freedom from issues such as nonlinear and thermo-optic effects that can affect optical waves travelling in solid material. Hollow core fibres can be packaged into cable formats deployable for optical data transmission in the same way as conventional fibres, but are not directly compatible with existing transceiver equipment configured for connection to solid core fibres. This presents a significant obstacle in the roll-out of hollow core fibres for data transmission. The provision of alternate transceiver equipment incorporating hollow core fibre inputs and outputs is currently a costly and impractical solution. Coupling of hollow core fibres to existing solid core equipment using conventional splicing or connectorisation techniques and tools commonly available at appropriate locations (such as data centres) is not feasible. A significant mismatch in the mode field diameters of conventional single mode fibres and hollow core fibres makes direct joining of the two fibre types unworkable. Also, the structure of a hollow core fibre creates difficulties when implementing coupling in the field. If exposed, the hollow core should be sealed to prevent ingress of contamination into the fibre, and the highly structured and delicate cladding around the core is susceptible to mechanical and thermal damage.

Accordingly, approaches enabling the use of hollow core optical fibre with solid core optical fibre-based equipment are of interest.

SUMMARY

Aspects and embodiments are set out in the present disclosure.

According to a first aspect, there is provided an optical waveguide adapter assembly comprising: a solid core optical waveguide extending between a free end of the solid core optical waveguide and a coupled end of the solid core optical waveguide, and having a solid waveguiding core with an associated first optical mode field size; a hollow core optical waveguide extending between a free end of the hollow core optical waveguide and a coupled end of the hollow core optical waveguide, and having a hollow waveguiding core with an associated second optical mode field size; and an optical mode field adapter extending between a first end and a second end and having a waveguiding core configured to change an optical mode field of a waveguided optical signal substantially between the first optical mode field size at the first end of the optical mode field adapter and the second optical mode field size at the second end of the optical mode field adapter, the first end of the optical mode field adapter joined to the coupled end of the solid core optical waveguide to provide optical coupling between the waveguiding core of the solid

core optical waveguide and the waveguiding core of the optical mode field adapter, and the second end of the optical mode field adapter joined by a splice to the coupled end of the hollow core optical waveguide to provide optical coupling

between the waveguiding core of the hollow core optical waveguide and the waveguiding core of the optical mode field adapter.

According to a second aspect, there is provided an optical fibre cable comprising at least one transmission hollow core optical waveguide for defining an optical signal transmission pathway, and an optical waveguide adapter assembly according to the first aspect optically coupled to at least one end of the at least one transmission hollow core optical fibre.

According to a third aspect, there is provided an optical signal transmission system comprising an optical signal transmitter, an optical signal receiver, an optical fibre cable housing at least one transmission hollow core optical waveguide defining an optical signal transmission pathway between the optical signal transmitter and the optical signal receiver, a first optical waveguide adapter assembly according to the first aspect optically interconnecting the transmitter and a first end of the at least one transmission hollow core optical waveguide, and a second optical waveguide adapter assembly according to the first aspect optically interconnecting the receiver and a second end of the at least one transmission hollow core optical waveguide.

According to a fourth aspect, there is provided a method of installing an optical signal transmission system comprising: deploying a transmission hollow core optical waveguide to define an optical signal transmission pathway; joining an optical waveguide adapter assembly according to the first aspect to the transmission hollow core optical waveguide by forming a splice between the free end of the hollow core optical waveguide of the optical waveguide adapter assembly and a first end of the transmission hollow core optical waveguide; and joining the free end of the solid core optical waveguide of the optical waveguide adapter assembly to form an optical coupling with first optical transceiver equipment.

These and further aspects of certain embodiments are set out in the appended independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with each other and features of the independent claims in combinations other than those explicitly set out in the claims. Furthermore, the approach described herein is not restricted to specific embodiments such as set out below, but includes and contemplates any appropriate combinations of features presented herein. For example, optical fibre adapter assemblies may be provided in accordance with approaches described herein which includes any one or more of the various features described below as appropriate.

CLAIMS

1. An optical waveguide adapter assembly comprising:

a solid core optical waveguide extending between a free end of the solid core optical waveguide and a coupled end of the solid core optical waveguide, and having a solid waveguiding core with an associated first optical mode field size;

a hollow core optical waveguide extending between a free end of the hollow core optical waveguide and a coupled end of the hollow core optical waveguide, and having a hollow waveguiding core with an associated second optical mode field size; and

an optical mode field adapter extending between a first end and a second end and having a waveguiding core configured to change an optical mode field of a waveguided optical signal substantially between the first optical mode field size at the first end of the optical mode field adapter and the second optical mode field size at the second end of the optical mode field adapter, the first end of the optical mode field adapter joined to the coupled end of the solid core optical waveguide to provide optical coupling between the waveguiding core of the solid core optical waveguide and the waveguiding core of the optical mode field adapter, and the second end of the optical mode field adapter joined by a splice to the coupled end of the hollow core optical waveguide to provide optical coupling between the waveguiding core of the hollow core optical waveguide and the waveguiding core of the optical mode field adapter.

2. An optical waveguide adapter assembly according to claim 1, in which the hollow core optical waveguide is a photonic bandgap waveguide configured to guide light along the hollow waveguiding core by a photonic bandgap effect, the hollow waveguiding core surrounded by an inner cladding comprising a microstructured regular array of longitudinally extending capillaries.

3. An optical waveguide adapter assembly according to claim 1, in which the hollow core optical waveguide is an antiresonant waveguide configured to guide light along the hollow waveguiding core by an antiresonant effect, the hollow waveguiding core surrounded by an inner cladding comprising a ring of longitudinally extending capillaries.

4. An optical waveguide adapter assembly according to claim 3, in which the hollow core optical waveguide is a nested antiresonant nodeless hollow core waveguide, the

inner cladding comprising one or more additional capillaries nested within each longitudinally extending capillary.

5. An optical waveguide adapter assembly according to any one of claims 1 to 4, in which the first optical mode field size is smaller than the second optical mode field size.

6. An optical waveguide adapter assembly according to any one of claims 1 to 5, in which the solid core optical waveguide comprises a single mode optical waveguide with a doped or undoped silica waveguiding core.

7. An optical waveguide adapter assembly according to any one of claims 1 to 6, in which the optical mode field adapter comprises a graded index optical waveguide.

8. An optical waveguide adapter assembly according to claim 7, in which the optical mode field adapter additionally comprises a large mode area optical waveguide having a solid waveguiding core with an associated optical mode field size substantially matched to the second optical mode field size, the large mode area optical waveguide joined between the graded index optical waveguide and the hollow core optical waveguide.

9. An optical waveguide adapter assembly according to any one of claims 1 to 6, in which the optical mode field adapter comprises a further solid core optical waveguide having a solid waveguiding core enlarged by thermal expansion at the second end of the optical mode field adapter.

10. An optical waveguide adapter assembly according to claim 9, in which the further solid core optical waveguide is a portion of the solid core optical waveguide at the coupled end of the solid core optical waveguide.

11. An optical waveguide adapter assembly according to any one of claims 1 to 6, in which the optical mode field adapter comprises a further solid core optical waveguide with a solid waveguiding core tapered over at least part of a length of the solid waveguiding core.

12. An optical waveguide adapter assembly according to claim 9 or claim 10, in which the optical mode field adapter additionally comprises a second further solid core

optical waveguide with a tapered solid waveguiding core, the second further solid core optical waveguide joined between the further solid core optical waveguide and the hollow core optical waveguide.

13. An optical waveguide adapter assembly according to any preceding claim, in which the optical mode field adapter is joined to the solid core optical waveguide by a splice.

14. An optical waveguide adapter assembly according to any preceding claim, and further comprising a mechanical connector at the free end of the solid core optical waveguide configured for engagement with a mechanical connector on equipment to enable optical coupling into and out of the solid core optical waveguide.

15. An optical waveguide adapter assembly according to any preceding claim, and further comprising one or more additional optical waveguide adapter assemblies and an outer jacket housing all the optical waveguide adapter assemblies as a single component.

16. An optical waveguide adapter assembly according to any preceding claim, and further comprising a transmission hollow core optical waveguide for defining an optical signal transmission pathway joined to the free end of the hollow core optical waveguide by a splice.

17. An optical waveguide adapter assembly according to claim 16, in which the transmission hollow core optical waveguide is comprised within an optical fibre cable.

18. An optical fibre cable comprising at least one transmission hollow core optical waveguide for defining an optical signal transmission pathway, and an optical waveguide adapter assembly according to any one of claims 1 to 15 optically coupled to at least one end of the at least one transmission hollow core optical fibre.

19. An optical signal transmission system comprising an optical signal transmitter, an optical signal receiver, an optical fibre cable housing at least one transmission hollow core optical waveguide defining an optical signal transmission pathway between the optical signal transmitter and the optical signal receiver, a first optical waveguide adapter

assembly according to any one of claims 1 to 15 optically interconnecting the transmitter and a first end of the at least one transmission hollow core optical waveguide, and a second optical waveguide adapter assembly according to any one of claims 1 to 15 optically interconnecting the receiver and a second end of the at least one transmission hollow core optical waveguide.

20. A method of installing an optical signal transmission system comprising:

deploying a transmission hollow core optical waveguide to define an optical signal transmission pathway;

joining an optical waveguide adapter assembly according to any one of claims 1 to 15 to the transmission hollow core optical waveguide by forming a splice between the free end of the hollow core optical waveguide of the optical waveguide adapter assembly and a first end of the transmission hollow core optical waveguide; and

joining the free end of the solid core optical waveguide of the optical waveguide adapter assembly to form an optical coupling with first optical transceiver equipment.

21. A method according to claim 20, further comprising joining a second optical waveguide adapter assembly to a second end of the transmission hollow core optical waveguide and to second optical transceiver equipment.

22. A method according to claim 20 or claim 21, in which the transmission hollow core optical waveguide is comprised within an optical fibre cable.