Plastic Fiber Active Optical Cables (AOCs) for UHD Video

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Trends in Display Technology

	1950 ～	1990	2005	2010	2015	2020
	Analog	SD	HD	HD+	HDMI 2.0	
Color Gamut	BT.1700	BT.601	BT.709	xvYCC, BT.2020		
Color Depth	-	8bits		10bits～16bits		
Frame rate	30fps	30fps		60fps	60fps	
Resolution	535line	720x480	1920x1080		4K	
Dimension	2D	2D		3D (w.glass)	3D	
Transmission speed	10MHz	0.25Gbps	1Gbps	10Gbps	18 Gbps	

RCA cable

HDMI cable

Optical cable

Source: Prof. Y. Koike, Keio University

HDMI 2.1 will reach 48 Gb/s for 8K video
Proprietary links inside HDTVs expected to exceed 100 Mb/s

Limitations of Copper Cables

Bandwidth

- For HDMI 2.0, (18 Gb/s) copper cables are quite practical and retain good flexibility up to ~5 meters
- For HDMI 2.1 (48 Gb/s) max length is expected to be ~2 meters
- Active copper cables are already widespread

Other problems

- Longer copper cables rapidly become quite large, heavy, and stiff
- More difficulty with non-latching connectors
- More difficulty in pulling behind walls

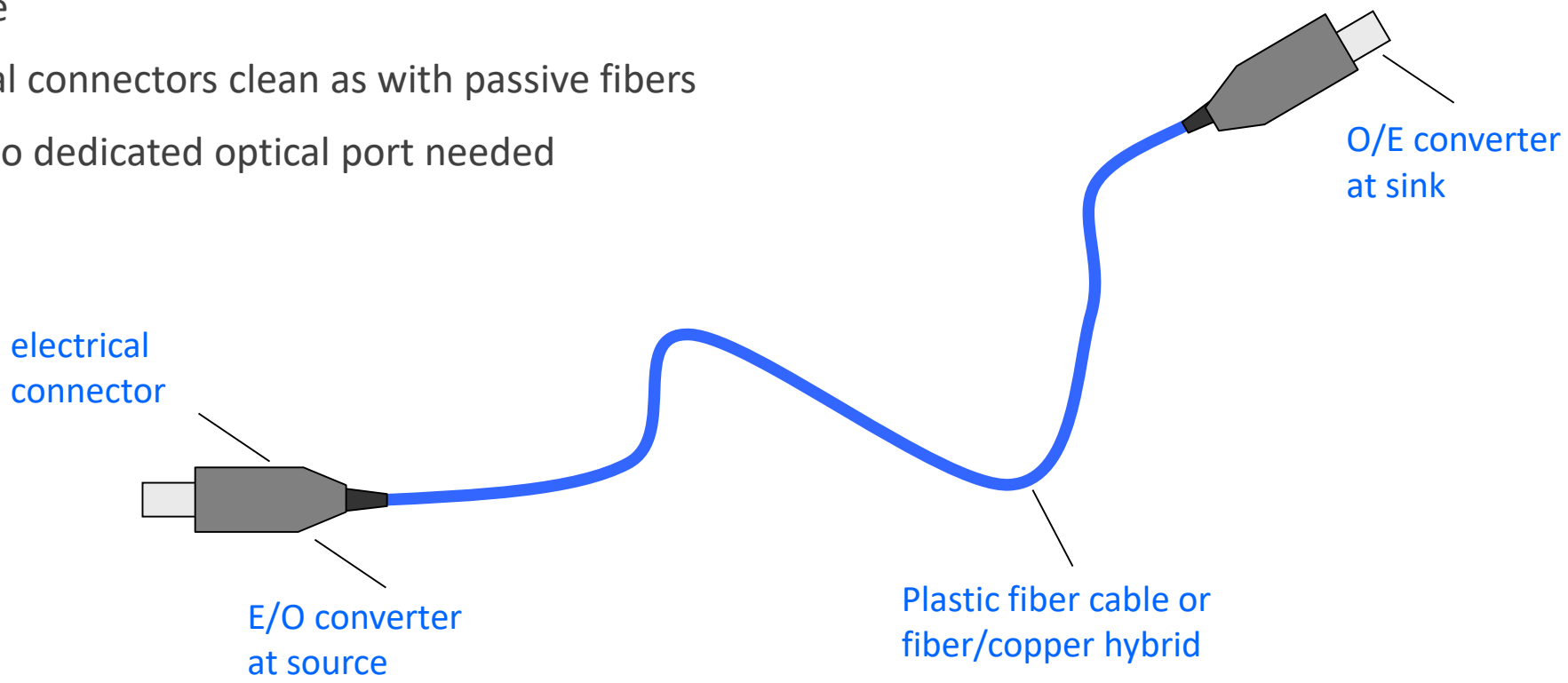
Optical implementations of HDMI 2.0 already widely used in commercial and school installations (10 -100 meters)

Optical HDMI not yet a factor in residential – but it will be!

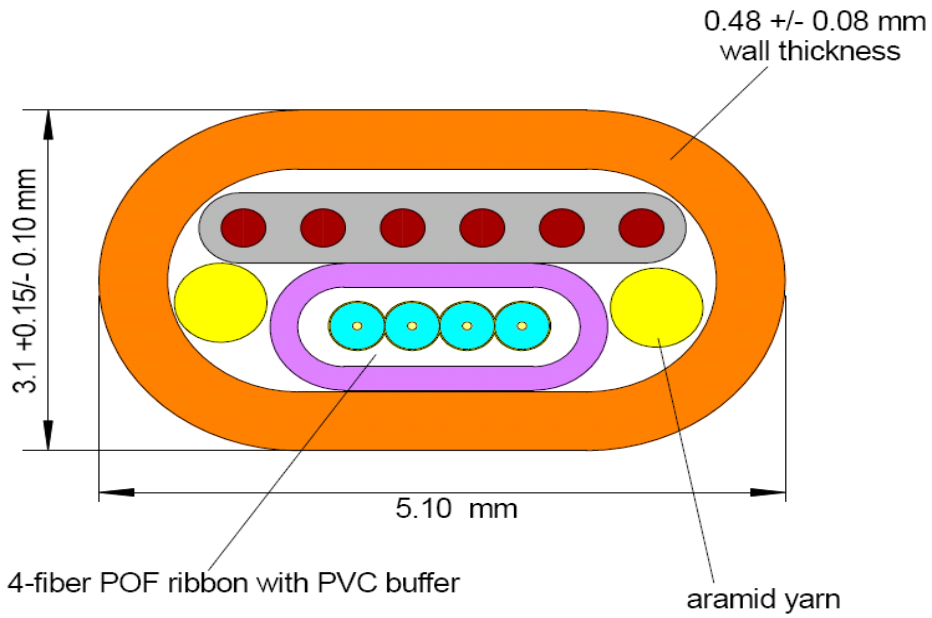
Solution: Active Optical Cables

Advantages of AOCs

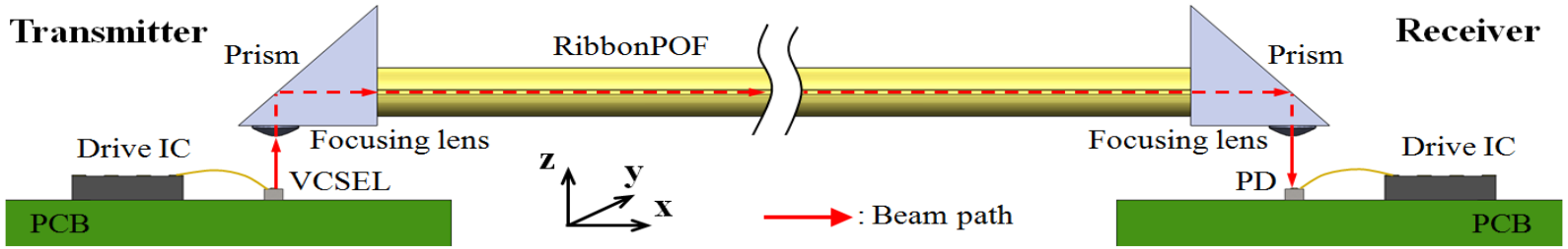
- supports much longer distances than copper
- cable reminds small and flexible
- no need to keep exposed optical connectors clean as with passive fibers
- uses standard electrical port - no dedicated optical port needed



Construction of GI-POF HDMI AOC

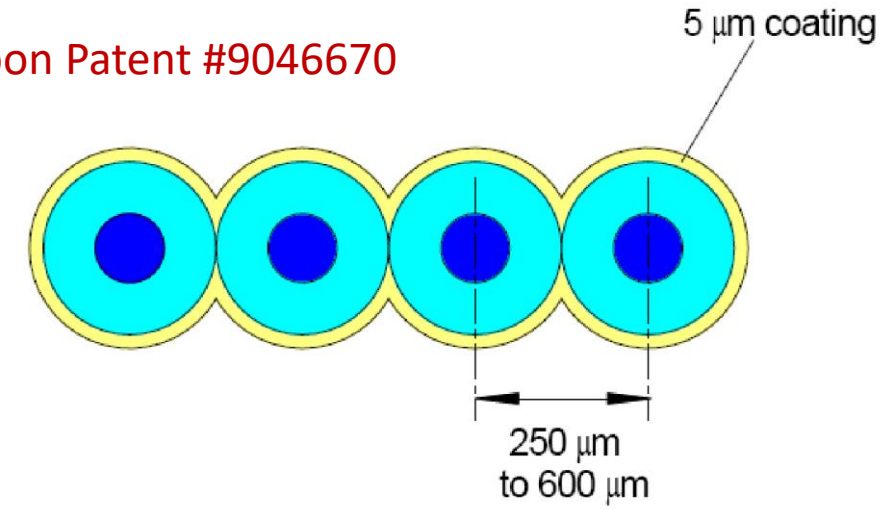


- fully ribbonized cable elements
- mechanical durability of POF simplifies construction of fiber/copper hybrid cables
- low-cost, non-hermetic OSA with chip-on-board mounting of VCSELs and PDs



Patented monolithic GigaPOF® ribbon is easy to terminate

GigaPOF® Monolithic Ribbon Patent #9046670



Patented Monolithic GigaPOF® Ribbons

- Terminate multiple fibers as a single unit
- No need to strip overcladding to terminate fiber
- 100% passive alignment of fiber to OSA

Reduces fiber termination costs

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Award-Winning Plenum HDMI 1.4 and 2.0 AOCs

InfoComm "Best New AV Accessory"

Commercial Integrator "25 Best of 2013"

EC&M "2014 Product of the Year"

- installed in ~ 100,000 video links in North America
- first large-scale use of GI-POF worldwide
- most volume now migrated to HDMI 2.0 product

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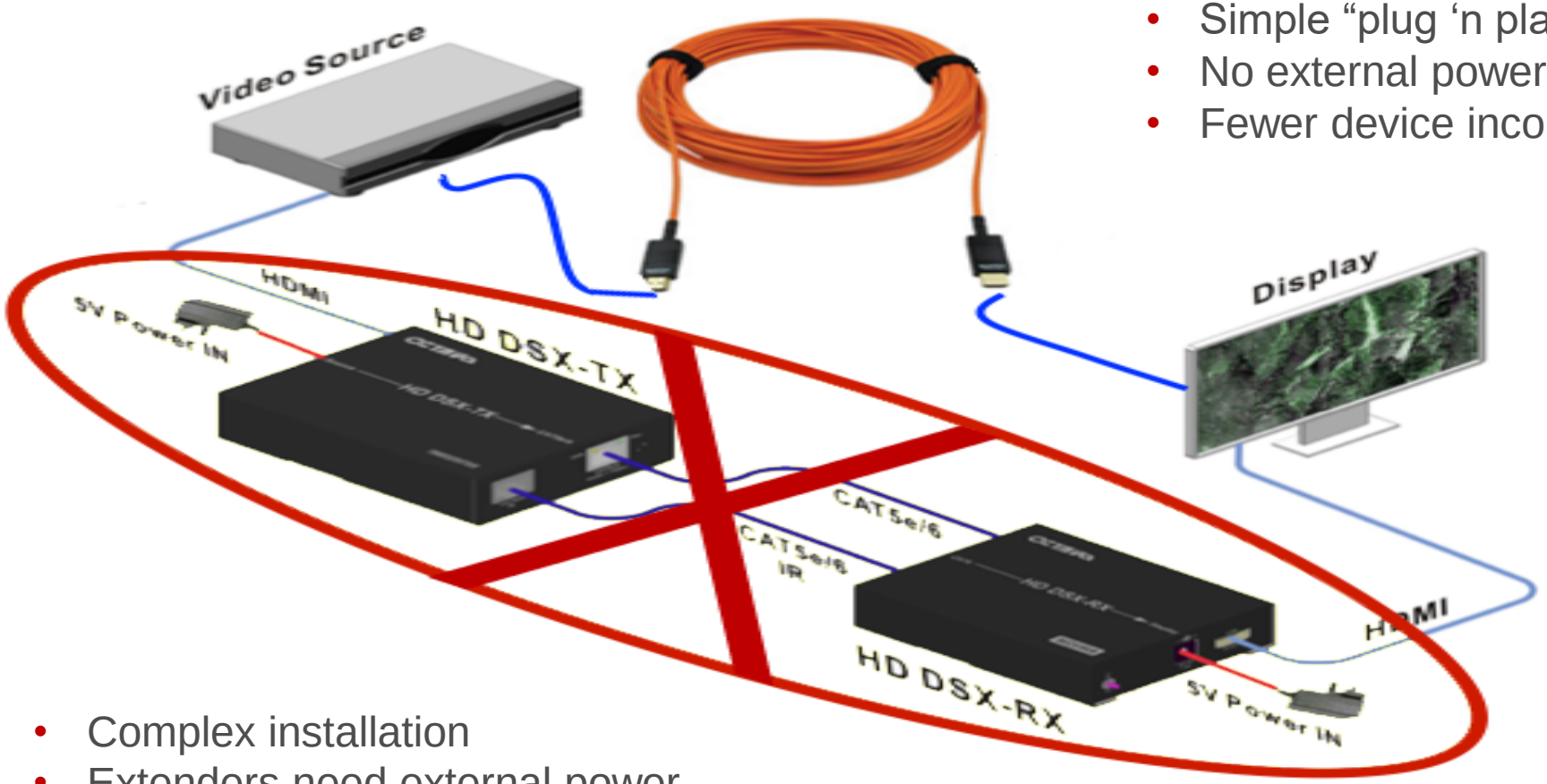
Long HDMI Link Alternatives

- Simple “plug ‘n play” install
- No external power needed
- Fewer device incompatibilities



- Complex installation
- Extenders need external power
- Many potential incompatibilities
- Relatively expensive

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DisplayPort AOCs

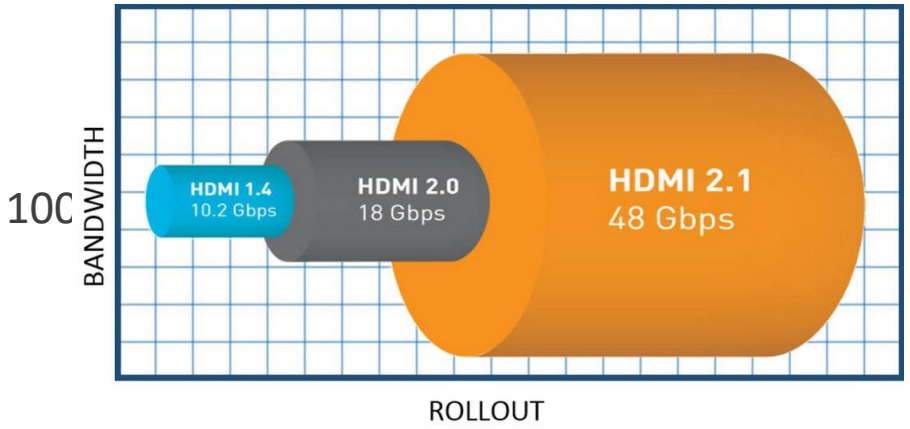
- DP 1.2 AOCs support up to 32.4 Gb/s data rate (8.1 Gb/s per channel)
- technically most robust solution for 4K/60 4:4:4 video
- but does not support HDCP 2.2
- DP 1.4 will support up to 32.4 Gb/s data rate (8.1 Gb/s per channel), and will also support HDCP 2.2

- much smaller volume than HDMI AOCs so far
- opportunities coming in AR/VR systems, gaming, and digital signage

What's Next for UHD AOCs?

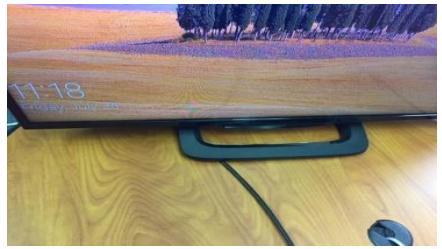
Higher bandwidths

- 48 Gb/s for HDMI 2.1
- links between TV processing units and display likely to exceed Gb/s in near future
- methods to achieve higher bandwidth are well known, no different between POF and glass fibers



Short distances and consumer environments

- ProAV - semi-skilled commercial installations, usually dragged through conduit and inside walls and ceilings
- with HDMI 2.1 and TV links, AOCs will extend down to consumer electronics - no control over abuse of cables
- glass fiber cables can tolerate this abuse on a short-term basis, but fail over time
- new applications not only require better durability, but also more cost sensitive



AOCs will need to tolerates kinks, pinches and knots on a permanent basis.

much lower assembled costs needed in consumer markets.

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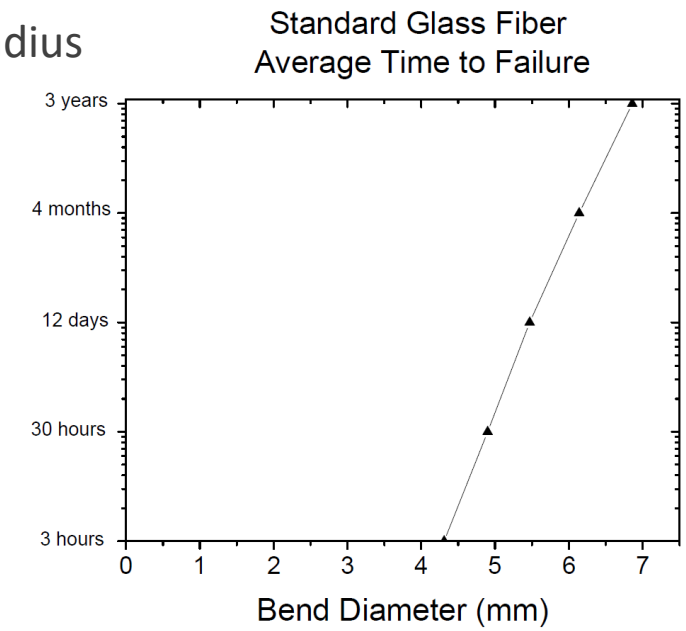
GigaPOF® is immune to static fatigue failures

Glass fibers suffer from static fatigue

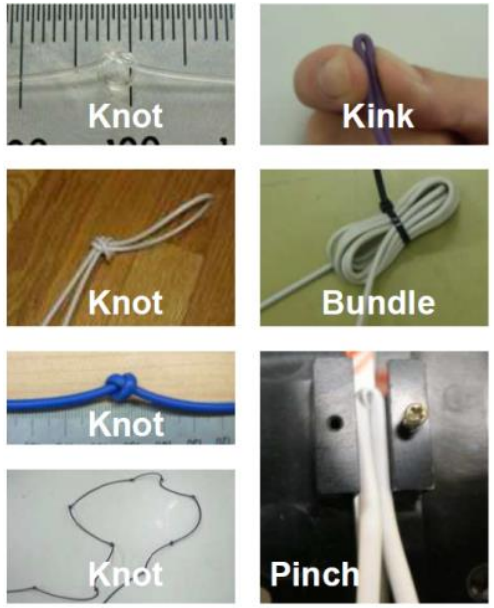
- when fiber is bent, material stretches on one side, compresses on the other
- strain makes it easier to nucleate cracks
- over time, cracks form spontaneously Time to cracking failure is related to fiber bend radius
- when fiber pushes against other elements, bend radius can be sharper then cable bend radius
- high speed copper cables are also vulnerable to strains that affect pitch of twisted wire pairs
- When fiber pushes against other elements, bend radius can be sharper than cable bend radius

Source: Corning, Inc.



Plastic fibers are immune to static fatigue

- polymer molecules can creep past each other over time,
  relaxing strain
- polymer fibers take a “set”, but they don’t crack
- so, polymer fiber cables can withstand pinches, knots and kinks permanently



AGC demo of tight-bending fiber type

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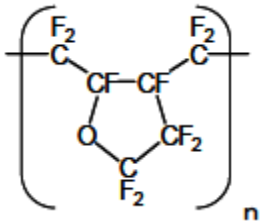
Synthesizing Polymers for Ultradurable Fibers

Material choices are critical for ultra-durable POF

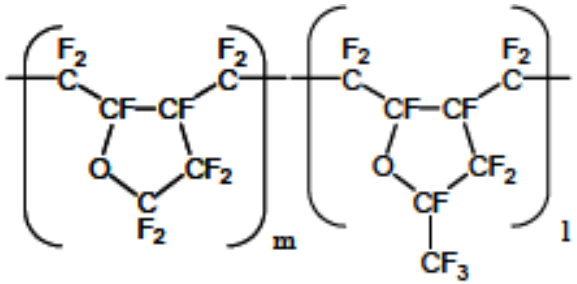
- Chromis started by making POF using only the PBVE (CYTOP) homopolymer, and an index-raising dopant

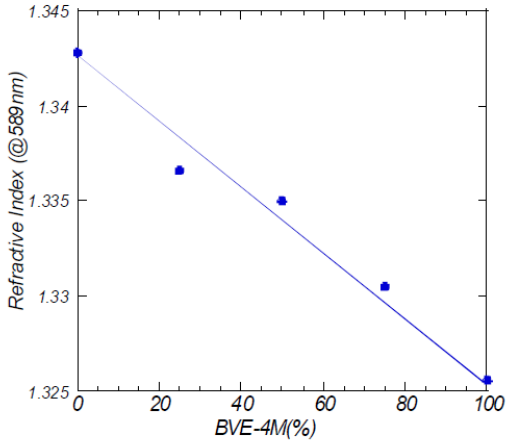


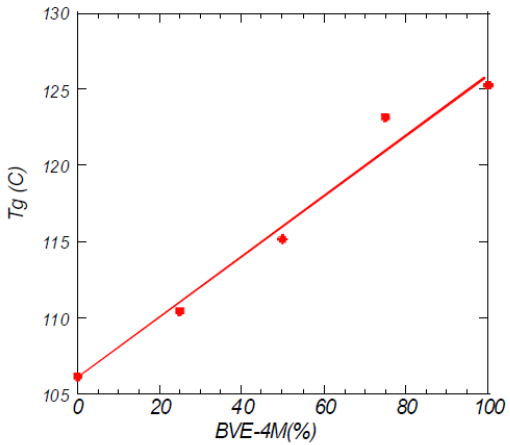
- dopant solubility and Tg depression limits NA practically to 0.18 or less using only dopant and PBVE homopolymer
- bend tolerance of ~1 mm requires NA ~ 0.23.
- this requires use of lower-index polymers as cladding materials

Copolymers for ultra-durable POF

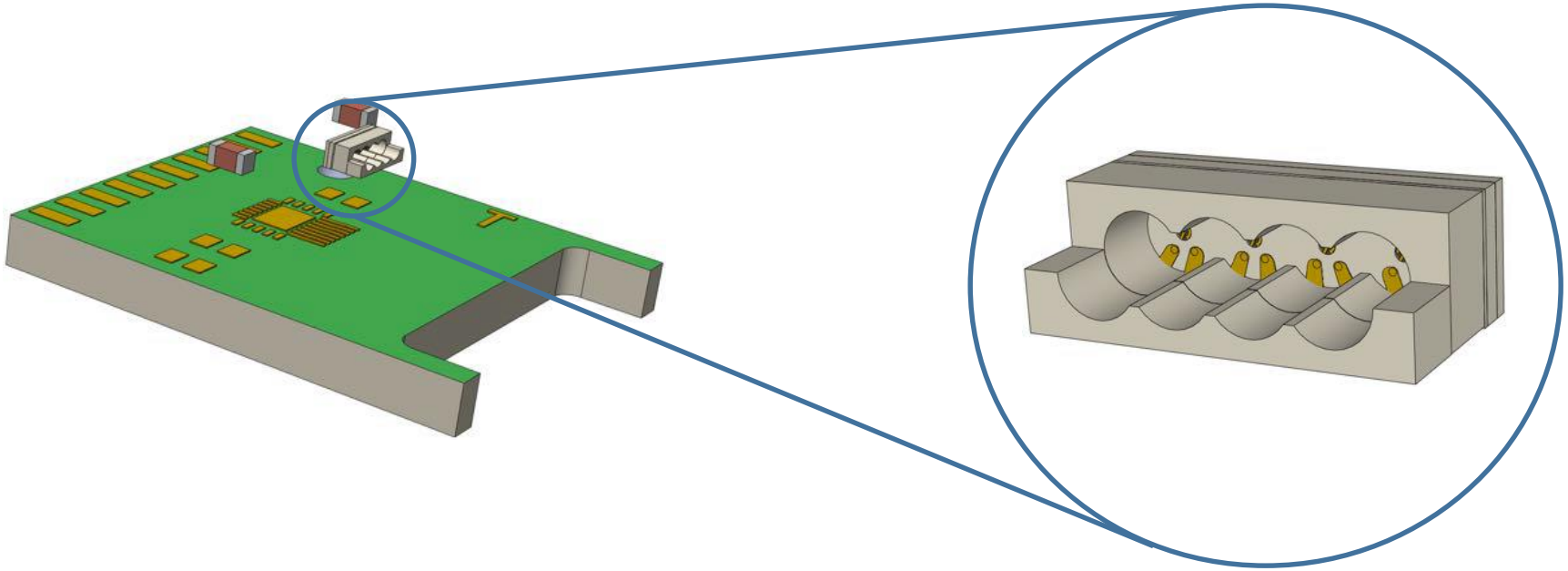
- by co-polymerization of PBVE with other monomers, we can make polymers that enable fibers with a much higher NA, and/or higher Tg



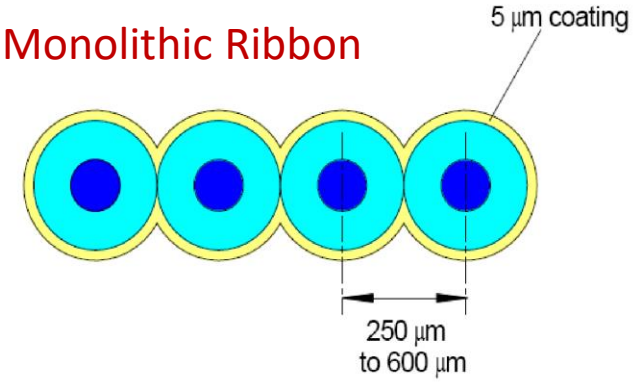




Innovative optical engine optimized for GigaPOF®



GigaPOF® Monolithic Ribbon



- prism- and lens-free optical sub-assembly design
- attaches to PCB as single unit with solder reflow
- shaped for Chromis monolithic GigaPOF® ribbon
- cheaper to make than traditional optical engines

Lower AOC bill of materials and assembly costs

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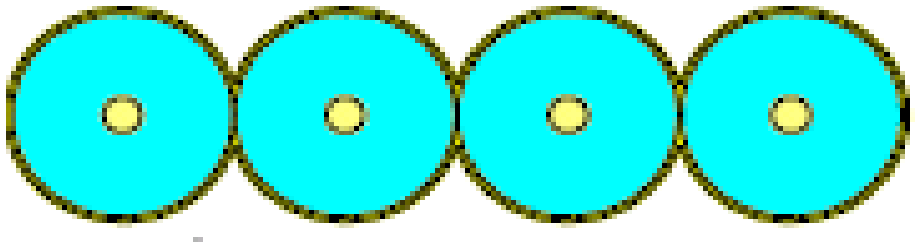
Ease of Assembly

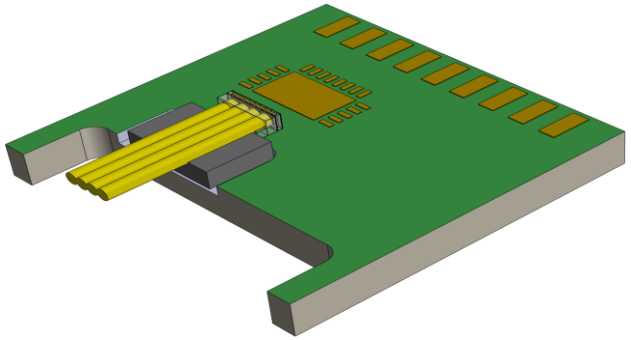
Monolithic POF Ribbon

- Terminates as single unit
- Guillotine cut and plug in to OSA



Use simplified OSA

- Attaches to PCB as single unit w. solder reflow
- Shaped to accept monolithic ribbon
- No lenses or hermetic seal



Keep Channel Count Low

- ~25 Gb/s each channel, not 10 Gb/s
- 2-4 fibers vs. 6-12

Requirements for Consumer POF Cables

Ease of assembly

- Millions of units per month required
- Assembly by unskilled operators with high turnover
- Most steps must be automated

Durability

- Optical ends protected against dust and contamination
- 1-2 mm permanent bending, knots, etc.

Low cost

- USD $100 active cables are OK in pro A/V
- Consumer cables need to wholesale below USD $20
- Highly automated assembly
- High volume partnerships with makers of ICs, VCSELs

GigaPOF® pathway to optical performance at copper cost

Graded-Index Polymer Optical Fiber
(Chromis GigaPOF® GI-POF)

+

Patented monolithic GigaPOF® ribbon

+

Lens- and prism-free optical engine that mounts by solder reflow

Innovative technology cuts bill of materials and assembly costs to make inexpensive AOCs possible

GigaPOF® Salus Series Plenum HDMI 2.0 AOC

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Conclusions

HD video cables represent a good opportunity for POF

Professional video AOCs have been the first market for GI-POF

8K standards represent the possibility to greatly expand this

- HDMI 2.0 takes special efforts not to require higher-bandwidth cables
- HDMI 2.1 and later standards will be unable to avoid improved cables
- POF has unique virtues for a multi-gigabit consumer cable
- Heroic strides in cost reduction will be needed for success – but POF enables these