Towards High-Capacity Fibre Optics Communication At The Speed Of Light In Vacuum

Review

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Outline

Introduction

The need for wide bandwidth, low latency and high capacity communication is emerging as a key requirement for future communication networks.
standard optical fibres provide unsurpassed transmission bandwidth, but light waves propagate 31% slower in silica than in vacuum, which affects the latency.
In order to reduce significantly the latency, hollow core fibres can be used, as they guide the light at near speed of light (99.7%)

Introduction

However, state of the are hollow core fibres cannot achieve the required bandwidth, latency and losses required for high capacity data transmission.
This paper presents an improved Hollow Fibre Photonic Bandgap Fiber (HC-PBGF) which provides low loss of 3.5 dB km^{-1}, wider bandwidth of 160nm and used to transmit 37 channels of 40 Gbps each.

Photonic Bandgap Fibre

Photonic bandgap fibers are optical fibres which utilize the photonic crystal periodic characteristics. This type of fibres rely on 2-D photonic crystal.
Guidance is obtained using coherent Bargg scattering where light, at the wavelength within the band gap, are reflected from the cladding (the photonic crystal) which confines the light in the core.

Hollow Core Photonic Band Gap Fibre

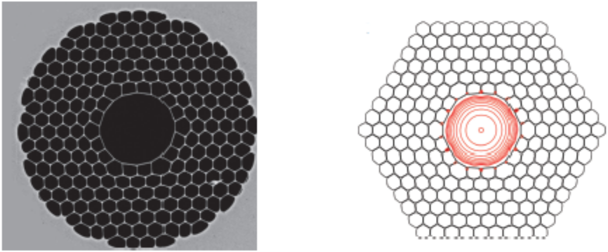

Figure 1: HC-PBGF. (A) Electron-scanning image. (B) Simulation. Francesco Poletti, Marco N. Petrovich and David J. Richardson, "Hollow-core photonic bandgap fibres: technology and applications", Nanophotonics 2013; 2(5-6): 315–340

Hollow Core Photonic Band Gap Fiber

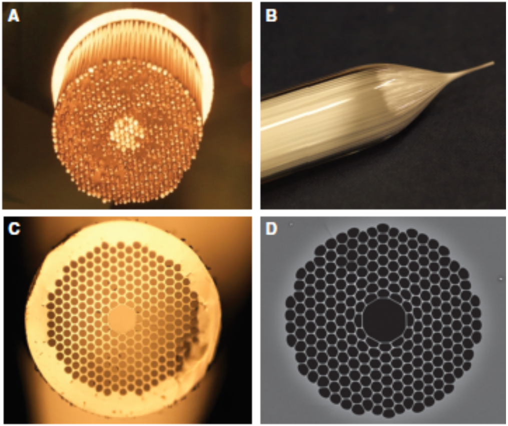

Figure 2: HC-PBGF. (A) Stacking of high purity, low hydroxyl silica glass. (B) Drawing. (C) Optical image of the cross section. (D) Scanning electron microscope image of the final fibre. Francesco Poletti, Marco N. Petrovich and David J. Richardson, "Hollow-core photonic bandgap fibers: technology and applications", Nanophotonics 2013; 2(5-6): 315–340

Theory

Up to the day of the paper, the lowest recorded losses for HC-PBGF were 1.7 dB km^{-1}. A study (conducted by P. J. Roberts, F. Couny, H. Sabert, B. J. Mangan, D. P. Williams, L. Farr, M. W. Mason and A. Tomlinson) showed that by using a HC-PBGF with 19-cell core surrender by a thick glass boundary minimizes the overlap of the fundamental mode with the glass interface which reduces the surface scattering (which is the leading cause of losses, as can be seen later).
The downside of using a thick is that it supports several lossy surface modes which reduces the workable bandwidth to 20 nm

Theory

Surface modes caused from the sudden termination of the periodic dielectric structure of the cladding. this generate spurious guided modes (A.K.A surface modes). this surface modes are localised at the core surround interface.
In most cases, the surface modes interact with the guided modes and a supermode forms partly in air and partly in the core surround interface. this interaction generates far greater propagation losses then the normal air guided modes.

Theory

These surface modes can be reduced or even eliminated by using thin walled core surrounds which are 50% of the thickness of the cladding struts.

This requires:

1. Omission of the large central capillary (which will reduce the drawing stability)
2. Extremely precise control of the core-cladding interface.

Up to the publication of this paper, only 7-cell core presented wide bandwidth of free surface modes.

Theory

The research group in this paper demonstrated the fabrication and the results of 19-cell core fibre with thin core surround.
The fibre which was fabricated comprised the following specifications:

1. 6.5 rings of cladding
2. Average hole-to-hole distance of 4.4 μm
3. Core diameter of 26 μm

Theory

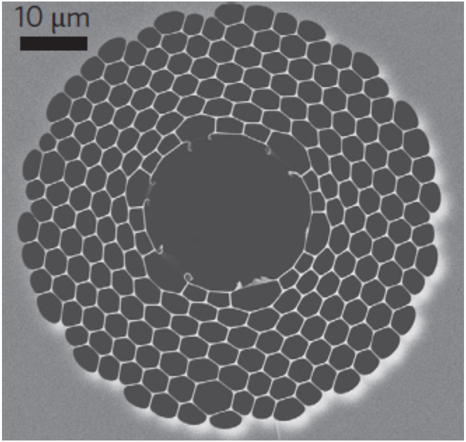

Figure 3: Cross section of The Fabricated HC-PBGF

Results

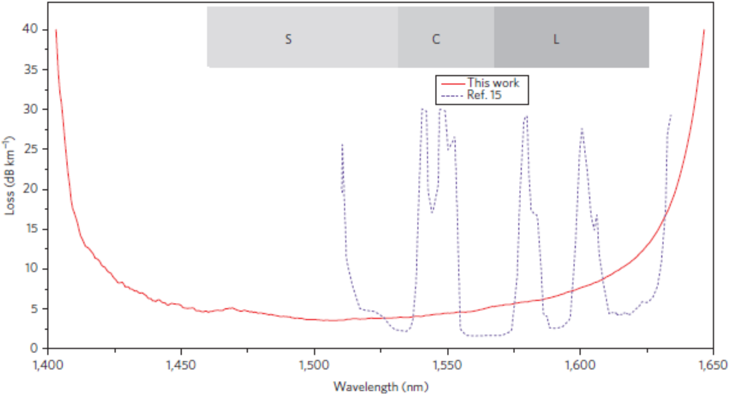

Figure 4: The Fabricated HC-PBGF presents 8 times wider 3 dB bandwidth (160 nm) with minimum loss twice as high (3.5 dB km^{-1})

Results

To understand the origin of the losses, a model of the surface scattering was developed. The results lead to that the surface scattering is the major cause of the losses

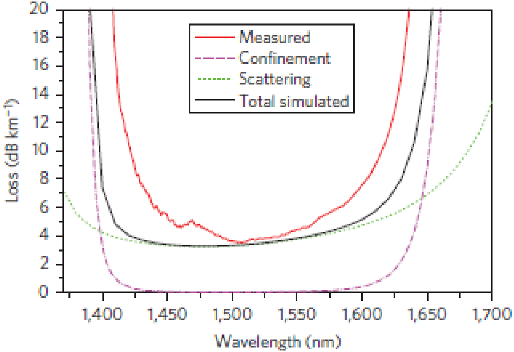

Figure 5: Simulated and Measured Losses

Results

To understand the complex modal behaviour, a combination of Time of Flight (ToF) and Self Interferometric (S^2) is used.
In order to excite higher modes, an offset launch of 12 μm is used

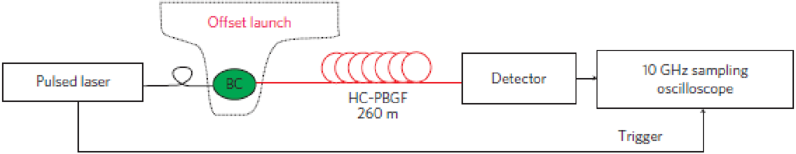

Figure 6: ToF Experimental Set-Up

Results

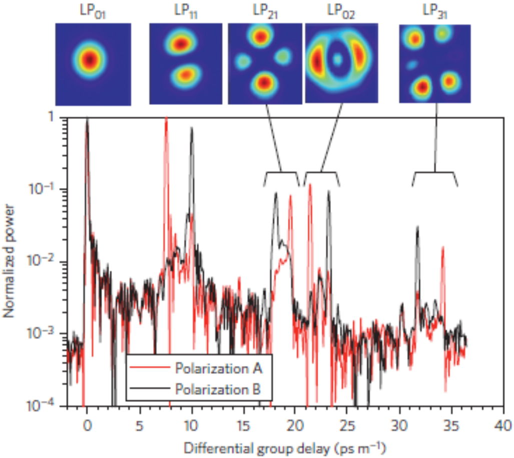

Figure 7: ToF Experimental Results - Low Intermodal Crosstalk

Results

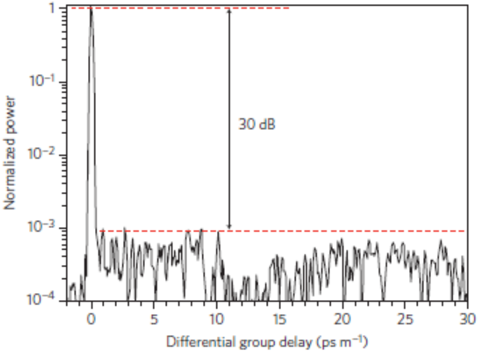

Figure 8: Central Launch - Single Mode

Results

In order to test the high capacity capabilities the following test settings were set up.

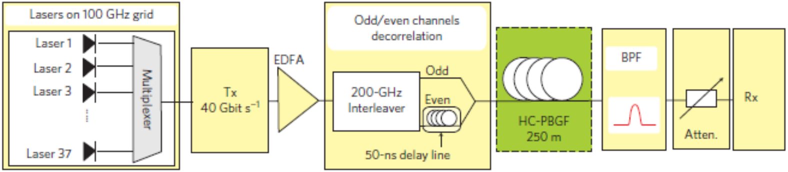

Figure 9: High Capacity Test Set Up

Results

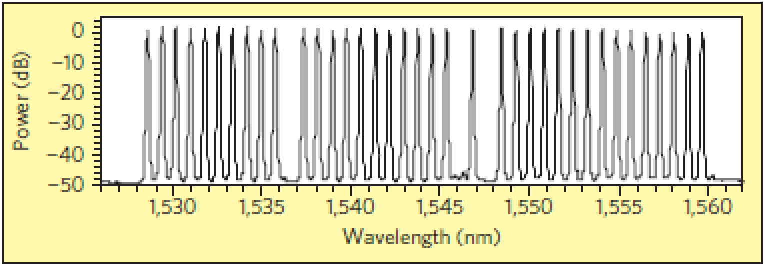

Figure 10: Transmitted Signal Spectrum

Results

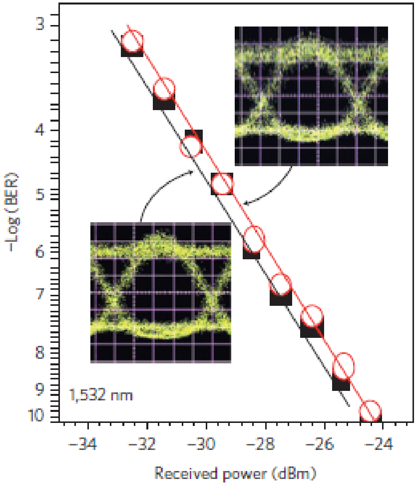

Figure 11: BER Resutls for wavelength of 1532 nm

Conclusion

This paper showed an improved fibre with better bandwidth, and lesser losses. Also, an improved reproducible control of the surface modes in large core fibre. because of low intermodal coupling and ultralow non-linearity these fibres are the best candidates for high capacity for single or multimode communication and support the important wavelength division multiplexing.
The achieved capacity of 1.48 Tbps improves the record distance–capacity product in HC-PBGFs by a factor of 250.

What Lays A Head?

1. Reduction of surface scattering to achieve 0.2 dB km^{-1}

QUESTIONS?

THANK YOU