



가

1.

. Image

fiber

PIF (Plastic Image Fiber)

Endoscope,

image fiber

1

PIF

가

가

가

가

4

(POF, Pla -

가

가

stic Optical Fiber)

가

. PIF

가

IT

POF

가

가

가

가

PIF

PIF

가

가

가

Single fiber

가 1

single fiber

(Pixel)

. Single fiber가

가

가

PIF

가

single

fiber

1

image fiber



1979

()

1981

()

1981

SKC



1991

()

1999

Tohoku Univ.

()

1991

SKC

The Technology of Plastic Image Guide

SKC (Youngki Hong and Jaseung Ku, SKC R&D Center, #911 Chongia - 1 dong, Changan - gu, Suwon, Kyonggi - do 440 - 301, Korea)

가 가 , ,

가 . 1980

50 - 90
PIF

15 mm
가

1

가 가 1

1988 1,500 , 1991

3,000

6,000

12,000

PIF GIF (Glass Image Fiber)

GIF

2. PIF

PIF

, clad , sea , jacket

4

2 PIF

1

가

50 - 90%

500 μ m

Ultrathin Endoscope

GIF가

clad

sea

가

3

150

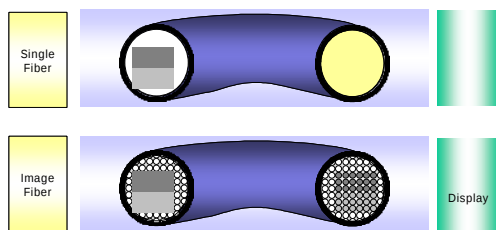
Clad

1

POF

가

AIDS,



1. PIF

1. Image Fiber

Image Fiber		glass	plastic
	高	高	中
NA		○	
Yellow Index		○	
		○	
가	高	高	低

POF

clad

가

clad

2

sea

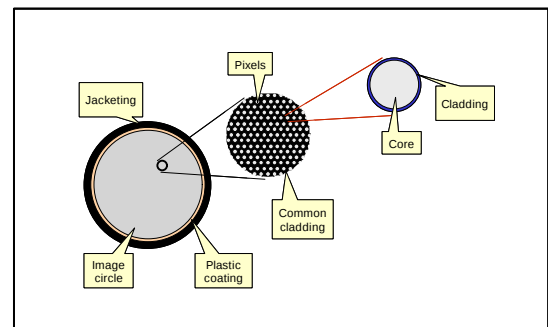
jacket

clad

1

clad

sea



2. PIF

가

Sea

clad
sea
clad
clad

sea

3

Jacket

bending

3. PIF

PIF가

, Yellow Index,

가

3

3.1

PIF
(Resolution)

2

PIF

1.5 mm

2

5 m

PIF

Resolution Test Target

(4). Reso -

lution Test Target

group

element

ment

PIF

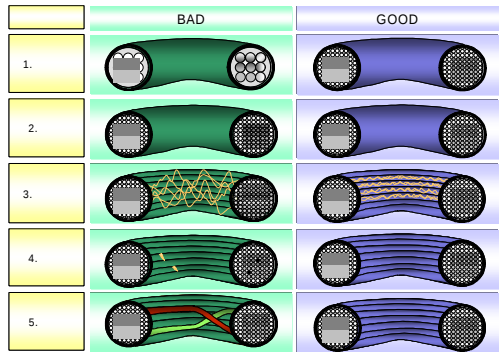
. PIF

element

10 μm, 1400
Resolution Test Target 4 group 5

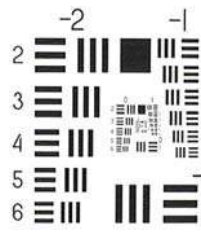
25.4

circle



3. PIF

Resolution Test Chart



Element						
Group	1	2	3	4	5	6
-2	0.3	0.3	0.3	0.4	0.4	0.4
-1	0.5	0.5	0.5	0.7	0.5	0.9
0	1.0	1.1	1.3	1.4	1.6	1.8
1	2.0	2.2	2.5	2.8	3.2	3.6
2	4.0	4.5	5.0	5.7	6.3	7.1
3	8.0	9.0	10.1	11.3	12.7	14.3
4	16.0	18.0	20.2	22.6	25.4	28.5

4. Resolution Test Target.

가

가

가

1.5 m

7 μm

가

Picture Circle

3.2

(Brightness)

Brightness Index

I가

. I

$$I = S \cdot NA^2 \cdot 10^{-(aL/10)}$$

S

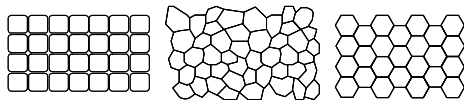
PIF

. NA

Numerical Aperture

, a

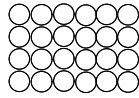
, L



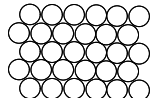
a -

b -

c -



d -



e -

5.

가 가

5

가

가

I

b

c, d, e

d e

e

5

가

e 가

I

NA

$$NA = \sqrt{n_1^2 - n_2^2}$$

n_1

, n_2 clad

가 가

clad

0.01

clad

PIF

NA 0.16

0.3 - 0.51

2

clad

2. PIF

Clad

Polymer		Polymer	
PMMA	1.49	CH = C (CH ₃)COORf	
PBMA/PMMA	1.47 - 1.50	Rf: CH (CF ₃)	1.38
PS	1.58	: C (CF ₃) ₃	1.36
PS/PAN	1.56	: CH ₂ CF ₂ CHFCF ₃	1.40
Poly - 4 - methyl pentene	1.46	: CH ₂ CF (CF ₃) ₂	1.37
PE/Poly vinyl acetate	1.46 - 1.50	fluoromethacrylate	
PC		/PMMA	1.37 - 1.43
Poly chloro styrene	1.61	CH ₂ =CHCOO Rf	
PVC	1.63	Rf: CH ₂ CF ₂ CHFCF ₃	1.41
Poly vinyl acetate	1.47	CH (CF ₃) ₂	1.38
Poly dimethyl siloxane	1.40		
Poly acetal	1.48		
PTFE	1.35		
PVDF/PMMA	1.42 - 1.46		

3. Light Transmison Loss

A (dB/m) at $\lambda = 6000$ nm		
diameter (μ m)	PMMA/FP	PS/PMMA
8 - 10	1.3	2.5
16 - 20	1.1	2.3
30 - 32	1.1	2.1
50	1.0	NA

4.

PIF I

	Run1	Run2	Run3	Run4	Run5
	1350	1350	1350	1350	1350
(μ m)	10	20	20	50	80
NA	0.47	0.47	0.47	0.47	0.47
n	0.077	0.077	0.077	0.077	0.077
(%)	60	69	40	75	80
A (dB/m)	1.3	1.1	1.1	1.0	0.85
L (m)	2	3	3	5	5
I ($\times 10^{-2}$)	7.2	7.1	4.1	5.2	6.6

a

3 PIF

6

가 PMMA clad가 fluoropolymer
/clad가 PS/PMMA

I 4.5×10^{-3}

4

PIF I

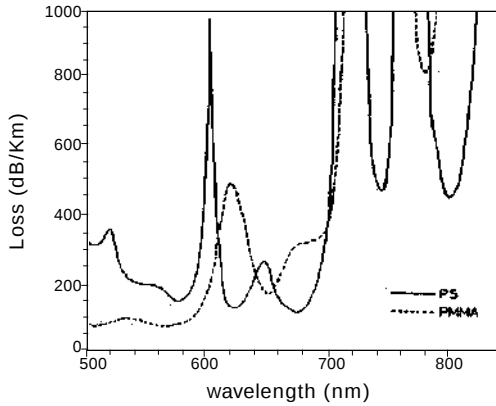
7

3.3 (Yellow Index)

PIF

가

. 380 nm 780 nm



6. PS PMMA Transmission Loss.

가 가

6 PS PMMA
PS 600 nm
PMMA 가

POF

Yellow Index

Yellow Index

Yellow Index=100 (128 X - 106 Z)/Y

$$X = \sum_{380}^{780} P_i X_i t_i, Y = \sum_{380}^{780} P_i Y_i t_i, Z = \sum_{380}^{780} P_i Z_i t_i$$

t_λ JIS Z 8722 - 1971

BoroScope

Yellow Index 가 40

3.4

가 gray point

가

dust

가

가

weak point

PIF

clad, sea

GIF

3.5

PIF

가

single fiber

sea

bundle

spinneret

, clad, sea

feed block

land

가 가

edge

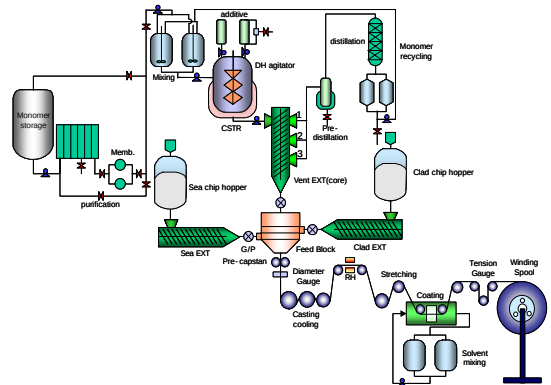
, clad,

sea

feed block

sea > clad >

. Feed block



7. PIF

dead space가

가

가

가

image fiber

1960

CCD

1983

Welch - Allyn

7 PIF

4. Muti

POF Preform Drawing Conju -
gated Melt Spinning Conju -
gated Melt Spinning

single multi

PIF

PIF Conjugated Melt Spinning -
Multi 가

5 multi

4.1

rigid
type 1800 flex -
ible type 1932 Shindler & Wolf

가
가

PIF
GIF

flexibility

가

가

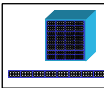
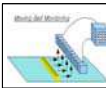
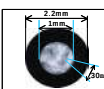
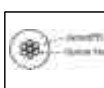
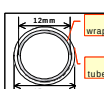
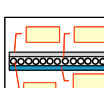
300 - 800 μ m

Ultr -

athin EndoScope

가

5. Multi

Image Guide			-GOF 가 低 -GOF () -1 가	- 12,000core/2.5mm - 6,000core/2.5mm
Image Sensor				- check : 75core /2.5mm - check : 3000core/2.5mm
multi-core			-Single core Bending loss 小 - SI () (GI)	-Core : 217core/mm - : 500Mbps - : 50m - (single fiber : 10mm)
Light Guide			-Single Fiber (3f) - () :	
Side Light			- () - Neon sign (100 /每) - 가 - 黒	-Core : 45-150 -30m (100W H lamp 3100°K)
Ribbon			- () -Sign, Back light	- Sign : 14% - Back light : 3%

가 flexibility가 PIF

가

가

body

PIF

4.2 Image Sensor

OA

가 image sensor

image sensor light point sensor, line point
light guide

Image sensor

가

scanning

가

가

4.3

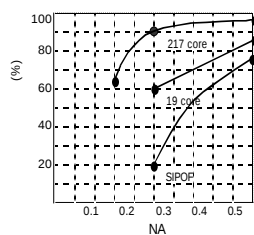
Multi

Multi

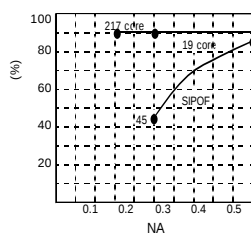
PIF

application

Multi POF NA multi NA SI POF clad 가 NA delay time POF NA 가 0.5 100 M 80 - 100 Mbps가 delay time 가 POF NA graded index 가 NA 가 multi SI POF Multi 가 POF NA 0.15 가 8 SI POF multi POF



(a) LED



(b) LED ()

* 10 mm 360° Fiber Diameter 1000 mm
SIPOF core diameter: 980 mm, 19 core: 18 mm, 217 core: 55 mm

8. POF

6. POF

POF		Fiber NA	(MHz 100 m)	
			NA 0.25	NA 0.50
Single	1	0.50	85	70
Multi	19	0.25	210	170

Multi POF single 가 Single 70 - 90% clad 가 multi single delay time 6 multi single 4.4 Analogue light guide 가 , 가 POF 60% 가 Light guide POF MH, 가

flexibility 3 mm 10 mm multi

fiber board sign, side light Conjugated Melt Spinning ribbon fiber 가

5.

PIF multi , , 가 가 POF 5

Single
less, Glass Fiber
가
PIF
POF
,
POF
PIF mult
Conjugated Melt Spinning

Copper, Wire -
,
multi
risk
single type
PIF

가

1. プラチック光ファイバ - , 共立出版, 257 (1997).
2. T. Tsumanuma. et al., *Proc. SPIE.*, 906, 92 (1988).
3. [http://www.nanoptics.com/Fiberoptic paper](http://www.nanoptics.com/Fiberoptic%20paper).
4. USFA 1951.
5. Mitsubishi Rayon Co. Ltd., USP 5,039,457.
6. Mitsubishi Rayon Co. Ltd., USP 4,872,740.
7. JIS Z 8722 - 1971.
8. Mitsubishi Rayon Co. Ltd., USP 4,812,012.
9. H. Munekuni, S. Katsuta, and S. Teshima, *Plastic Optical Fibers & Applications Conference*, 94, 148 (1994).