Perspectives on Multicore Fiber (MCF) Platforms vs. Incumbent Technology

WS2
OECC
July 7, 2019

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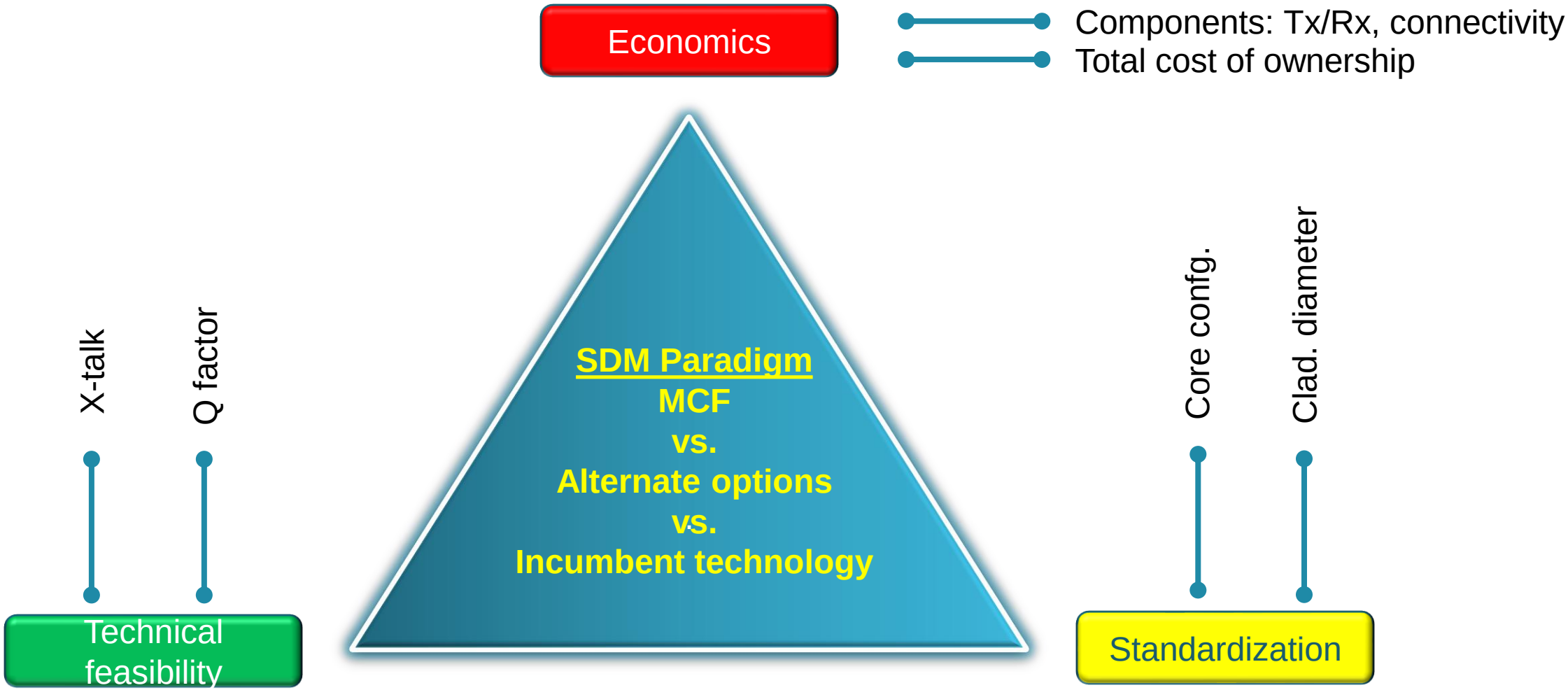
Acknowledgements
D. DiGiovanni, D. Inniss, A. McCurdy, R. Lingle, Jr., Y. Sun, K. Balemarthy, R. Shubochkin, D. Peckham, D. Braganza, A. Oliviero, P. Weimann (OFS) and R. Sugizaki, Y. Arashitani, K. Mukasa, T. Saito and M. Tsukamoto (Furukawa Electric Co.)

Outline

- Introduction
- Multicore fiber vs. alternate options
  - Datacom (Short reach)
  - Ocean (Ultra-long reach)
  - Metro (Mid-range reach)
- Concluding remarks

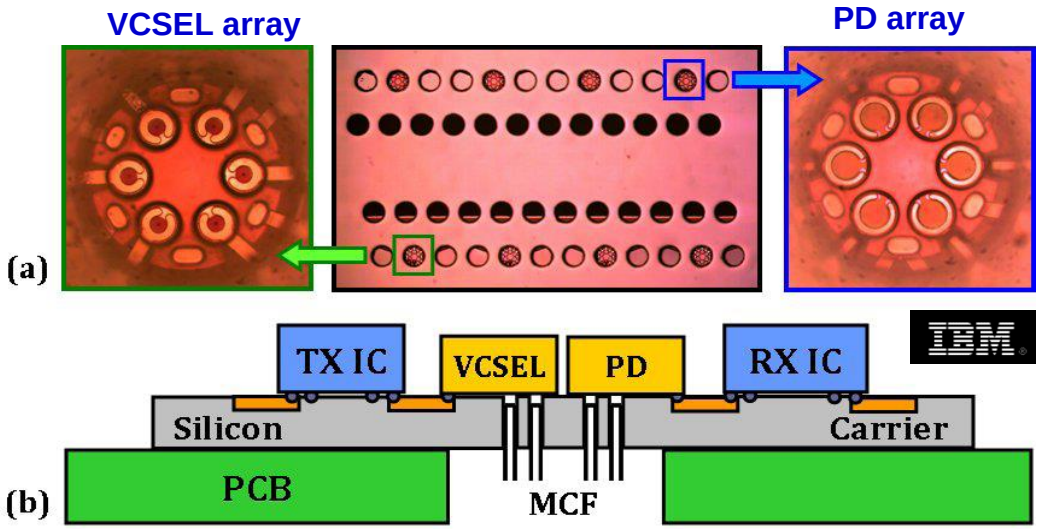
Technology adoption framework for SDM

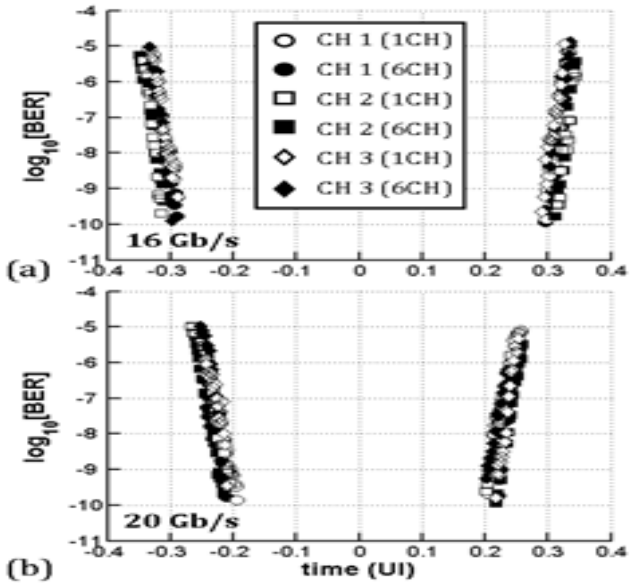


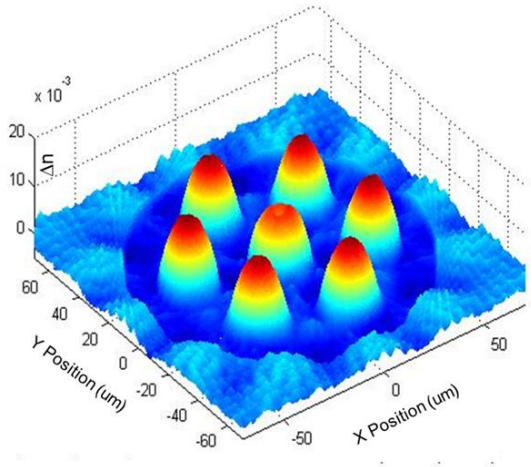
Datacom

Multicore fiber in datacom: 120Gb/s end-to-end multicore multimode fiber optic link

- 7-core graded-index MMF with low crosstalk and DMD
- 2-D VCSEL array and 2-D PD array interfaced with six cores in a multicore graded-index fiber
- 120-Gb/s end-to-end transmission link over 100m multicore MMF without fan-in/out
- Electrical and optical crosstalk had negligible effect on BER performance





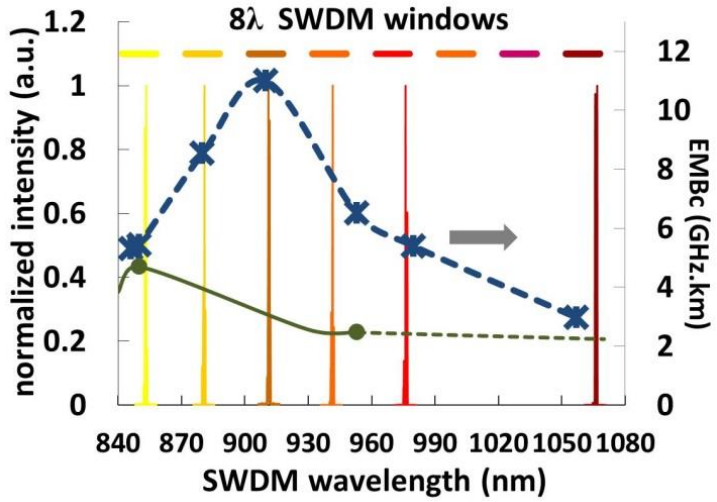


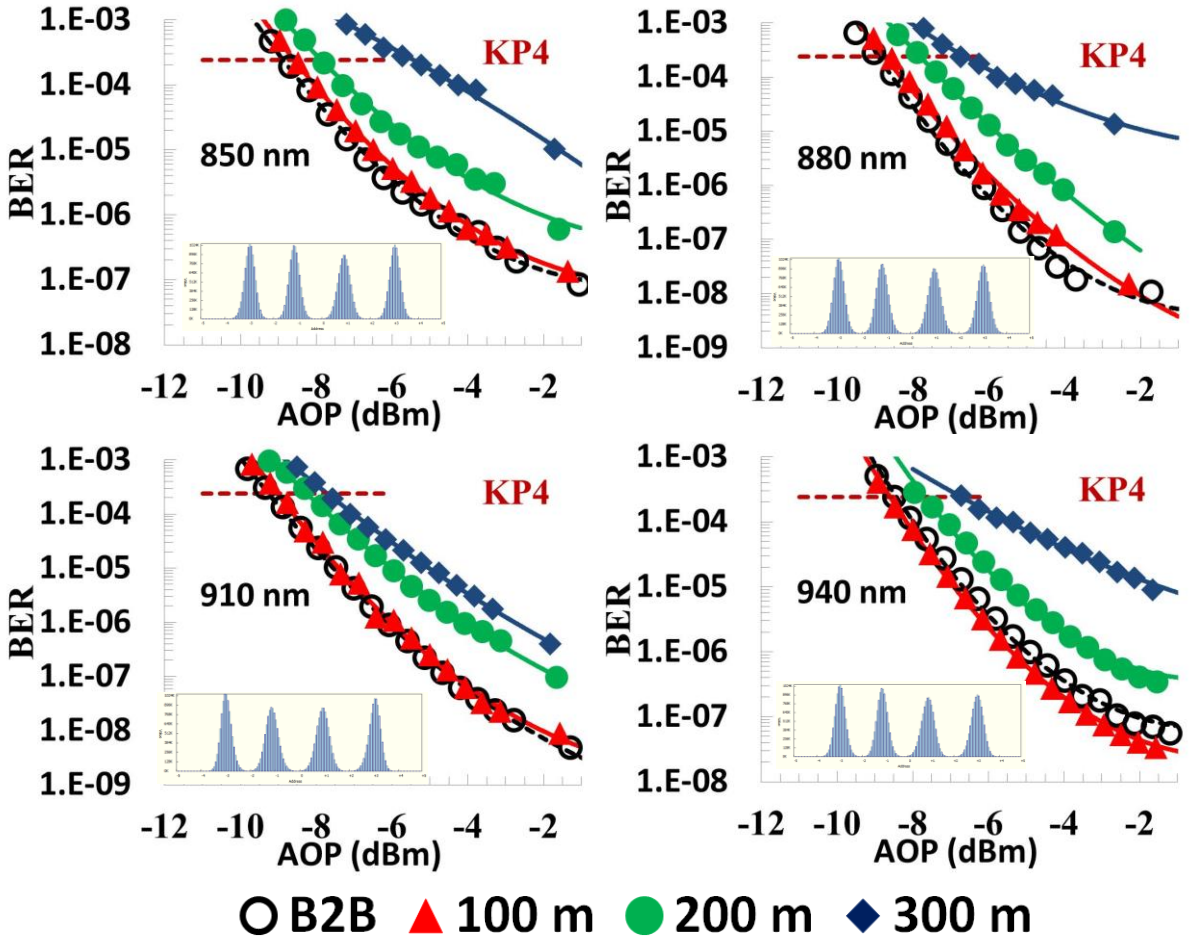
B. G. Lee, et al., JLT. Vol. 30, pp886, (2012)

Alternate option:
Multimode WideBand fiber (OM5)

50 Gbit/s PAM4 at 850, 880, 910, and 940nm over 300m OM5 Fiber

Y. Sun, et. al., JLT, Vol. 35(15), 2017 by OFS, Inphi, Furukawa, and Finisar

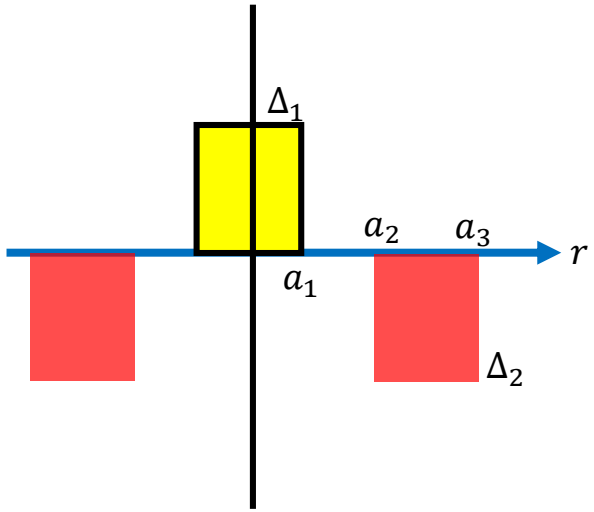


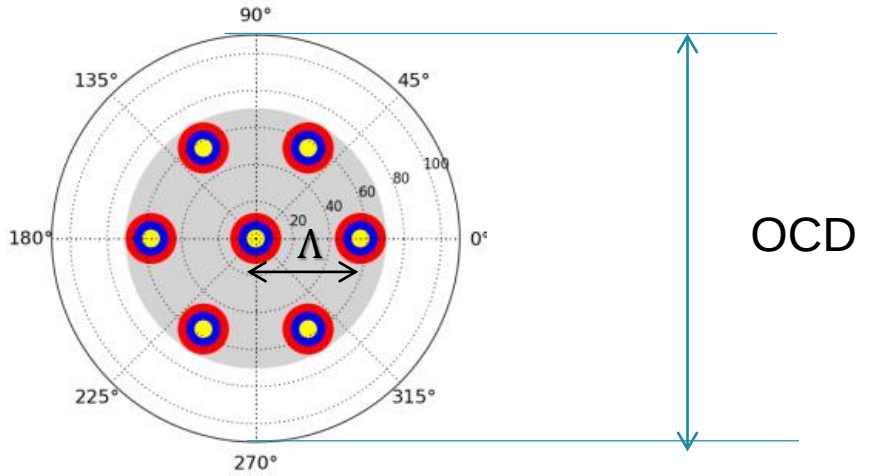


- Standardized in TIA-492-AAAE
- In draft in IEEE802.3cm
- Compatible with standard connectivity

Ocean

Multicore fiber in ocean:
Modeling crosstalk for homogeneous trench-assisted cores





- Crosstalk between two trench-assisted cores:

$$XT(\Lambda) \approx \frac{2\kappa_{pq}^2 R_{bend}}{\beta\Lambda} L$$

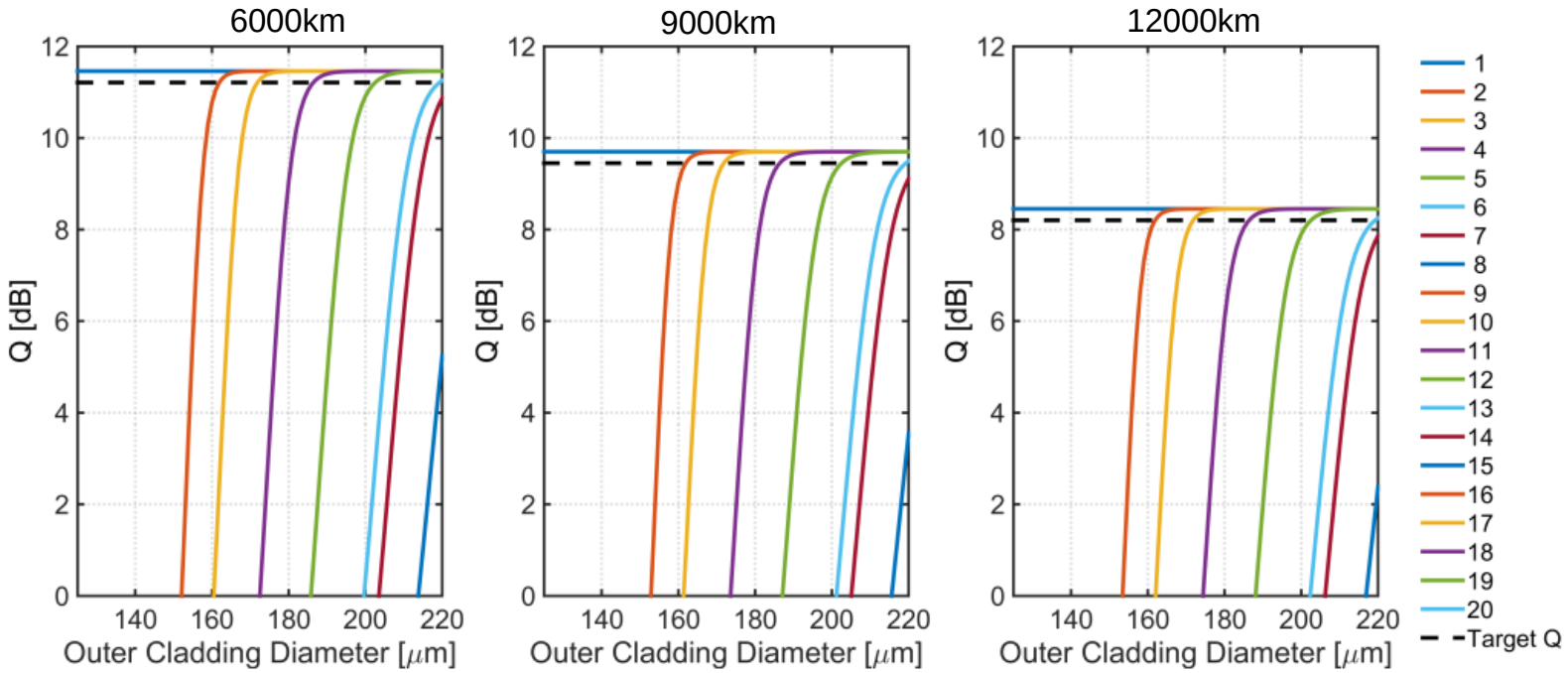
R_{bend}	bend radius
β	propagation constant
Λ	core pitch
L	fiber length
κ_{pq}	inter-core coupling constant

F. Ye et al, "Theoretical Investigation of Inter-core crosstalk Properties in Homogeneous Trench-Assisted Multi-Core Fibers," Proc. Photon. Soc. Summer Topicals, TuE4.2, Montreal (2014)

- For our analysis,
  - $a_1 = 4.5\mu\text{m}$, $a_2 = 2a_1$, $a_3 = 3a_1$
  - $\Delta_1 = 0.26\%$, $\Delta_2 = -0.3\%$

K. Balemarthy and R. Lingle, Jr., ECOC, (2015)

Multicore fiber in ocean: Q vs outer cladding diameter



- At 6000km, with 6 cores, Q is 11dB worse at 200μm OCD but no degradation at 220μm
- Analysis assumed a maximum allowable degradation of 0.25dB w.r.t. 1-core design

Maximum of 6 cores can be accommodated within an OCD of 220μm with ≤ 0.25dB Q degradation w.r.t. 1-core design (6000-12000km)

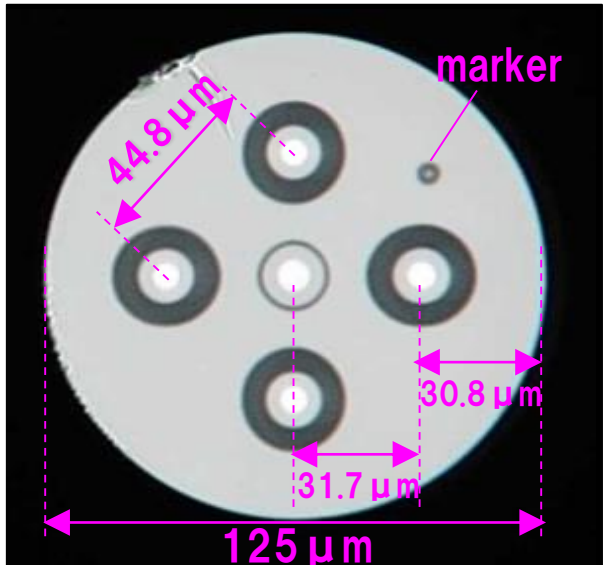
- Alternate Option/Incumbent Tech.: Increase count of single-core SMF in each cable

➡ The search for a 125μm OCD-compatible MCF design in SDM would need to allow greater Q degradation

Metro

Multicore fiber in metro applications

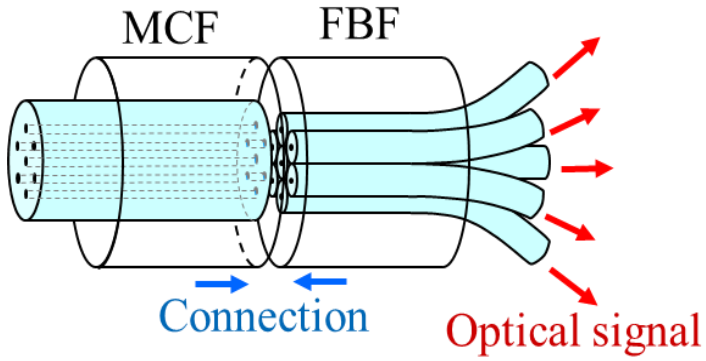
Fiber Design

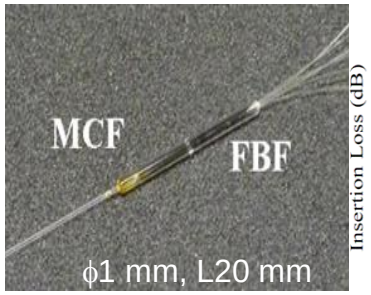


5-core, 125mm clad trench-assisted design
G.657.A1 cutoff, MFD, bend loss
Low crosstalk @ 1km length

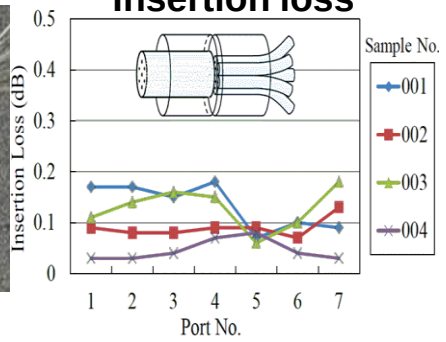
T. Gonda, et. al., ECOC2016, W.2.B1 (2016)

Fan-in/Fan-Out





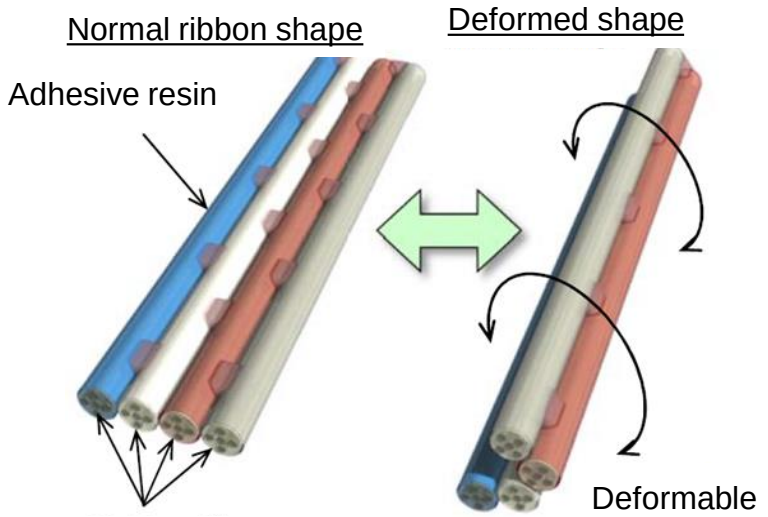
Insertion loss



- Insertion loss (1.55µm) <0.2dB
- Crosstalk (1.55µm) <-65dB

T. Saito, et. al., OECC2016 ThC1-1

MCF in Rollable Ribbon

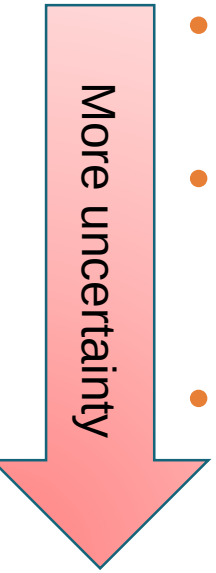


4-core MCF in Rollable Ribbon
Achieved cabled density of 8.4 cores/mm²

M. Tsukamoto, et. al., IWCS2016, p594 (2016)

Alternate option for high-density metro: 250µm SM in RR, 3.5 – 4.5 fibers/mm²

Concluding Remarks



- Commercialization of MCF technology faces strong economic challenges from alternate options
- Datacom: Multimode fiber with CWDM has an advantage over MCF
  - Short-reach CWDM transceiver cost reduction has outpaced cost reduction of MCF connectivity
- Ocean: Multifiber appears to have the edge in medium term
  - 125μm cladding diameter MCF will require greater Q degradation than with larger cladding
  - Inflection point for MCF is estimated to be around 48 fiber pairs in cable
- Metro: Evolution to MCF is uncertain
  - MCF adoption will be dictated by practices for field termination and maintenance
  - Rollable ribbon + 4-core MCF can achieve 2x the density of standard SM in RR
- Influencers for standardization and commercial adoption:
  - Consensus on core configuration (e.g. 4 cores) and design space anchored at 125μm OCD
  - Economies of scale via convergence of Ocean and Long Haul Terrestrial segments for active and connectivity components, e.g. FIFO devices.

Thank You!