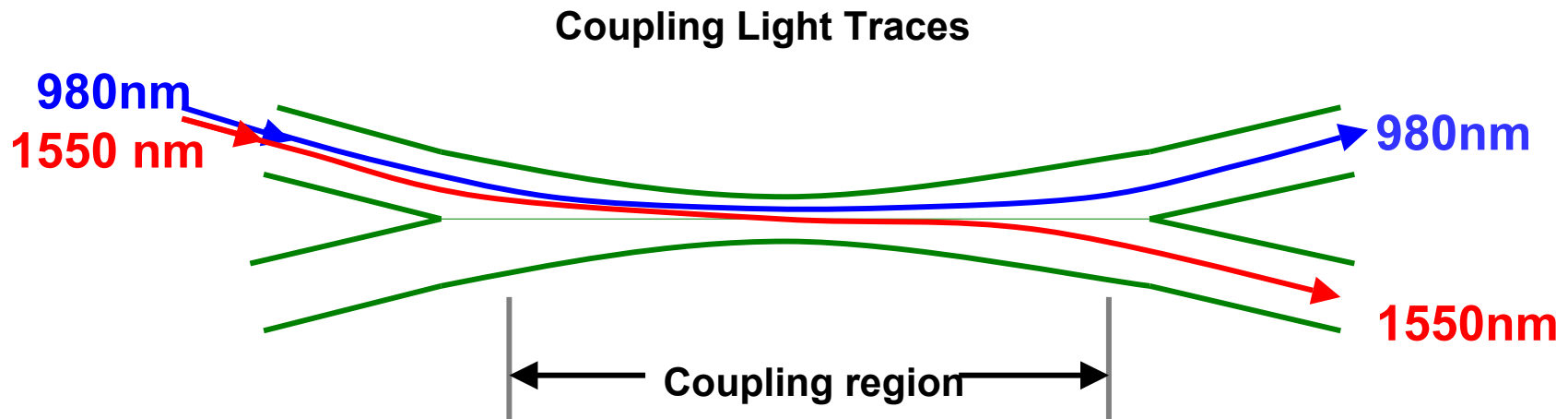
1. Main Fused Fiber Products in EDFAs

- (1) 2x2 980nm Splitters
- (2) 1x2 980/1550nm WDMs
- (3) 1x2 1480/1550nm WDMs
- (4) 1x2 C or L-band Taps

MAIN FFPs in EDFAs

2. 980/1550nm Fused Fiber WDMs Made by Using Superfusion Process

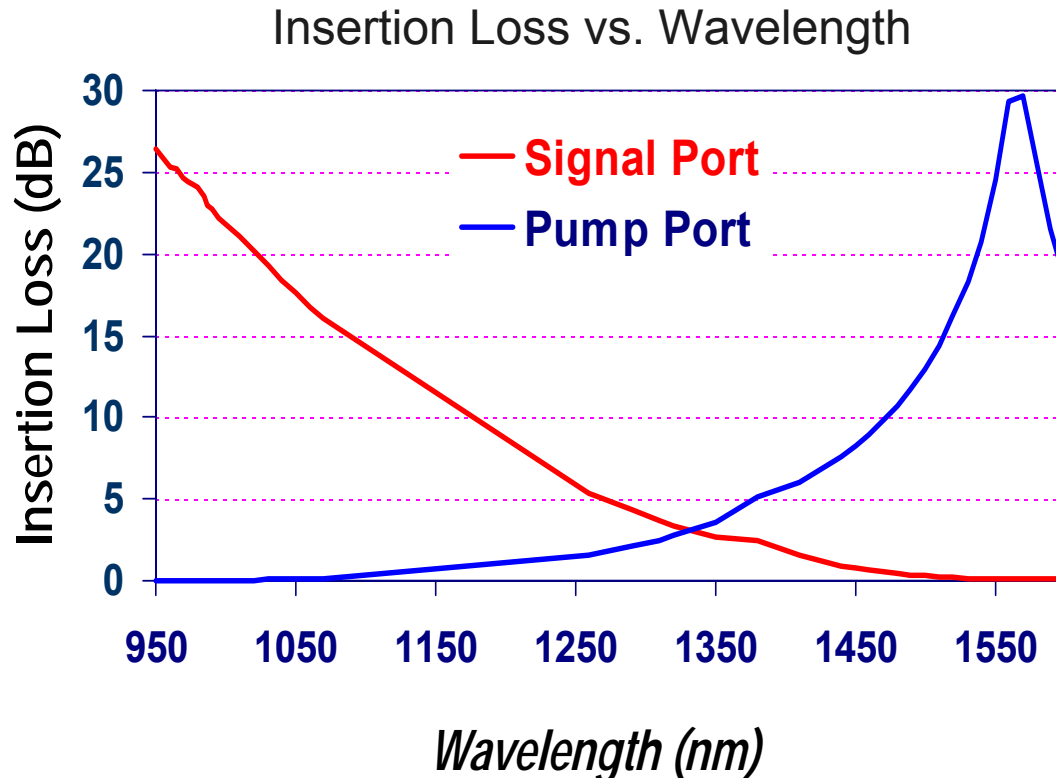
(1) Light traces in WDM Made by Using Superfusion Process



MAIN FFPs in EDFAs

2. 980/1550nm Fused Fiber WDM Made by Using Superfusion Process

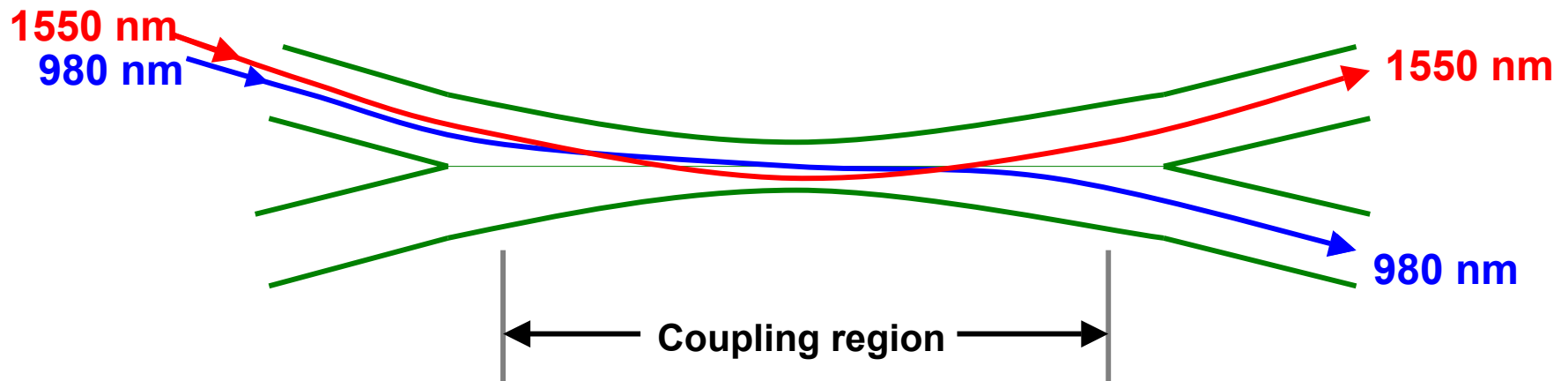
(2) Insertion Loss Versus Wavelength



MAIN FFPs in EDFAs

3. 980/1550nm Fused Fiber WDMs Made by Using Stick Process

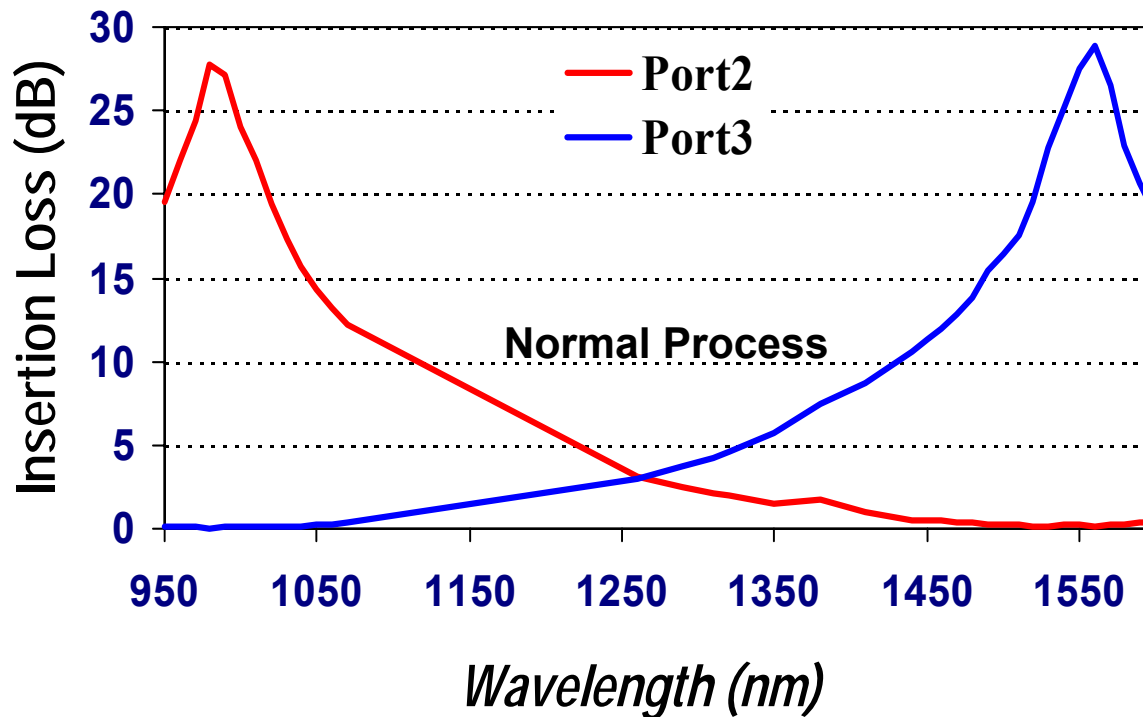
(1) Light traces in WDM Made by Using Stick Process



MAIN FFPs in EDFAs

3. 980/1550nm Fused Fiber WDMs Made by Using Stick Process

(2) Insertion Loss vs. Wavelength



MAIN FFPs in EDFAs

4. 980/1550nm Fused Fiber WDM Performance

	Comcore's	Others
Typical Excess Loss (dB)	0.005	0.1
Max. Excess Loss (dB)	0.01	0.2
Typical Insertion Loss (dB)	0.03	0.15
Max. Insertion Loss (dB)	0.05	0.25

MAIN FFPs in EDFAs

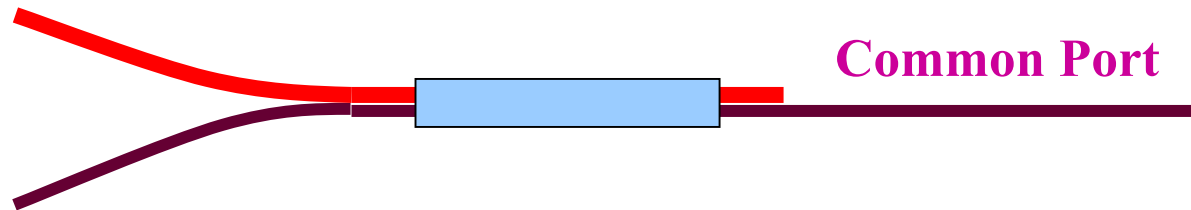
5. 980/1550nm Fused Hybrid Fiber WDM

(1) Structure

Signal Port

Pump Port

Common Port



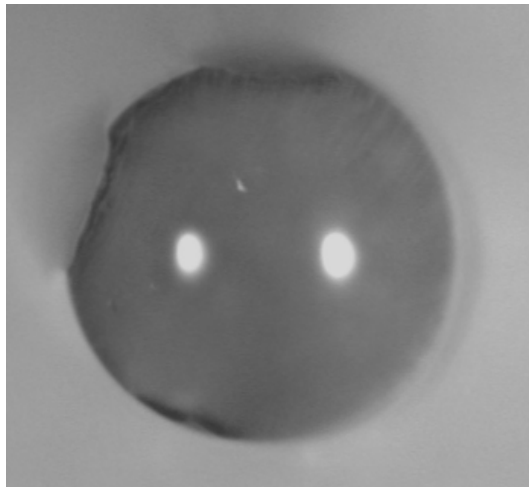
— SMF-28 Fiber

— Corning HI1060 Flex Fiber
Or OFS 980 Coupler Fiber
Or Equivalent Fiber

MAIN FFPs in EDFAs

5. 980/1550nm Fused Hybrid Fiber WDM

(2) Cross-sectional Shape and Product Features

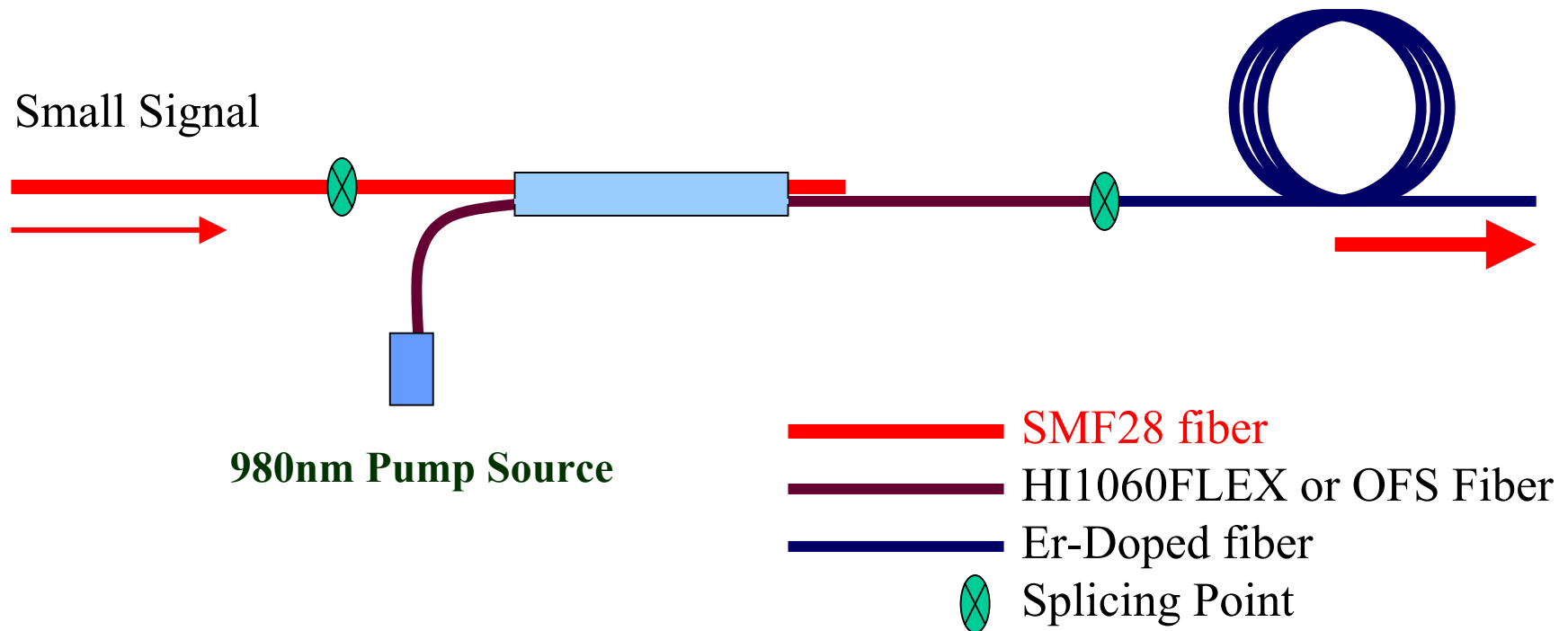


- **Hi-Reliability**
- **High Performance**
- **PDL-Free: <math><0.01\text{dB}</math> for Path Ports**
- **TDL-Free: <math><0.0001\text{dB}/^\circ\text{C}</math> for Path Ports**
- **Telecordia1221 fully Complied**

MAIN FFPs in EDFAs

5. 980/1550nm Fused Hybrid Fiber WDM

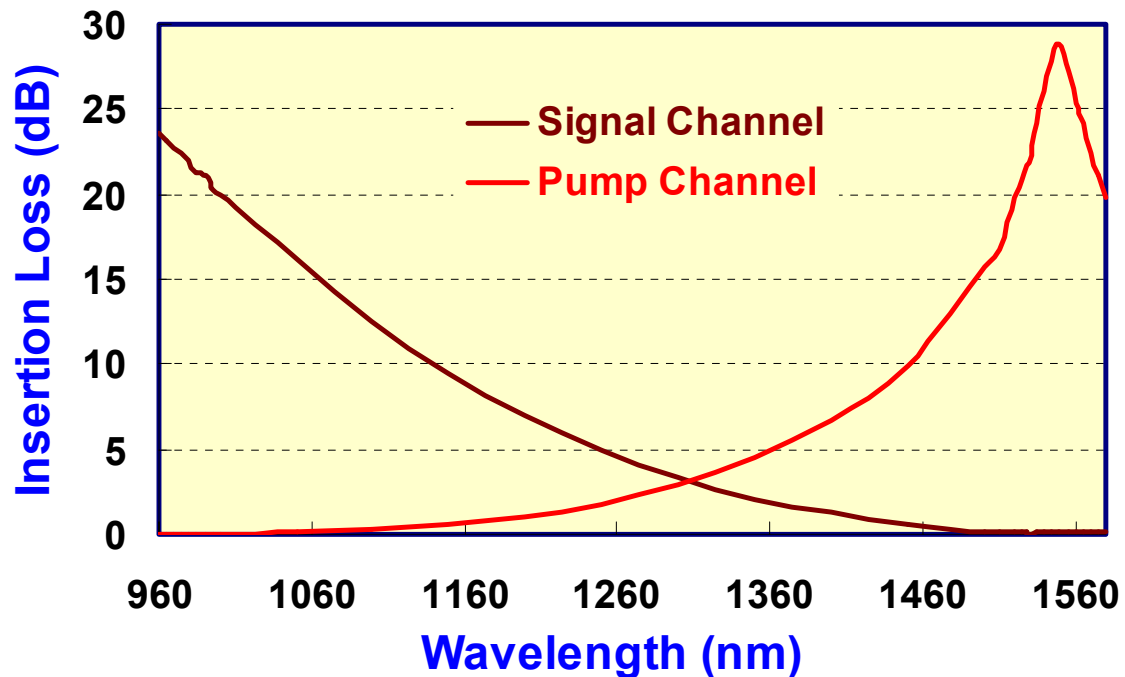
(3) Application in EDFAs



MAIN FFPs in EDFAs

5. 980/1550nm Fused Hybrid Fiber WDM

(4) Typical Insertion Loss Dependence with Wavelength



MAIN FFPs in EDFAs

5. 980/1550nm Fused Hybrid Fiber WDM

(5) Key Optical Performance

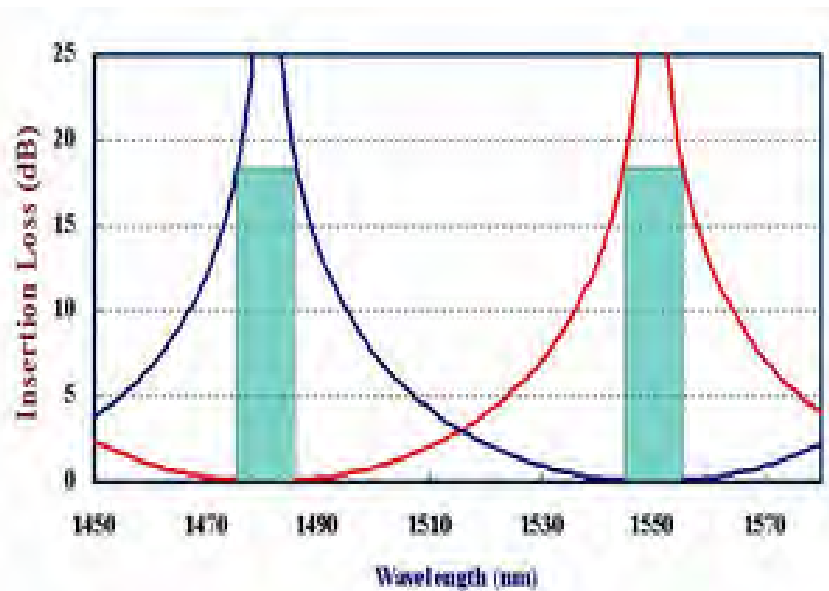
		P-Grade	A-Grade
IL (dB) for Signal to Common Port	Max.	0.2	0.3
PDL (dB) at 1550nm	Max.	0.02	0.05
Isolation (dB) for Signal to Common Port	Min.	20	20
IL (dB) for Pump to Common Port	Max.	0.1	0.2
PDL (dB) at 980nm	Max.	0.02	0.05
Isolation (dB) for Pump to Common Port	Min.	20	18
Return Loss (dB)	Min.	55	50

Bandwidth : 975+/-15nm for Pump Channel; C or L-band for Signal Channel

MAIN FFPs in EDFAs

6. 1480/1550nm WDM

(1) Theoretical Result for IL or ISO of 1480/1550nm WDM



- Channel Space is 70nm for 1480/1550nm WDM, 240nm for 1310/1550nm WDM and 570nm for 980/1550nm WDM.

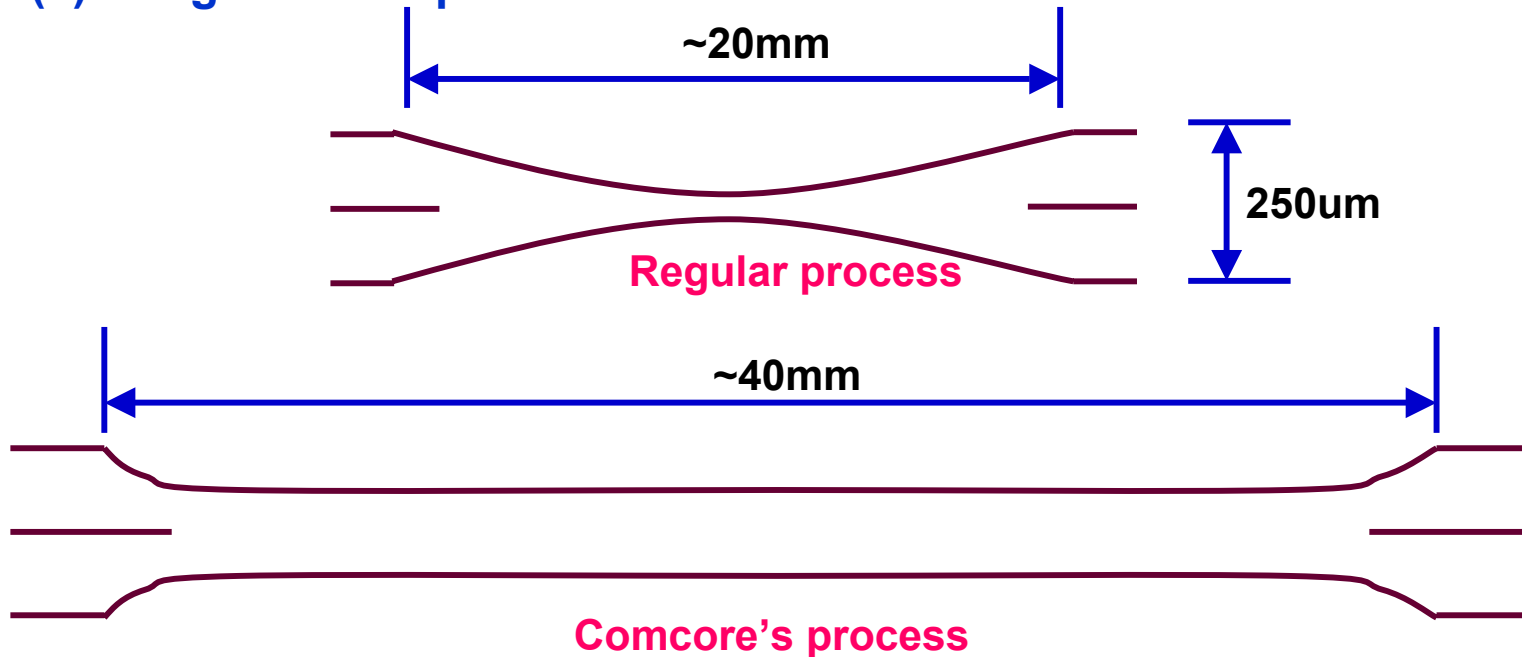
- The smaller the channel space is, the more difficult WDM is built

MAIN FFPs in EDFAs

Not in scale

6. 1480/1550nm WDM

(2) Longitude Shape

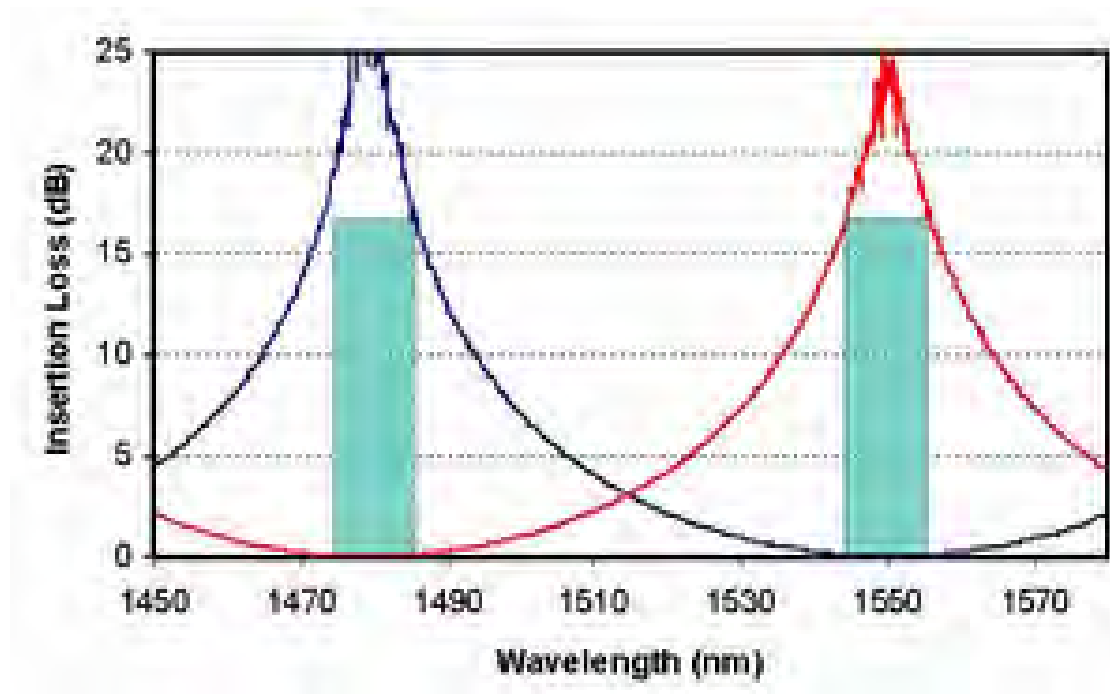


- The smaller the diameter is, the easier the fiber is broken
- The smaller the diameter is, the more sensitive the performance is
- The smaller the diameter is, the higher the PDL is

MAIN FFPs in EDFAs

6. 1480/1550nm WDM

(3) Real Product Result for IL or ISO of 1480/1550nm WDM



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PRODUCT RELIABILITY

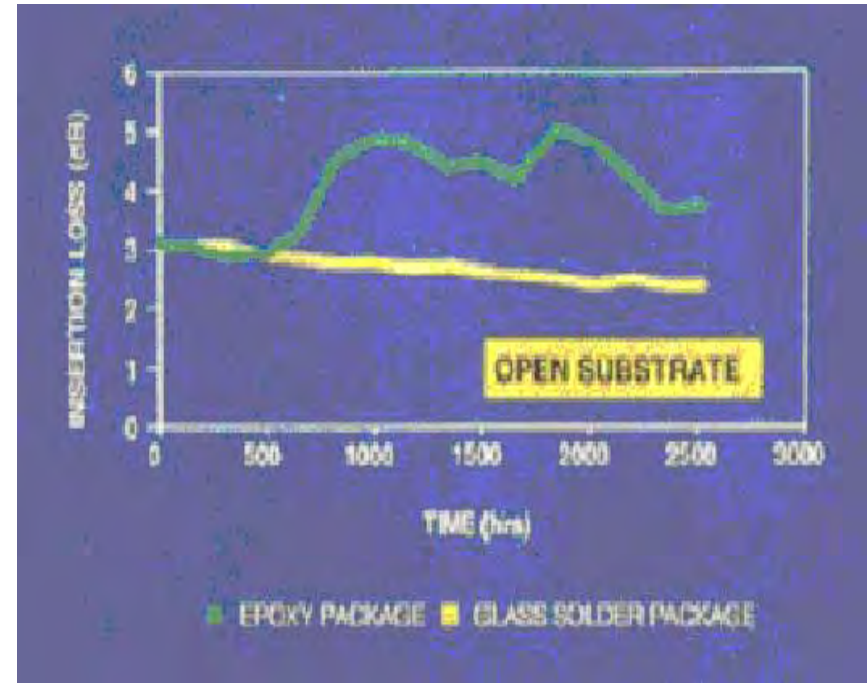
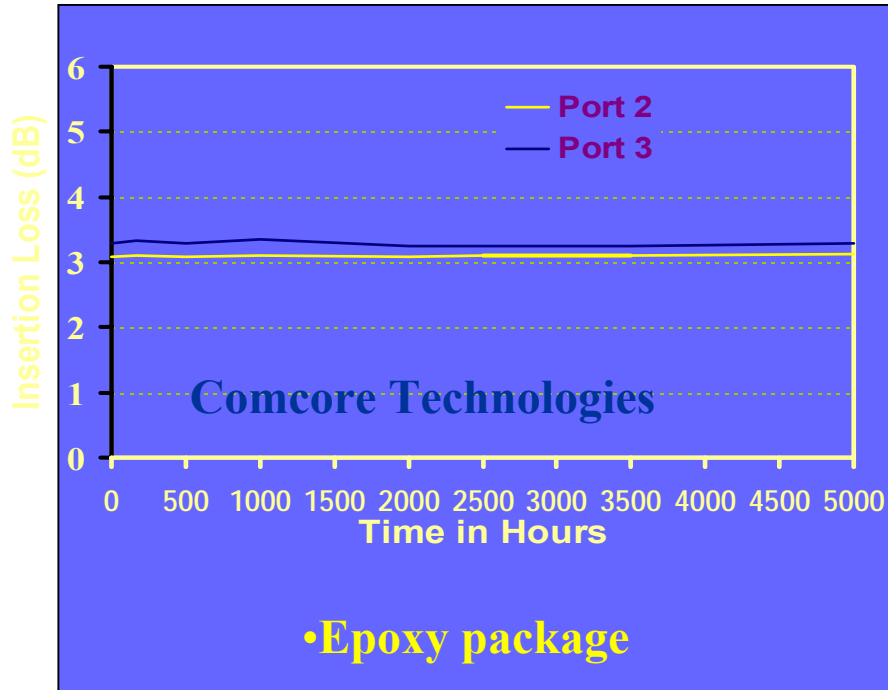
1. Quality Control Systems

- (1) Quality Assurance System: ISO9001**
- (2) Qualification & Reliability: Submarine Standard**
- (3) Process Control: Comcore's Process System**

PRODUCT RELIABILITY

2. Qualification Test Results

(1) Damping Heat Test Results for 3-dB splitter in 85C/RH85%



<http://www.gouldfo.com/tech/glas.html#figure2>



Comcore Technologies'

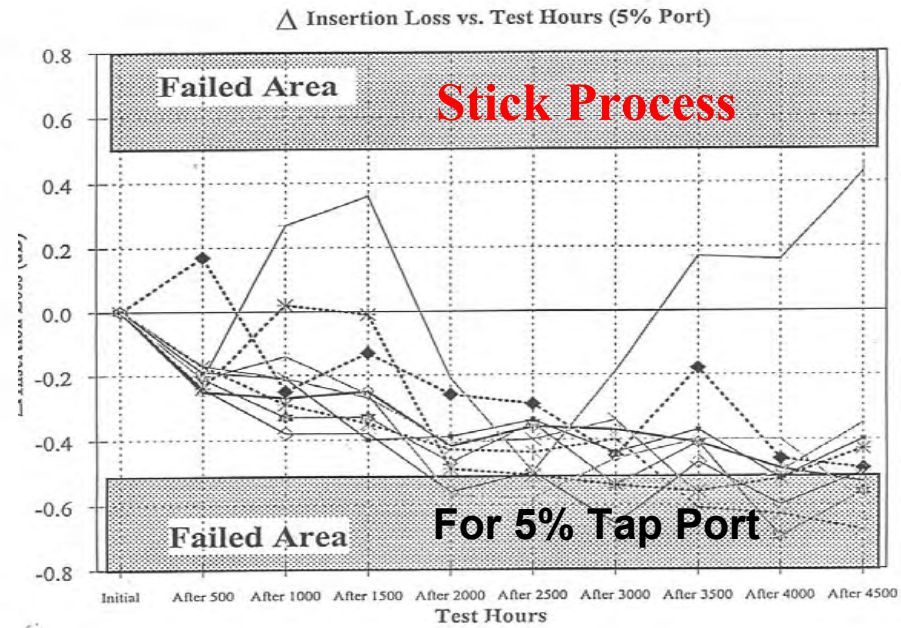
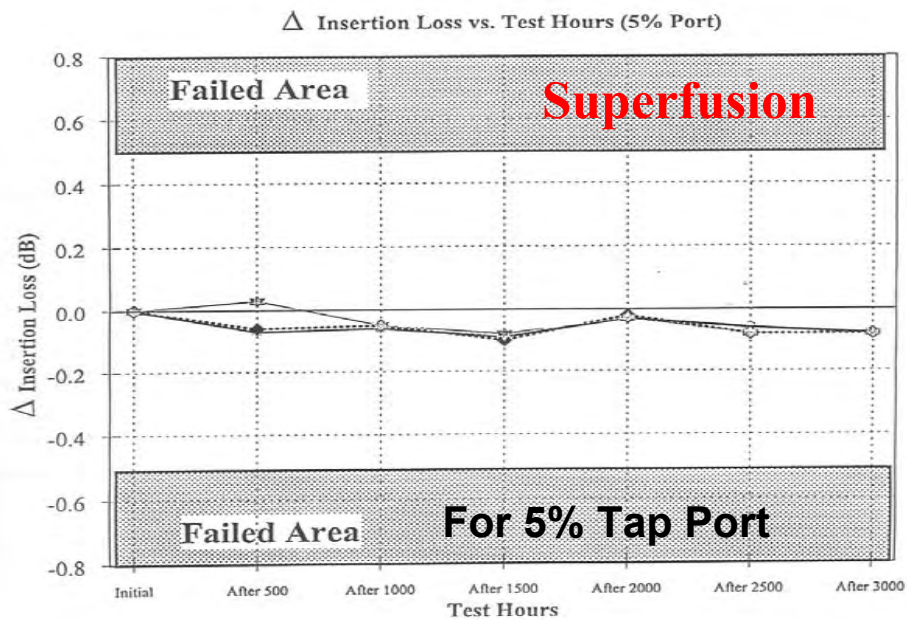
Comcore Technologies Properties
<http://www.comcore.com>

Competitor'

PRODUCT RELIABILITY

2. Qualification Test Results

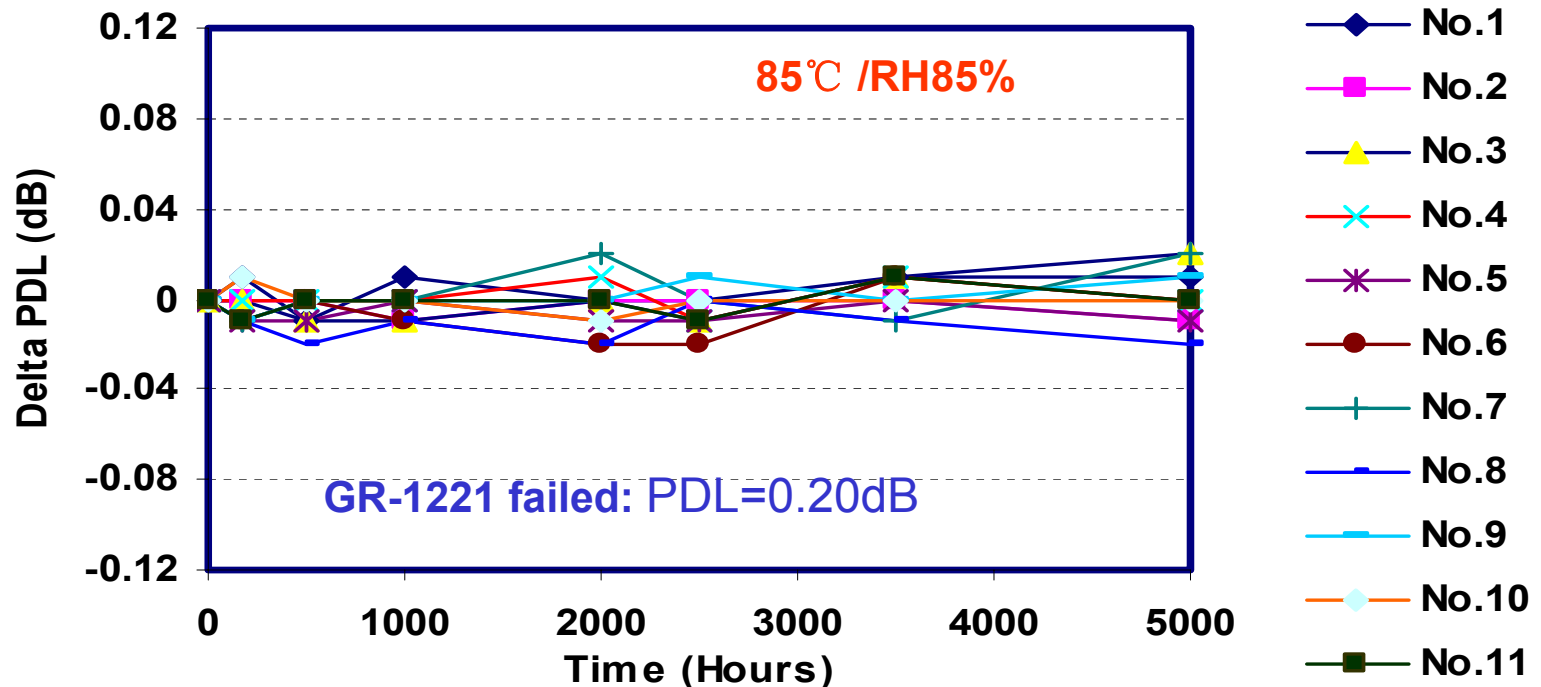
(2) Damp-Heat Testing for 1550nm 95/5% 1x2 Tap (Initial Data)



PRODUCT RELIABILITY

2. Qualification Test Results

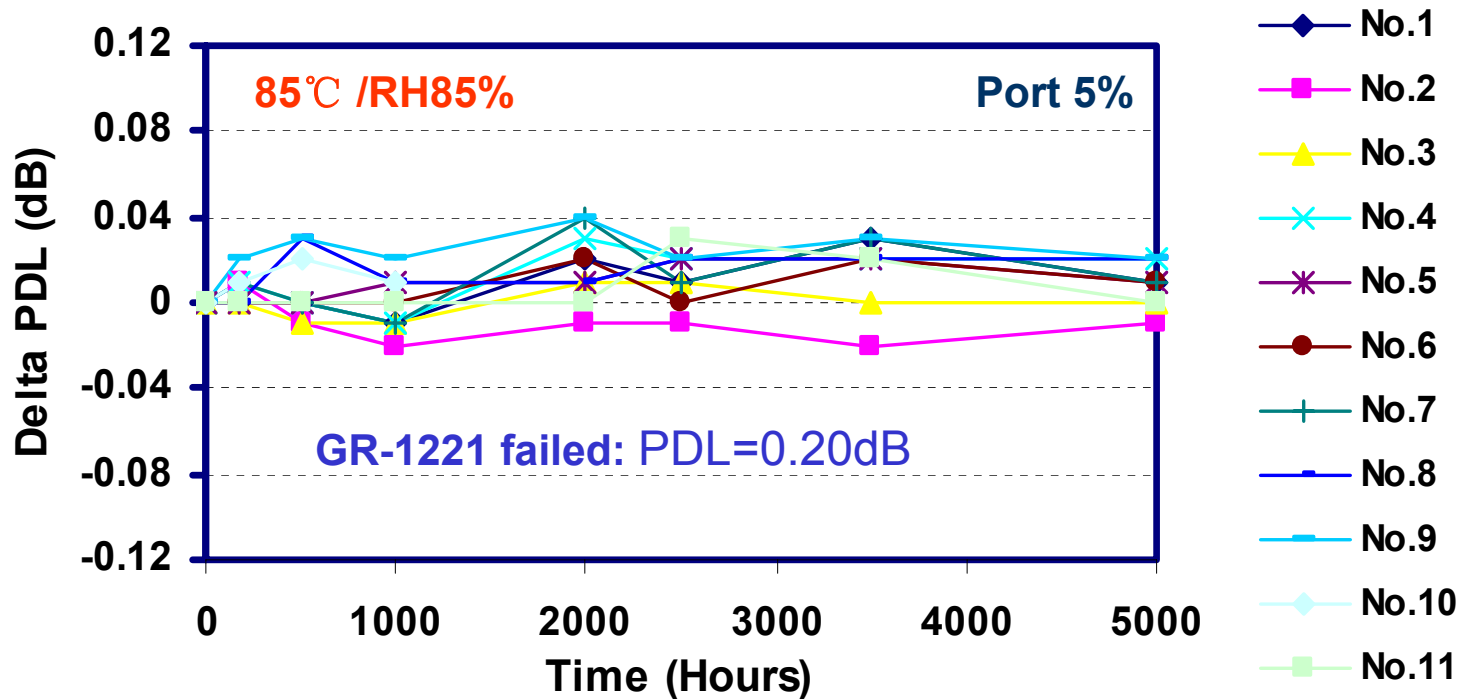
(3) Δ PDL Results of Damp Heat Test for 1550nm 50:50 1x2 Splitter



PRODUCT RELIABILITY

2. Qualification Test

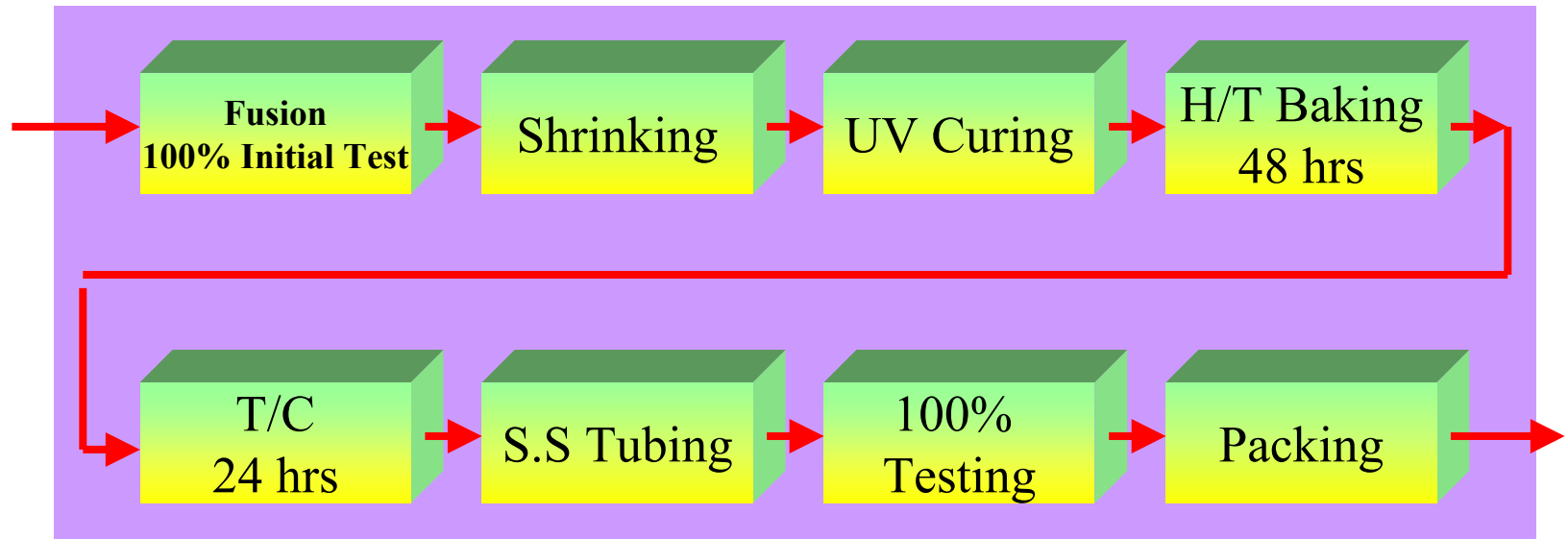
(4) Δ PDL Results of Damp Heat Test for 1550nm 95:5 1x2 Tap



PRODUCT RELIABILITY

4. Process Control: Comcore's Process System

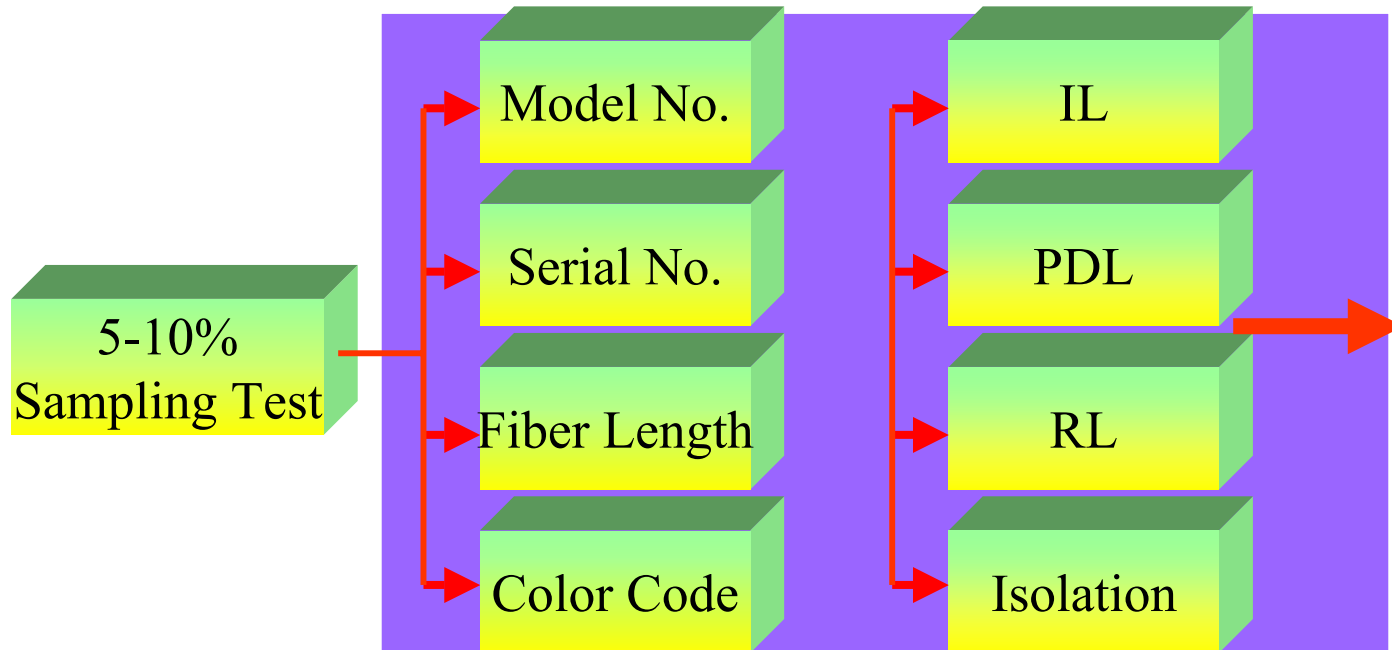
Standard Manufacturing Process of FFP



PRODUCT RELIABILITY

5. Quality Control: Comcore's Process System

Optical Quality Assurance Process



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CAPABILITY AND CAPACITY

2. Manufacturing Capacity For Optical Amplifier Applications*

Product Type	Qty/Month
2x2 980nm Splitters	500
1x2 980/1550nm WDMs	500
1x2 1480/1550nm WDMs	200
1x2 C or L-band Taps	700

* On base of one workstation for each model and one working shift

Ultra-High Reliability Fused Fiber Products

For Optical Amplifier Applications

Thank You!