Plastic Optical Fiber Trade Organization
POF SYMPOSIUM
Plastic Optical Fiber Symposium @ OFC/NFOEC 2011
March 10, 2011 | Los Angeles Convention Center | Los Angeles, CA

Microstructured Polymer Optical Fibres (mPOF)

Dr. Alexander Argyros
Institute of Photonics and Optical Science (IPOS)
School of Physics, University of Sydney
& Kiriama Pty Ltd

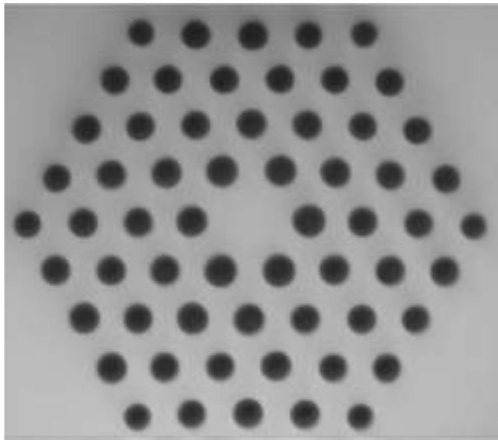
kiriama

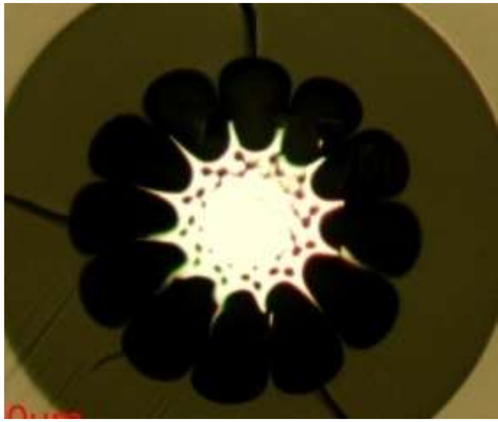
THE UNIVERSITY OF SYDNEY

mPOF

- mPOF since 2001
  - Like silica PCF, only plastic
  - Like POF, only with holes

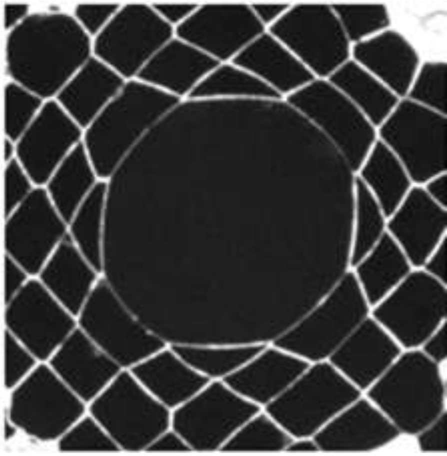
- Differences:
  - fabrication methods
  - materials – polymers – dopants
  - material properties

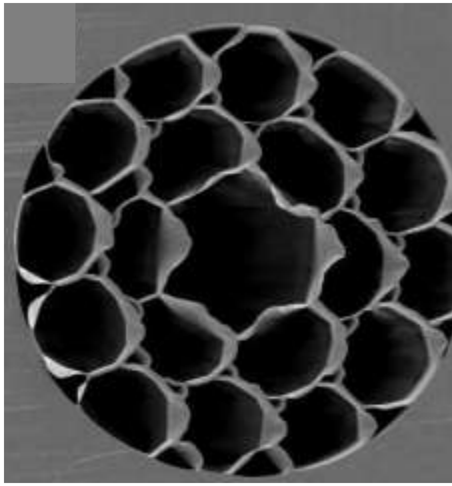


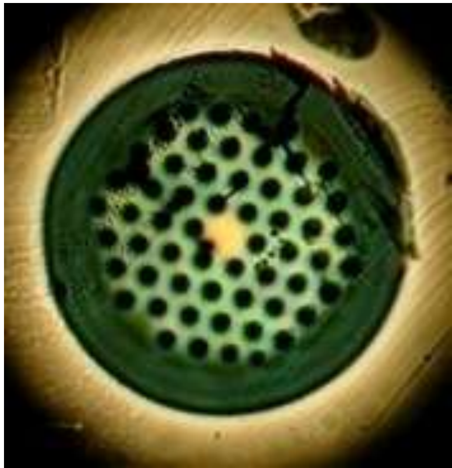


mPOF

- mPOF since 2001
  - Just like silica PCF, only plastic
  - Like POF, only with holes
- Differences:
  - fabrication methods
  - materials – polymers – dopants
  - material properties

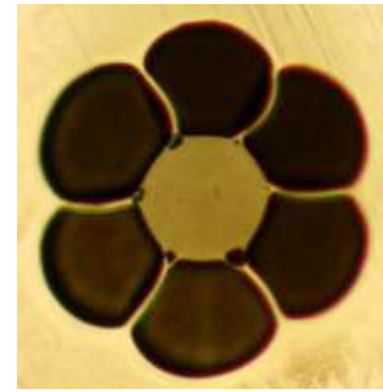




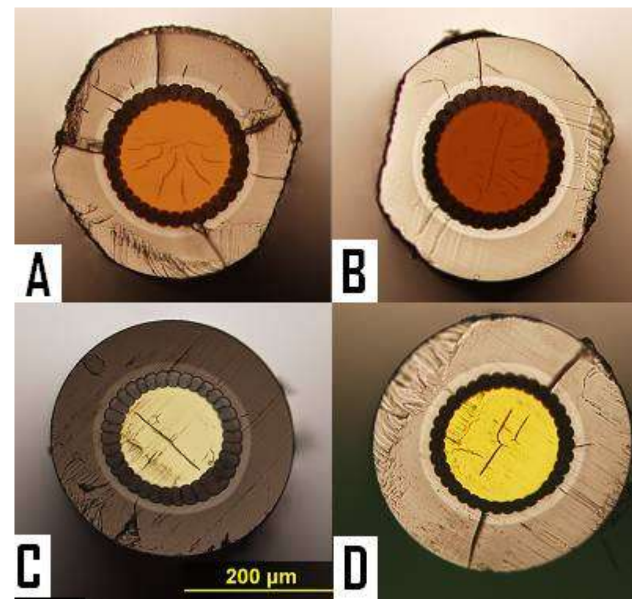


mPOF

- mPOF since 2001
  - Just like silica PCF, only plastic
  - Like POF, only with holes



- Differences:
  - fabrication methods
  - materials – polymers – dopants
  - material properties

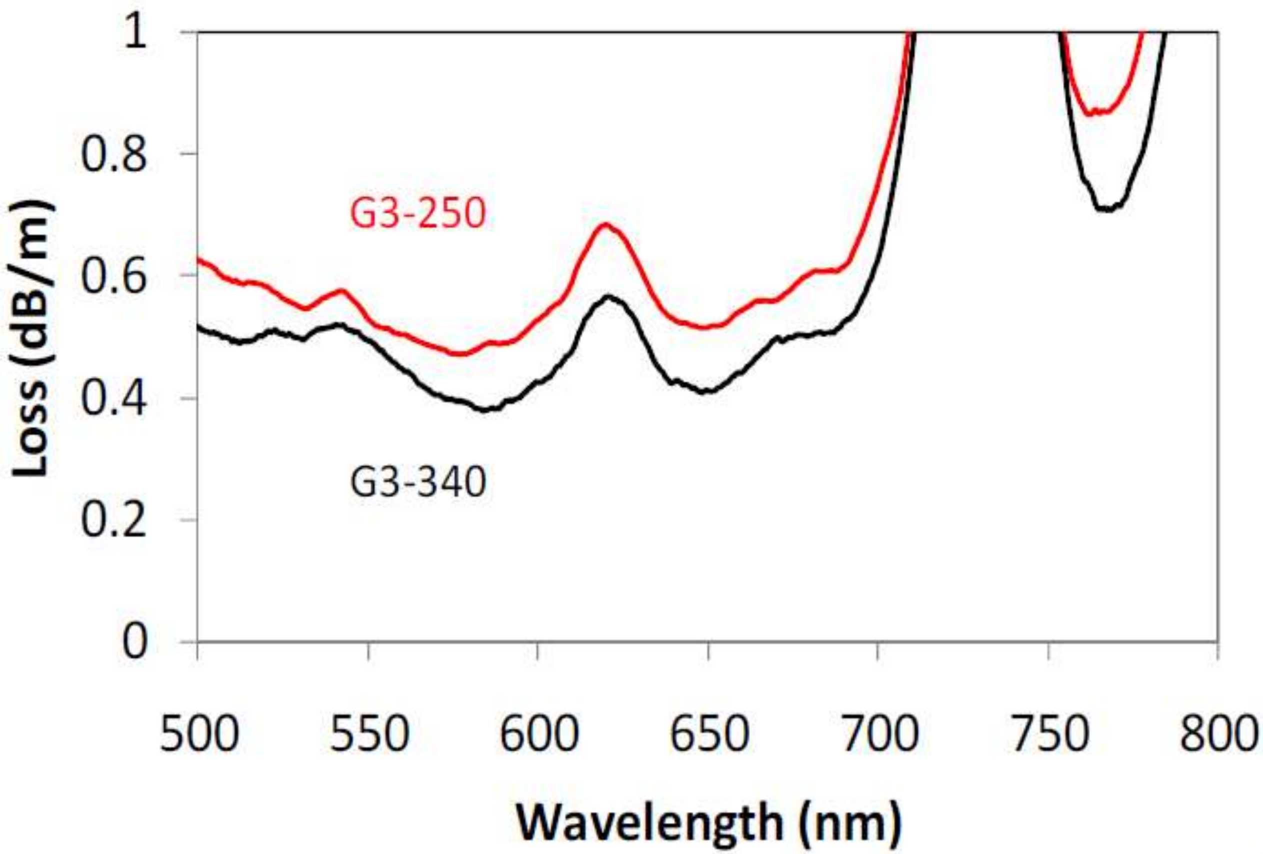


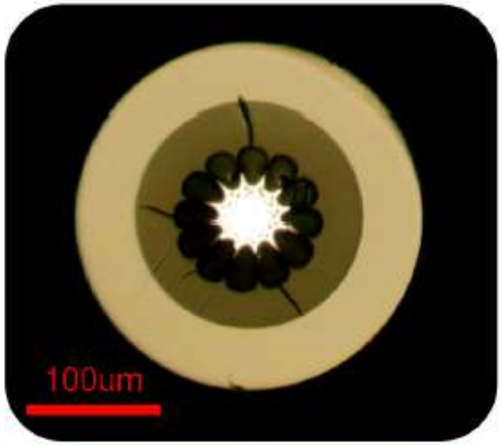
mPOF

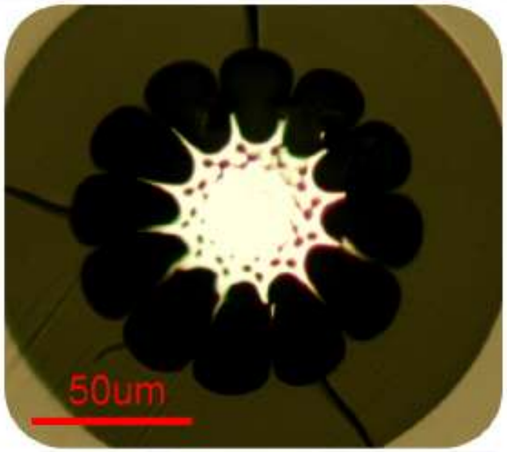
For this talk I will focus on selected topics

- High data rate fibres
- Single-mode polymer fibres
- Specialised examples for sensing
- Practicalities

High Bandwidth Fibres – G3





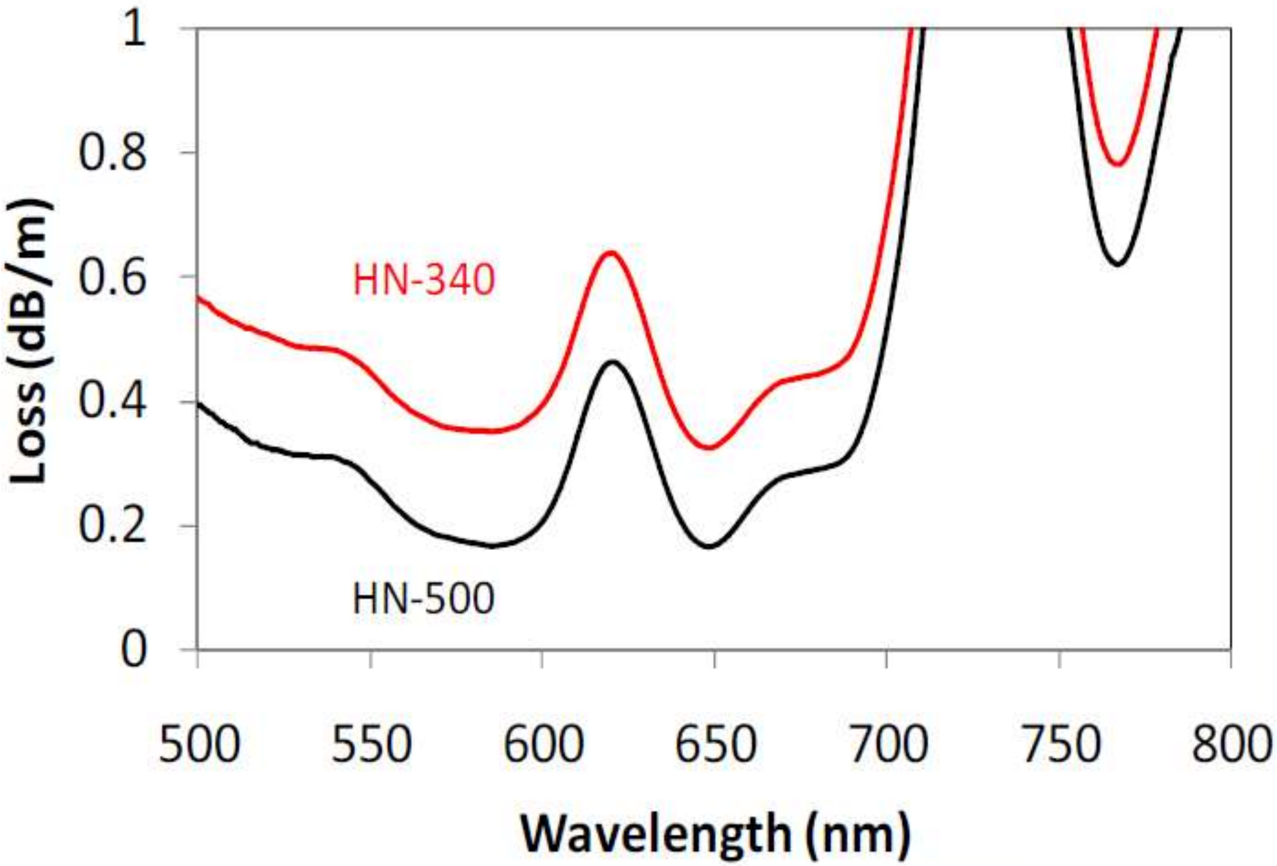


Outer Diameter
250, 340, 500 µm

Core Diameter
35 – 85 µm

Minimum Loss @ 650 nm
0.35 dB/m

High Bandwidth Fibres - HN



Outer Diameter
340, 500 µm

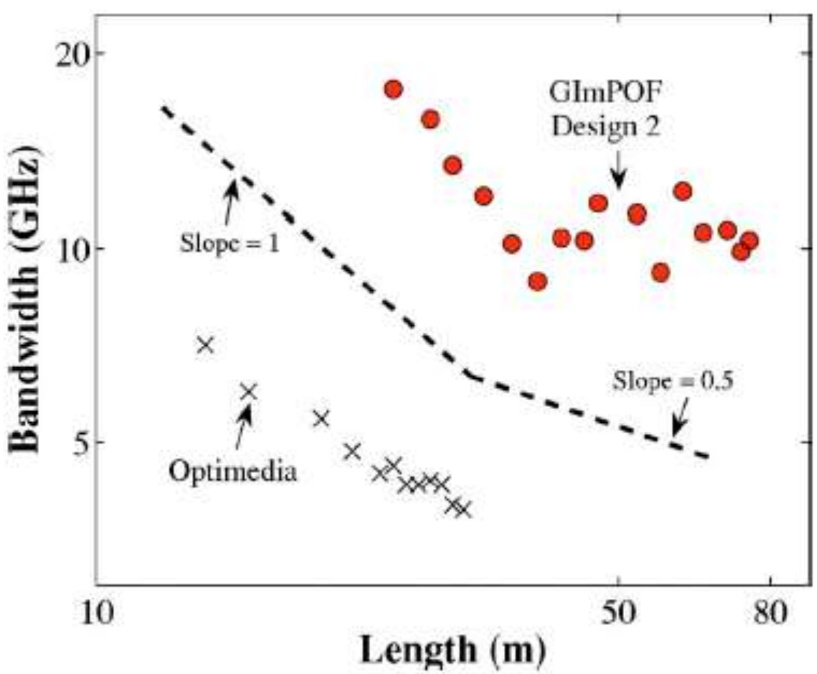
Core Diameter
110 – 150 µm

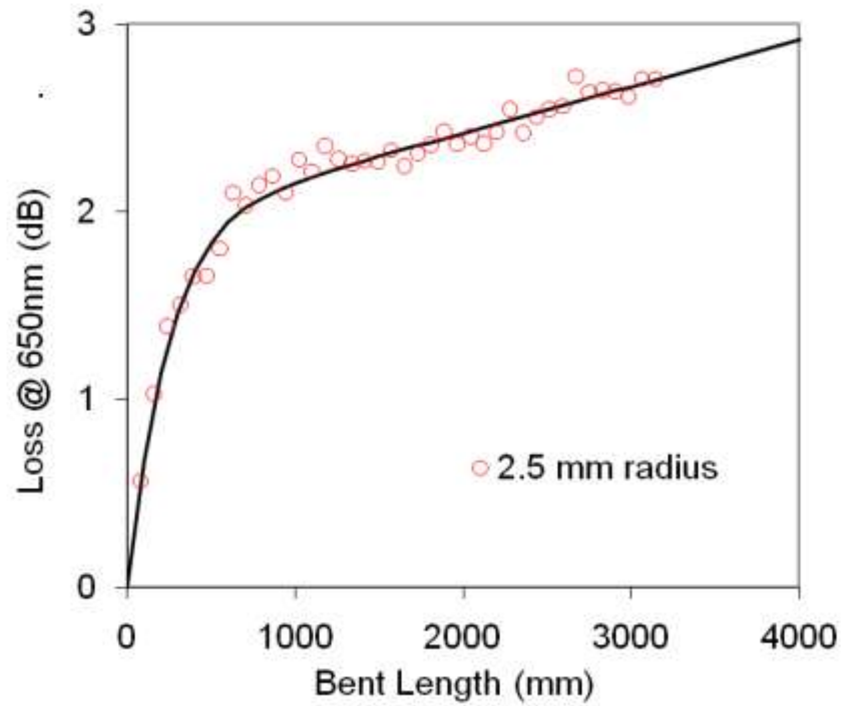
Minimum Loss @ 650 nm
0.16 dB/m

High Bandwidth Fibres

2007: Infer **20 Gb/s over 75 m**, using red light (pulse spreading)
Bandwidth length product is not constant.

2008: Bending loss is not constant



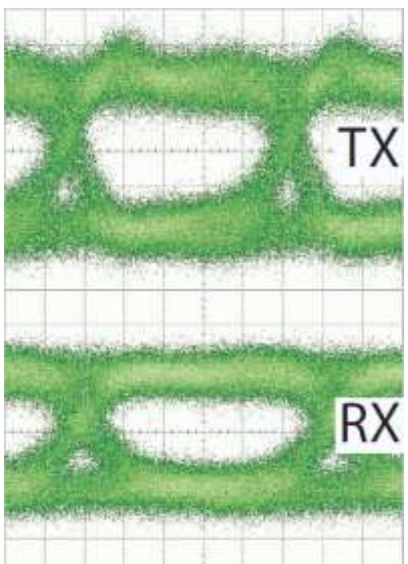


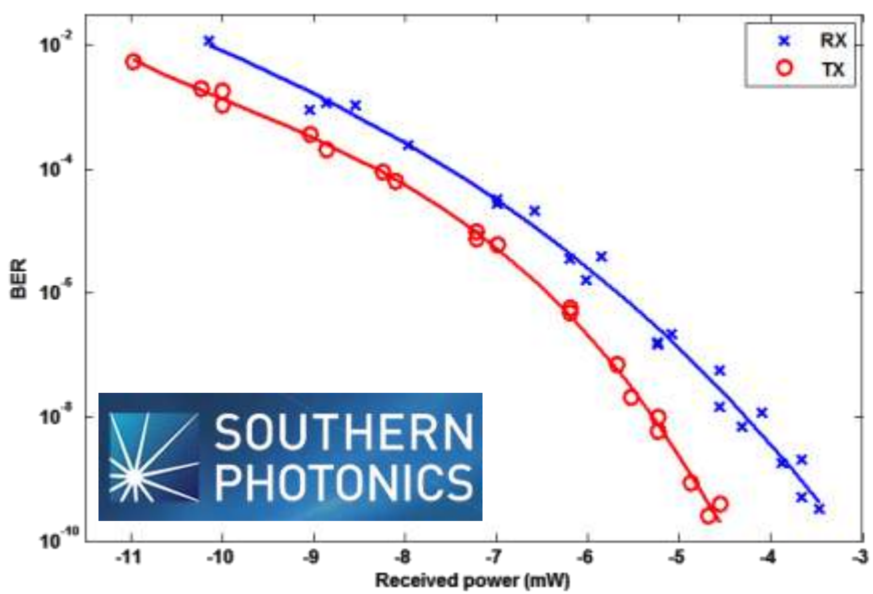
R. Lwin, Appl. Phys. Lett. 2007; A. Argyros, Opt. Express 2008

High Bandwidth Fibres

2009 : Demonstrate **10 Gb/s over 37 m**, BER, red light

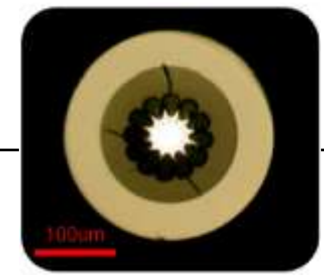
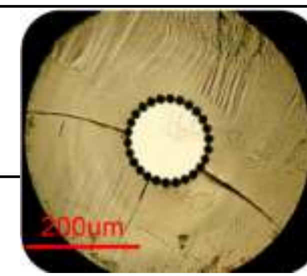
2011: Demonstrate **10 Gb/s over 50 m**, BER, red light





E. Le Cren, PECS, Sydney, Australia 2009; R. Provo, OFC, San Diego, USA 2010

High Bandwidth Fibres

Result	Core Diameter (µm)	Outer Diameter (µm)	Loss at 650 nm (dB/m)	
Pulse spreading, infer **20 Gb over 75 m**	70	250	0.35	
Demonstrate **10 Gb over 37 m**	100	500	0.4	
Demonstrate **10 Gb over 50 m**	150	500	0.16	

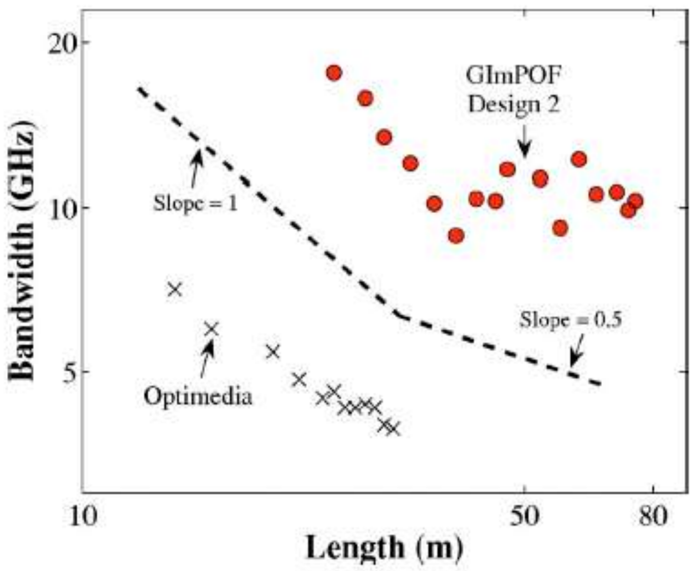
Largest core = highest bandwidth?

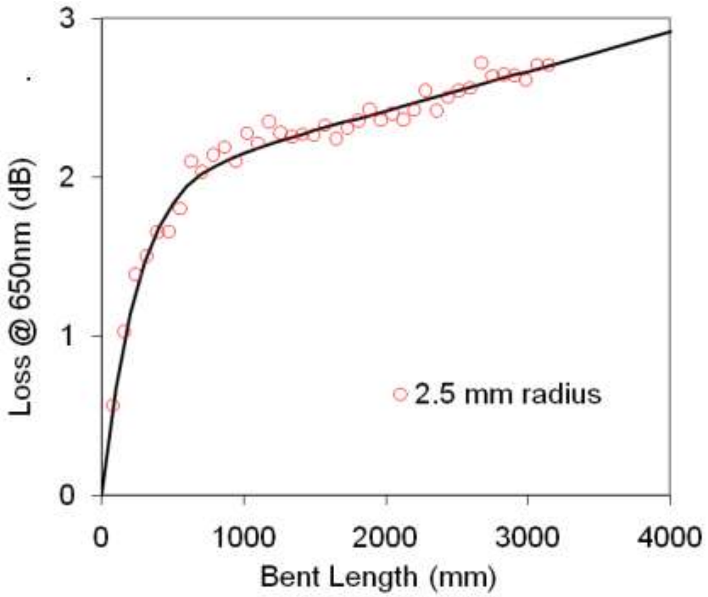
Measurements limited by source and receiver, not the fibre.

If you have faster source/receiver in the red, please let me know!

High Bandwidth Fibres

- Mechanisms for high bandwidth
  - Modal filtering – lose high order modes



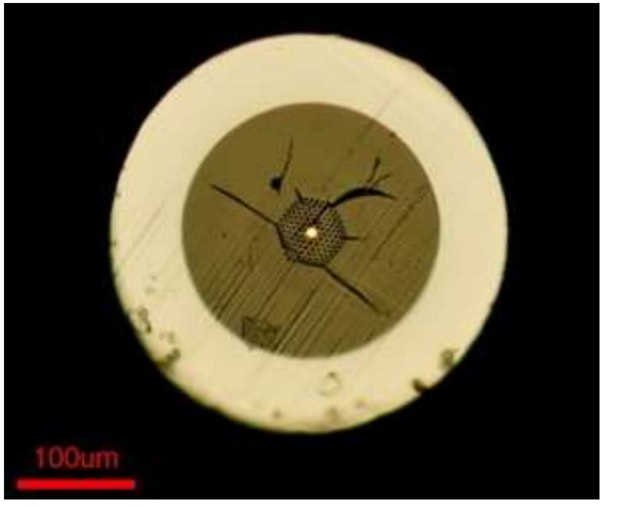


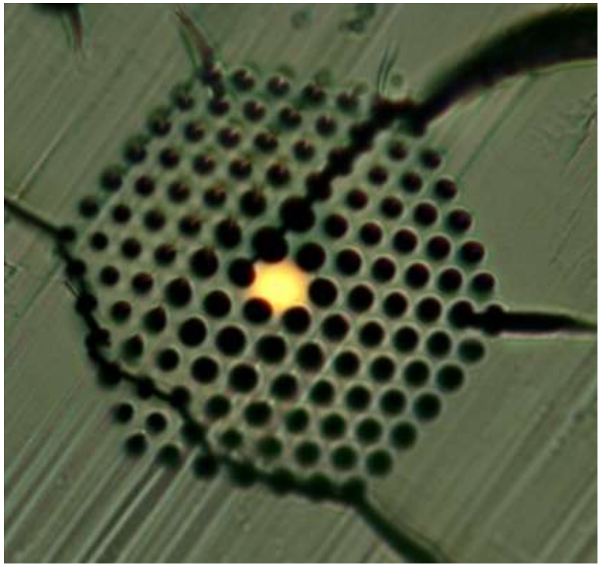
  - Mode mixing – pulse spreads as (length)^0.5

Single-mode mPOF

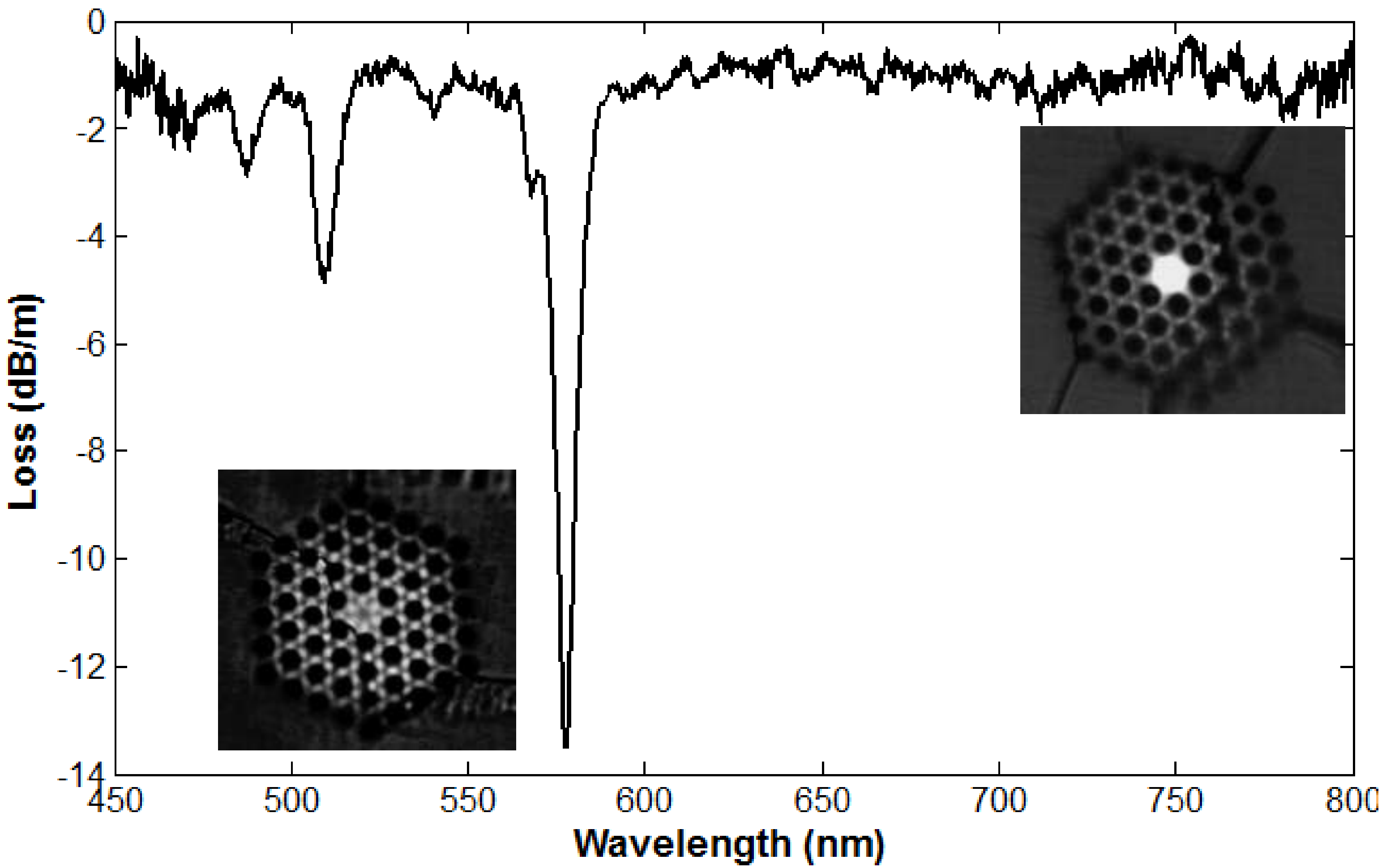
- Single-mode is easy…
- 1.6 dB/m loss
- 8 um core
- Use few metres of fibre

- Stamping method
- LPG 0.9 – 1.1 mm period

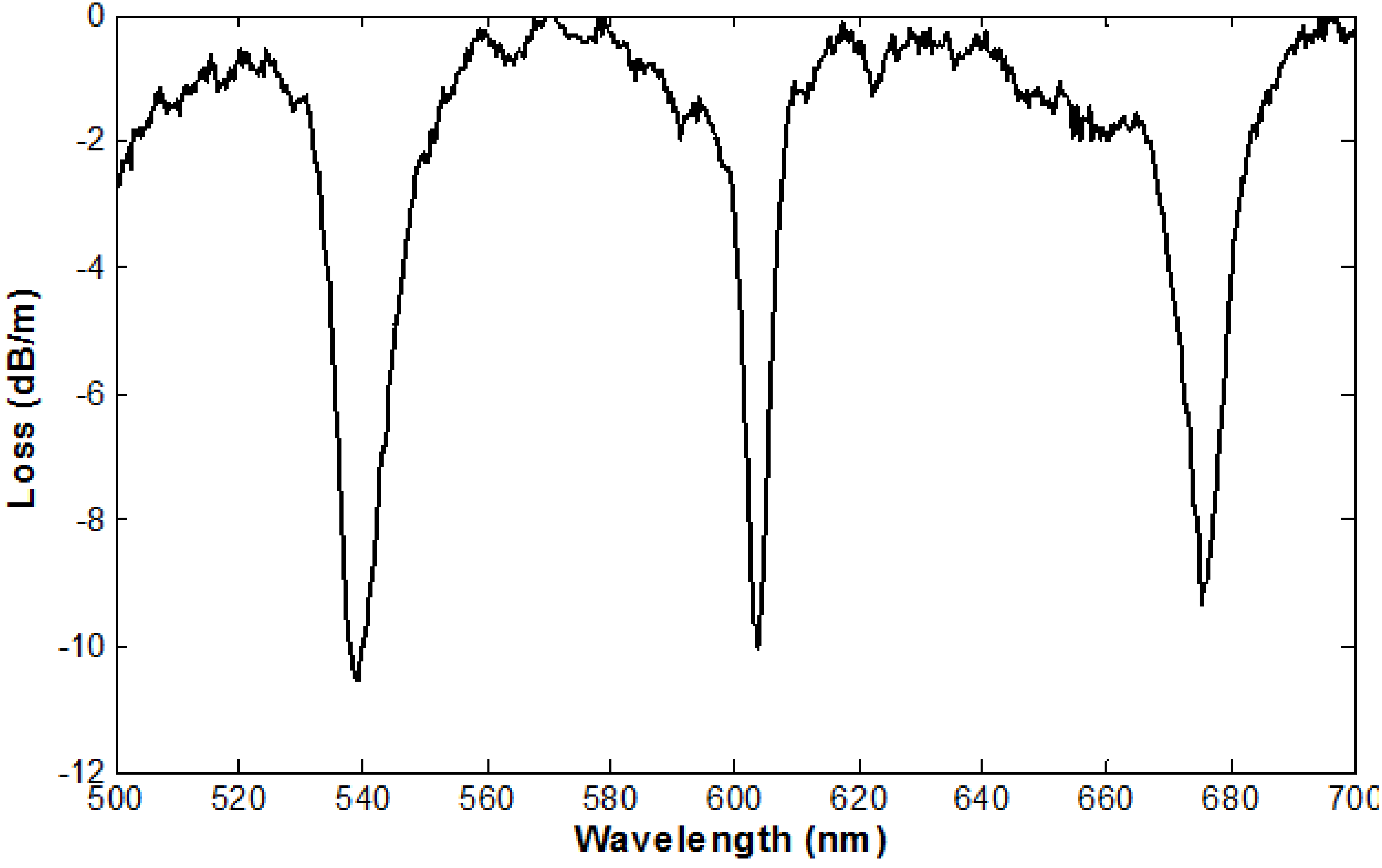




LPG in single-mode mPOF



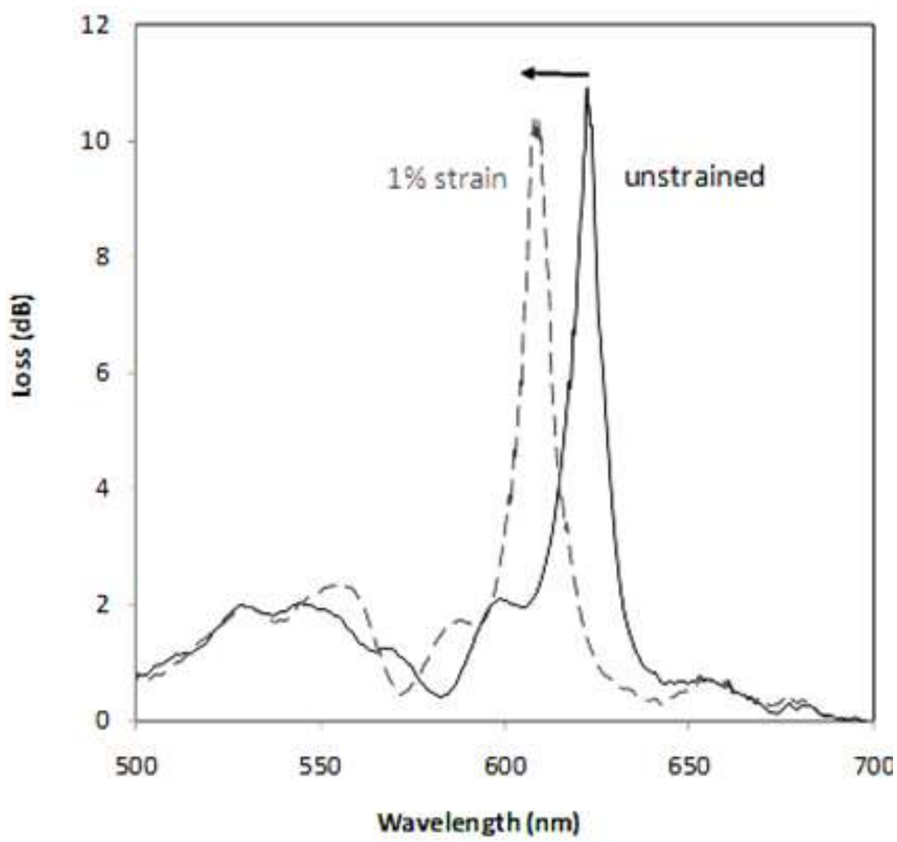
LPGs in single-mode mPOF



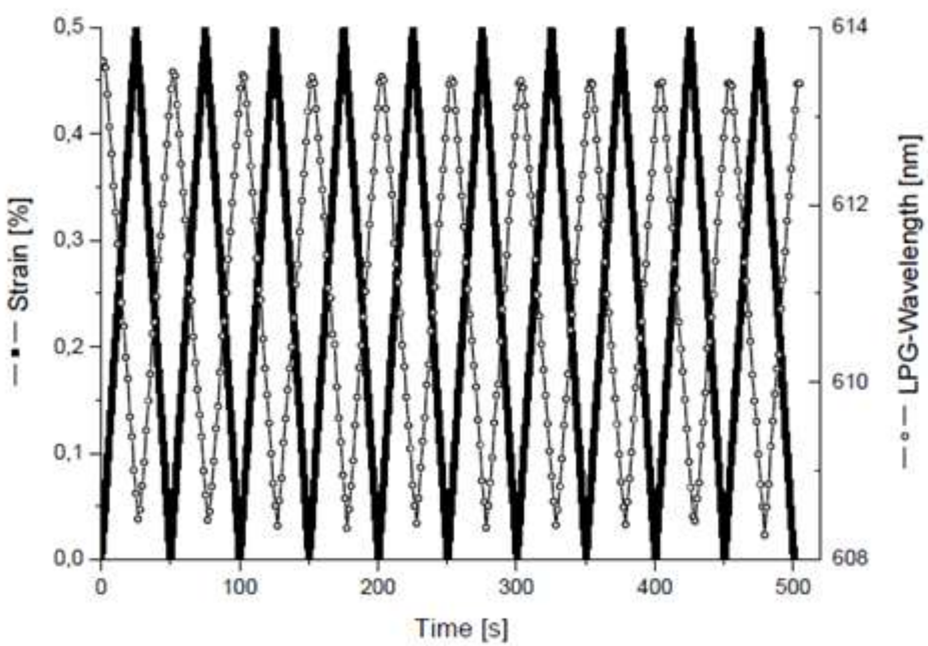
Strain sensing

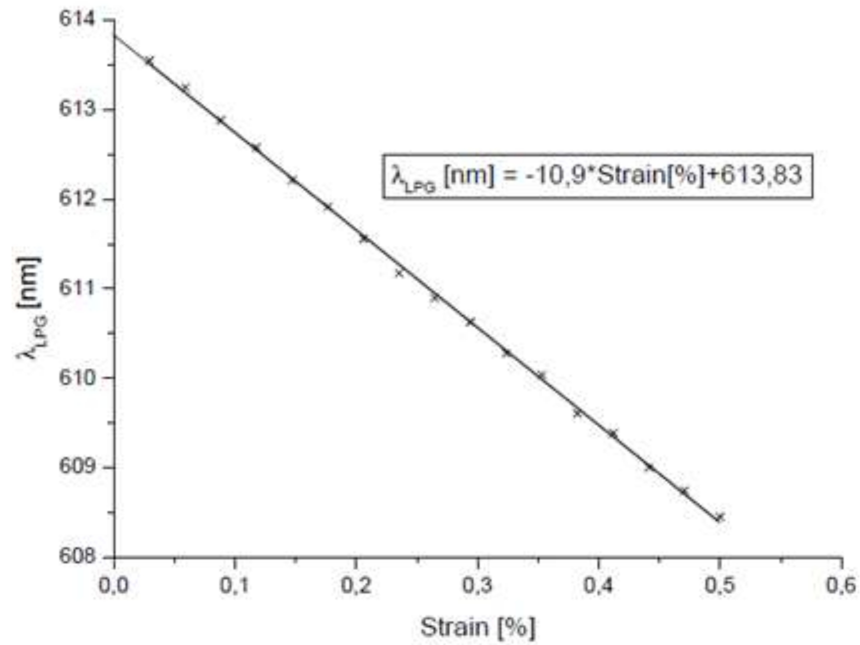
- Well known approach, already commercial

Strain → grating period → wavelength -11 nm/%



Just a little strain



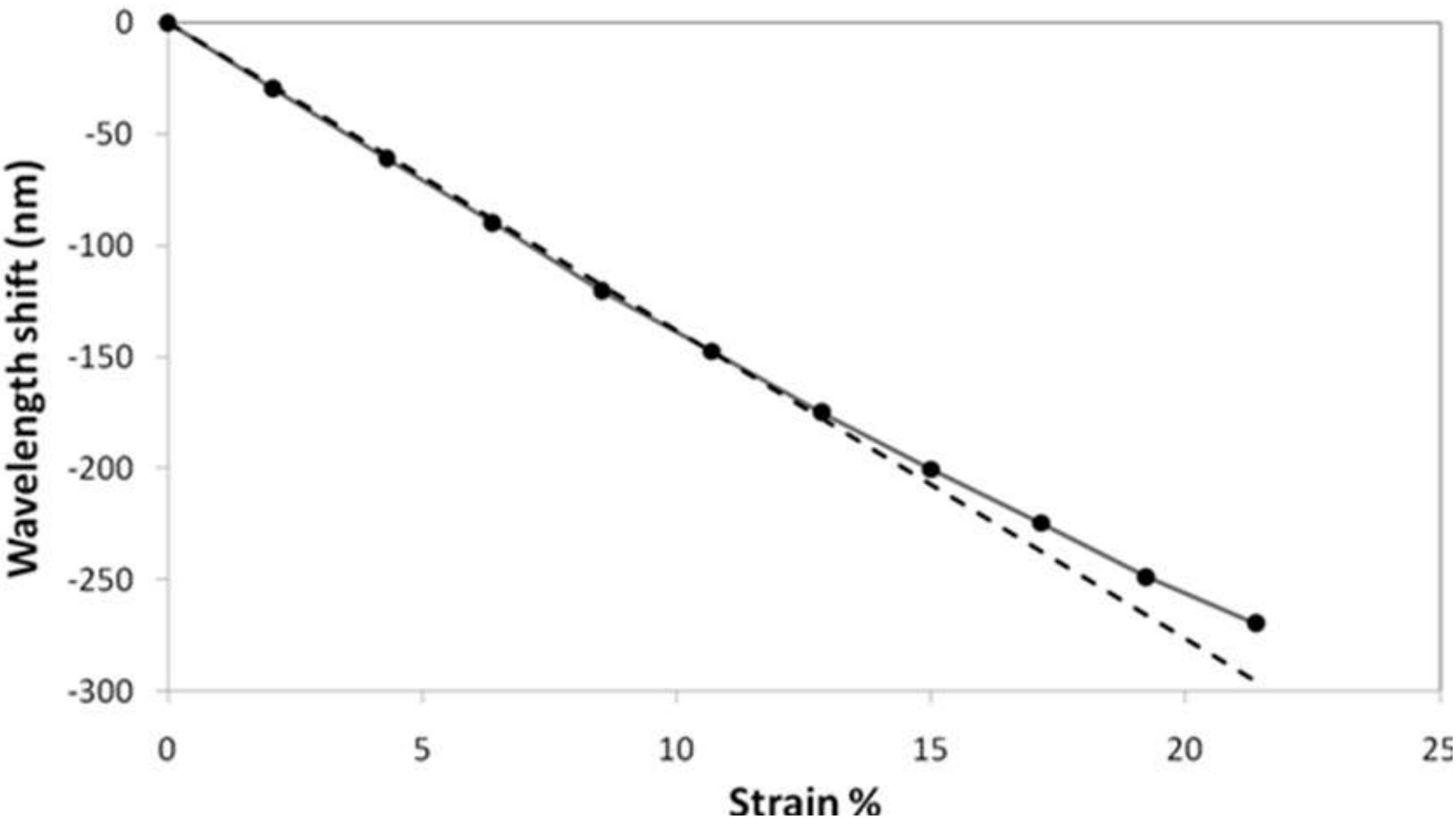


Resolve <0.05% strain, instant response

Elastic limit around 4%

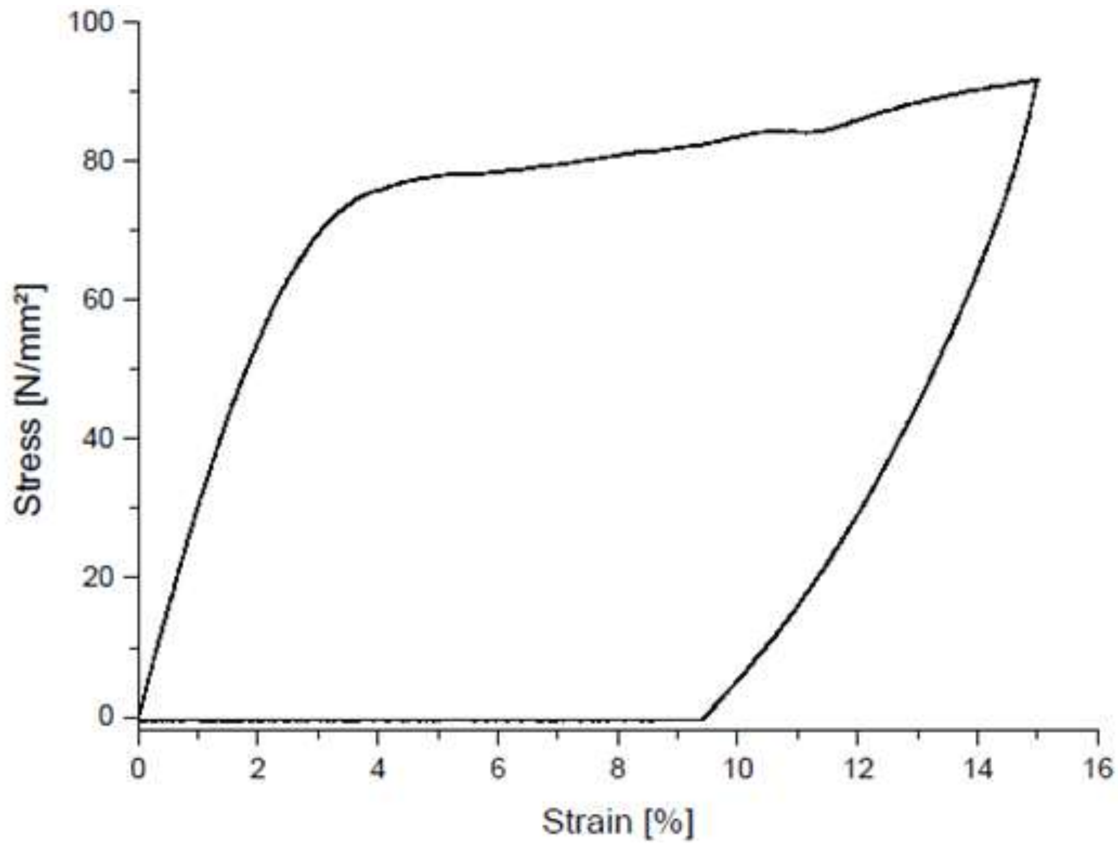
M. Steffen et al, 18th International Plastic Optical Fibre Conference, Sydney, Australia 2009

Extreme strain



Extreme strain

- Elastic limit is 4%
- At larger strains consider:
  - Strain
  - Strain rate
  - Time
  - Creep/Relaxation
  - Recovery

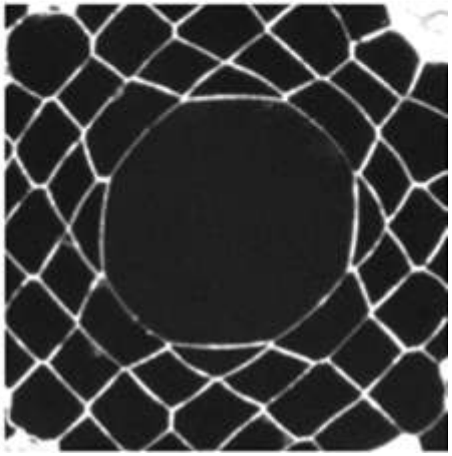


J. Moran et al, Meas. Sci. Technol. (2009)

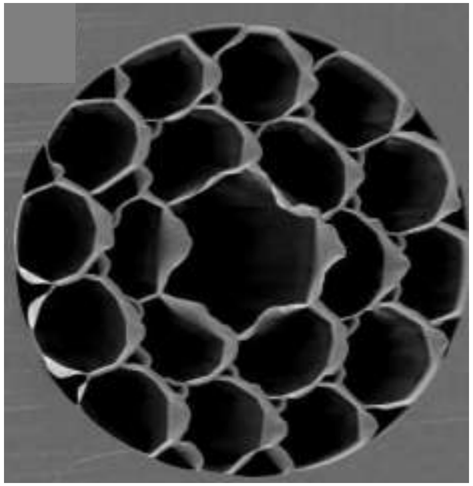
M. Steffen et al, 18th International Plastic Optical Fibre Conference, Sydney, Australia 2009

Other Applications

- Hollow-core mPOF
  - Guide light in hollow core
  - Guide IR
    (reduce material loss x1000)

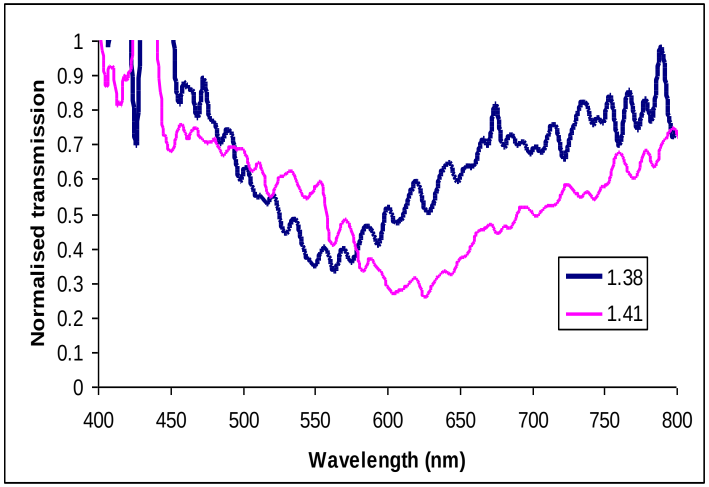


  - Fill core with gas/liquid for sensing
  - Raman spectroscopy (or SERS) small vol., guide pump and signal in fibre



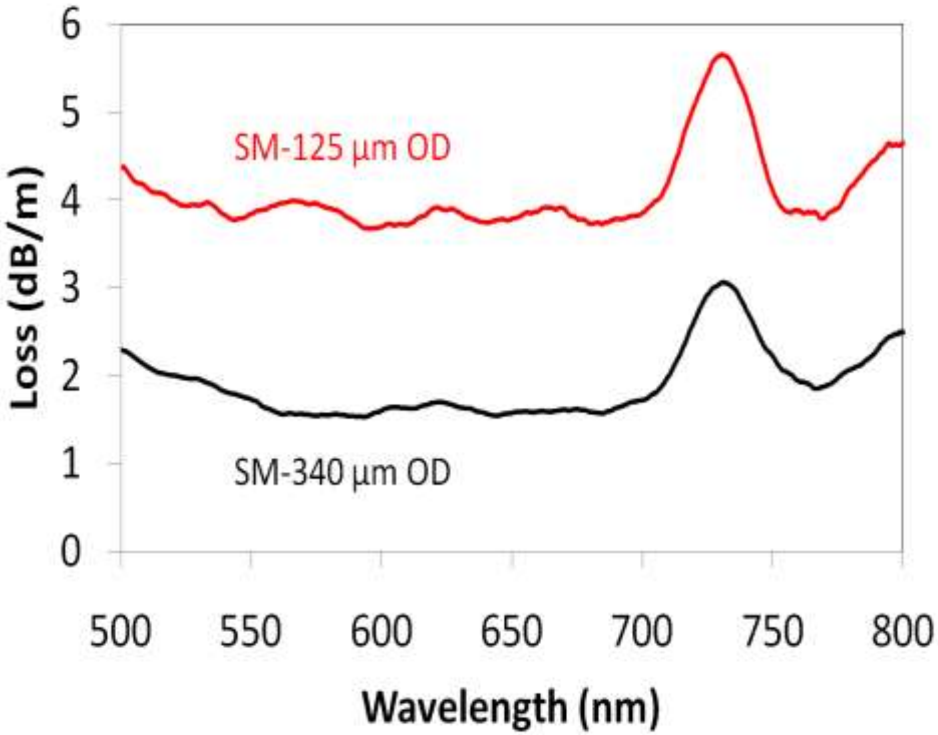
Other Sensing Applications

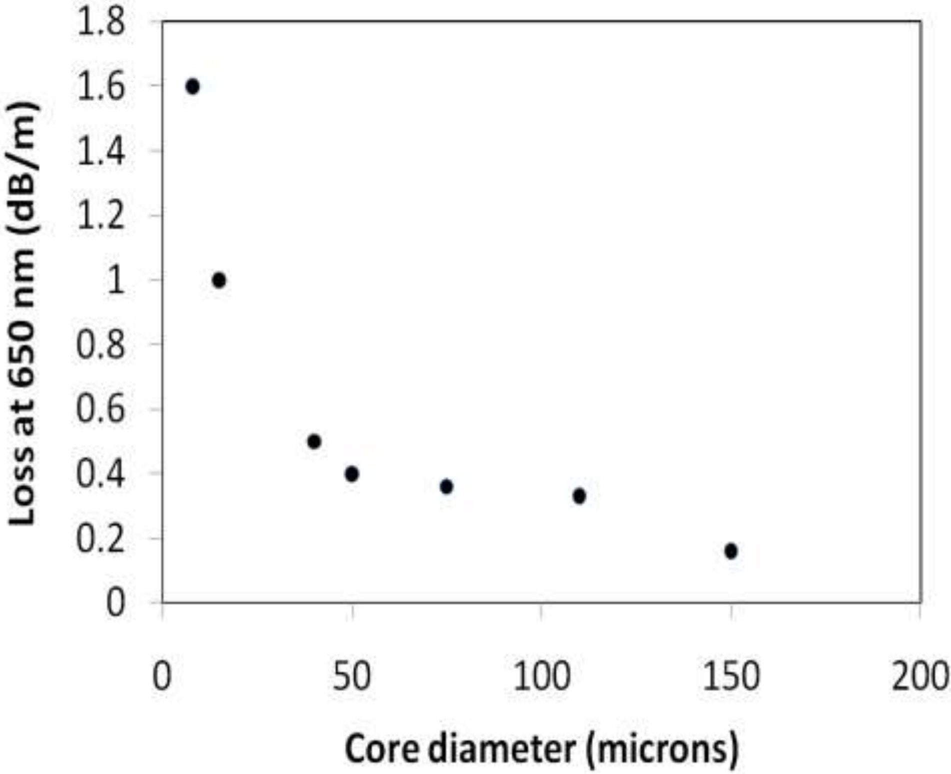
- Exposed core fibre
  - Maintains structural integrity
  - Immerse in gas/liquid for spectroscopy
  - Coat with gold to observe plasmon resonances (sensitive to refractive index)



Practicalities

- Diameter < 250 µm too difficult to handle, and too much loss (microbending)
- Smaller core = higher loss (surface roughness)





Practicalities - handling

- Cleaving: use razor blade
- Free space launch/butt coupling
- SMA or FC (or ST) connectors
  - Successful for MM fibres; SM work in progress.
- Preliminary tests up to 90 ^{o}C (need low-T annealing)
- Can be bend insensitive:

31 x 3 mm radius turns = 1.5 dB loss

Conclusions

- High bandwidth fibres: 0.16 dB/m loss, 150 μm core
  - 10 Gb/s over 50 m … what's the limit?
- Single-mode fibres
  - LPG, strain sensing, temperature sensing

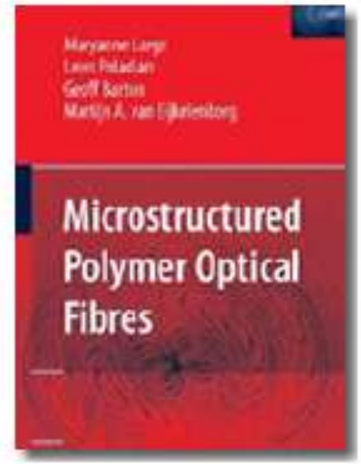
- Other more specialised
  - Sensing, hollow-core, dopants…

Further Information

a.argyros@kiriama.com

www.kiriama.com

sydney.edu.au/ipos



Latest review paper:

A. Argyros, "Microstructured polymer optical fibres," J. Lightwave Technol. **27**, p.1571 (2009)

Book:

Large, Poladian, Barton, van Eijkelenborg, *Microstructured Polymer Optical Fibres* (Springer-Verlag, 2007)

Gratuitous Pretty Picture