Fiber Optics and Expanded Beam Termini

John McNeil
Timbercon Inc.
May 21, 2009
Before Fiber Optics...

Before optical fibers, optical waveguides existed. One early idea used water as a “light pipe” to guide light around a home for illumination.
Snell’s Law

Snell’s Law:

\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]
Total Internal Reflection

- Glass: $n = 1.5$
- Air: $n = 1.0$

Angles of incidence: $0^\circ, 15^\circ, 30^\circ, 45^\circ, 60^\circ$

Critical angle: $49^\circ$ for total reflection.
Light can be guided by an interface...
Optical fiber consists of two types of glass: core and cladding

Core: inner cylinder of doped glass (i.e. Ge); 9, 50, 62.5 μm diameter

Cladding: outer cylinder of glass; standard 125 μm diameter
How is this produced?

• Create the preform that contains the structure of the fiber

• Drop the preform into furnace to melt it. The glass falls due to gravity, thinning as it falls.

• Micrometer measures fiber diameter and adjusts accordingly

• Acrylate ‘buffer’ applied and baked on to protect fiber
Types of fiber

- Single Mode
  - SMF-28
  - Polarization Maintaining
- Multimode
  - 50 µm / 62.5 µm core
  - Laser Optimized
- POF – Plastic Optical Fiber
Fiber Manufacturing

- Core – 9, 50, 62.5 μm
- Cladding – 125 μm
- Acrylate – 250 μm
- PVC Buffer – 900 μm
- Aramyd Yarn (Kevlar)
- Outer Jacket – 2, 3mm
That was for a single fiber...

That structure is combined in a number of ways to form multi-fiber cables.
Standard Connectors
Biconical Connectors

• The earliest connectors were termed “Biconical”

• Examples include TFOCA-1 and Bioconic connectors

• Relied on the conic section for alignment

• Air gap between the two connectors
Problems of Biconical Connectors

Small amounts of dust caused alignment issues, and connectors were difficult to keep clean.
Cylindrical butt-couple connectors:

- Connectors come into Physical Contact. These connectors are often referred to as PC or UPC (Ultra Physical Contact).

- Springs behind the termini maintain physical contact at all times.
Cylindrical butt-couple connectors are almost universally used today. However, they remain vulnerable to contamination and scratches:
Expanded Beam Termini
Expanded Beam termini use ball lenses to collimate the beam output between fibers.
The impact of dirt:

Graphic courtesy of Gigacom Inc. www.gigacom.se

Human hair approx. 60-100um

1 au = 1 arbitrary unit = size of single mode beam

Graphic courtesy of Gigacom Inc.
Also, reduced sensitivity to Lateral Misalignment:

Graphic courtesy of Gigacom Inc.  www.gigacom.se
All this for ruggedized fiber applications:

- UAV – Unmanned Aerial Vehicle
- SBX-1 – Sea-based X Band Radar
More ruggedized fiber...

- Stainless steel furcation
- D38999 Military connector
- Deployable Reels
Timbercon Inc.

- Timbercon produces custom and ruggedized Fiber Optic assemblies, test equipment, cleaning and installation kits
- We serve telecom, medical and military customers
- AS & ISO certified
Questions???

Thank You.