Technologies for Cabled Fibre MOS & IFS

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Fibre system fundamental requirements

- Flexible, ruggedised relay from focal plane to spectrographs
- High transmission over desired wavelength range
- F/# matched to both input (targets) and output (spectrograph F/in)
- Fibre size optimised to target scales and spectral R requirements
- Low system focal ratio degradation (FRD)
  - Minimal stress-induced FRD
  - Good quality control of end preparation
- High stability. Minimal variation in throughput & NF/FF stability → relates to FRD
Generic fibre system schematic

System Input → SRB → Cable → SRB → Output slit

F/in from telescope Fore-optic, microlens array? → F/cable

F/cable → F/out to spectrograph, microlens array? Relay optic?
FMOS example
Fibre type considerations

- Minimal optical loss in the glass (varieties of fused silica employed typically, for long $\lambda$ UV to H-band)
- Default fibre profile is circular core (square, octagonal for high res...)
- Appropriate N.A. for application
- Low inherent FRD
- Cost – custom core size versus off-the-shelf
- Clad thickness (evanescent wave loss considerations)
- Buffer material? Acrylate? Polyimide?

Usual providers Polymicro, Ceramoptec, Fibercore, Fujikura...
Polymicro FBPI broadband fibre

Developed primarily for astronomical applications. Fused silica, ultra low OH, polyimide buffer.
IFU Inputs – close packed

MANGA-style input, pitch = fibre OD.
IFU Inputs – custom pitch

GMOS-IFU Fields – capillary tube arrays – RMS errors increase with fibre count

3-D Biospec randomiser – laser cut hole arrays in Cirlex - field size is unlimited. Also silicon, glass options
Focal plane terminations - PFS

Black zirconia ferrules

Parts List:

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<th>ITEM</th>
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<th>DESCRIPTION</th>
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Third Angle Projection

Title: PFS FERRULE

Material: 
Treatment: 
Finish: 

Scale: 1:1
Do not scale drawings

Issue: RELEASE
Date: 10/01/14

Similar To:

Drawn By: C.M. DURRIDGE
Date: 10/01/14

Approved By: NAME
Date: DATE

Project: DUR-DWG-PFS
Focal plane terminations – PFS fibre arms
Strain relief boxes

Allow tensions to dissipate due to differential movements / “settling” in the fibre cable, Decouples the main cable from the end termination, serve as a reservoir of fibre during manufacturing
Stranded cable design

- As used for FMOS, PFS, DESI
- Tensile load supported by high strength core
- Additional fibre per unit length (~2%) ensures minimal stress due to cable bending - ‘racetracking’.

Collaborative R&D with PPC Broadband Fiber Ltd. Formerly m2fx
Fibre pull into tubing – Miniflex production line

Pay-off tower with spools (purple) → Eyelet plate → Boron nitride powder bath → Input to Miniflex extruder
The planetary strander

The completed strander, minus the fibre in Miniflex tubing. The motor and drive belt can be seen on the far right. The inset photos bottom left show stranded cable coming off the line; (left) the cable emerges from the machine, (right) the cable after tape binding.
Planetary stranding

The production line, starting with the tensile element on the right, leading through to a finished stranded and tape-bound cable core on the left.
Slit units – v-groove arrays

- Slit formed from sub-blocks
- Low FRD
- In each block pointing is parallel, blocks arranged to approximate curvature
- AR coat carried on windows / field lenses / microlenses
- Large gaps
Monolithic v-groove array

New slit technology – monolithic v-groove arrays. Borofloat 33 glass. Lid not shown.

- Transparent – enables novel bonding strategies
- True pointing
- Curved slits – two axes?!
- Extremely high tolerance
- Low FRD
- AR coat

- Thin
- Both surfaces can carry v-grooves
- No gaps – best for IFUs

R&D supported by NAOJ Subaru & Kavli IPMU.
Microlenses

Current manufacturing techniques enable both positive and negative arrays → doublets, even triplets are possible in a variety of glasses → HiRES
Can be AR coated.
Summary

• A variety of established and new technologies can be deployed for MOS & IFS fibre systems

• Trade-off can be undertaken of cost versus efficiency
  • Off the shelf approach versus custom, highly optimised “custom component” approach