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Tutorial

Photonic Bandgap Fibres

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Abstract

Photonic bandgap fibres have a cladding that is carefully structured to reject light of certain frequencies and propagation constants. The light is therefore confined to a core that can even be made of air, something that is not possible in conventional fibres that guide by total internal reflection. Since the first one was made 10 years ago, bandgap fibres have been demonstrated that guide light with low loss, low optical nonlinearity, strong gas-phase interactions and useful transmission spectra. This tutorial will review the various designs and applications of bandgap fibres, and consider how their bandgaps arise.

Tim Birks

Tim Birks is a Professor of Physics at the University of Bath. He has studied tapered optical fibres since starting his PhD in 1986, and from 1994 he was a pioneer in the design, fabrication and conceptual understanding of photonic crystal fibres. He was also a founder of the spin-out company BlazePhotonics Ltd, sold in 2004. He has co-authored several highly-cited journal papers, including four with over 400 citations each. His work was recognised by the award of a Royal Society University Research Fellowship in 1995 and election as a fellow of the Optical Society of America in 2007.

Extended Abstract

A photonic bandgap fibre guides light along its core by a photonic bandgap of the cladding, instead of the more-usual total internal reflection. The bandgap - a range of forbidden propagation constants sandwiched between allowed ones - arises from the way the cladding is patterned. Freed from the constraints of total internal reflection, the light can propagate in a core of low refractive index.

Bragg fibres with a cladding structured in concentric rings were proposed long ago [1,2]. However, the first bandgap fibres to be made had claddings with an array of isolated air holes [3-5], a design capable of guiding light along an air-filled hollow core [4-6]. More recently, all-solid bandgap fibres have been made in which the cladding includes an array of high-index glass rods [7-9].

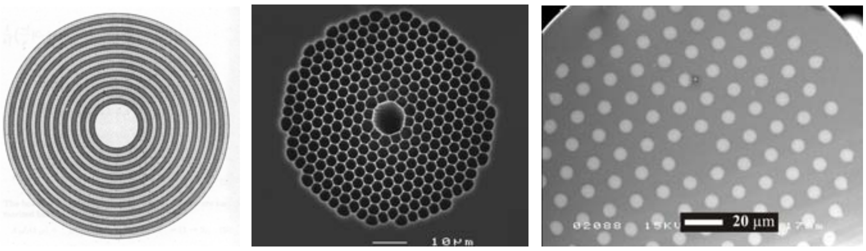

Fig. 1. Different designs of photonic bandgap fibres. From left to right: a Bragg fibre (schematic [2]), a hollow-core fibre (air holes in a silica background) and an all-solid bandgap fibre (Ge-doped silica rods in an undoped silica background).

The physical explanation of light guidance in bandgap fibres has historically lagged behind the ability to compute their properties numerically, but the so-called ARROW model [10] is a good starting point for an intuitive understanding. Both numerical and conceptual results are useful for explaining how bandgaps arise, and how they can control the propagation of light in fibres.

Applications of bandgap fibres include delivery of high-power laser light, strong and sustained gas-phase interactions, transmission of wavelengths outside the usual low-loss window of the glass, and intra-cavity spectral filtering.

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