end of a preform to a second end of the preform, and forming at least one radially inwardly-extending slot within the preform such that the slot intersects at least some of the holes, wherein the slot does not intersect at least one hole. The method also includes establishing a first pressure in the holes intersected by the slot by introducing the first pressure to the slot, and establishing a second pressure in the at least one hole not intersected by the slot by introducing the second pressure to an end of the at least one hole not intersected by the slot. The method further includes drawing the preform into a fiber while independently controlling the first and second pressures.

WO 03/078338 discloses a method of making a preform for a microstructured optical fiber using a sol-gel process. The described preform may comprise concentric tubes and a plurality of tubes and/or rods placed between the concentric tubes.

DESCRIPTION OF THE INVENTION

According to a first aspect of the present invention, there is provided a preform element for a fiber preform, said preform element has a length and a center axis along its length, a first and second end defined by its length and an outer preform element surface and said preform element comprising a plurality of longitudinal structures disposed to form longitudinal hole(s) in a background material, said preform element comprises at least one slot extending from its outer preform element surface and intersecting at least one of said longitudinal holes and wherein the at least one slot does not fully intersect the preform element, wherein said plurality of longitudinal structures is encaged in said background material and extends in the length direction of the preform element, wherein at least a part of the background material is provided by solid longitudinal structures and/or by material of hollow longitudinal structures.

According to a second aspect of the present invention, there is provided a method of forming an optical fiber comprising:

- forming an optical fiber preform assembly comprising at least one interface void and comprising a plurality of longitudinal holes and one or more longitudinally extending voids; and
- drawing the optical fiber preform assembly into the optical fiber while pressuring at least one of the holes through a radially inwardly extending slot in the preform assembly and while evacuating said at least one interface void.

In an embodiment it is an object to provide a preform element for a microstructured optical fiber preform which makes the production of the preform relatively simple compared to prior art methods.

In an embodiment it is an object to provide a preform element for a microstructured optical fiber preform which makes the production of the preform economically beneficial compared to prior art methods.

In an embodiment it is an object to provide a preform element for a microstructured optical fiber comprising a plurality of holes extending along the length of the fiber.

In an embodiment it is an object to provide a method of producing a microstructured optical fiber which is relatively simple and offers large freedom in design of the fiber and where the diameter of longitudinal holes can be controlled with a high accuracy.

PATENT CLAIMS

1. A preform element for a fiber preform, said preform element has a length and a center axis along its length, a first and second end defined by its length and an outer preform element surface and said preform element comprising a plurality of longitudinal structures disposed to form longitudinal hole(s) in a background material, said preform element comprises at least one slot extending from its outer preform element surface and intersecting at least one of said longitudinal holes and wherein the at least one slot does not fully intersect the preform element, wherein said plurality of longitudinal structures is encaged in said background material and extends in the length direction of the preform element, wherein at least a part of the background material is provided by solid longitudinal structures and/or by material of hollow longitudinal structures.

2. The preform element of claim 1, wherein one or more of said plurality of longitudinal structures are hollow tubes with said longitudinal holes and/or said longitudinal holes are longitudinal interspace holes formed between said longitudinal structures, wherein said least one slot extending from its outer preform element surface intersects at least one of said holes of said hollow tubes and/or at least one of said interspace holes.

3. The preform element of claim 2, wherein the hollow tubes each comprise a plurality of longitudinal holes substantially parallel to the center axis of the preform element, said plurality of holes of each hollow tube are preferably arranged in a predetermined cross sectional pattern comprising at least one ring of holes and optionally a center hole.

4. The preform element of any one of the preceding claims, wherein said intersected holes are closed at a position from the slot to the first end, such as at said first end of the preform and/or at the intersection towards the first end and/or a position there between.

5. The preform element of any one of the preceding claims, wherein said preform element is adapted to form part of a preform for a microstructured optical fiber, wherein said preform element is adapted for being assembled with at least one additional preform element.

6. The preform element of any one of the preceding claims, wherein the at least one slot is an annular slot intersecting a plurality of said holes of said hollow tubes and/or all of said interspace holes, preferably, such as substantially all of said holes of said hollow tubes and/or all of said interspace holes of the preform cladding region or the outer preform cladding region are intersected by said annular slot.

7. The preform element of any one of claims 1-5, wherein said preform element is a preform ring element wherein said preform ring element has an inner preform element surface and said outer preform surface is in the form of an outer preform ring element surface, said background material is in the form of a ring wall background material, said slot intersecting said at least one of said longitudinal holes extending from its outer preform element surface and wherein the at least one slot does not fully intersect the ring wall.

8. The preform element of claim 7, wherein said ring wall background material comprises a ring wall inner background material and a ring wall outer background material, which inner and outer background material may be equal or may different from each other.

9. The preform element of any one claims 7 and 8, wherein said preform ring element comprises a ring of said longitudinal structures arranged with interspace between adjacent longitudinal structures to form said one or more longitudinal interspace holes, said longitudinal structures encaged in the ring wall background material optionally comprises one or more solid structures, such as at least one solid structure having a refractive index different from an index of the ring wall background material.

10. The preform element of any one of claims 7-9, wherein said preform ring element comprises a ring of hollow tubes, preferably the hollow tubes each comprise a plurality of longitudinal holes substantially parallel to the center axis of the preform ring element, said plurality of holes of each hollow tube are preferably arranged in a predetermined cross sectional pattern comprising at least one ring of holes and optionally a center hole.

11. The preform element of any one of the claims 7-10, wherein said ring wall has an average inner diameter (ID) defined by the inner preform element surface and an average outer diameter (OD) defined by said outer preform element surface, said ID/OD in at least a cross section of the preform ring element is from about 0.3 to about 0.95, such as from about 0.7 to about 0.9.

12. The preform element of any one of the claims 7-11, wherein said ring wall comprises an inner hollow cane, an outer hollow cane and said plurality of longitudinal structures encaged between said inner cane and said outer cane.

13. The preform element of any one of the claims 7-12, wherein the at least one slot is an annular slot intersecting a plurality, such as substantially all of said holes of said hollow tubes and/or all of said interspace holes.

14. The preform element of any one of the claims 7-13, wherein said preform ring element has an inner diameter of at least about 3 mm, such as at least about 5 mm, such as at least about 10 mm, such as from about 15 to about 50 mm.

15. A method of producing a preform element of any one of the preceding claims, wherein said method comprises providing a plurality of longitudinal structures and disposing said longitudinal structures to form longitudinal hole(s) in a background material, said method comprising providing at least one slot extending from said outer preform element surface and intersecting at least one of said longitudinal holes and wherein the at least one slot does not fully intersect the preform element, wherein the method further

comprises closing said intersected holes at a position from the first end of the preform to the intersection, such as at the first end of the preform and/or at the intersection towards the first end of the preform and/or at an additional slot intersecting the holes, said intersected holes are preferably closed by collapsing and/or by filling a solid material into the holes.

16. The method of claim 15, wherein the method comprises performing said at least one slot is an annular slot intersecting a plurality of said holes of said hollow tubes and/or all of said interspace holes, preferably, such as half of or substantially all of said holes of said hollow tubes and/or all of said interspace holes of the preform cladding region or the outer preform cladding region are intersected by said annular slot.

17. The method of any one of claims 15-16, wherein said preform element is a preform ring element, said method comprises providing an outer ring wall section, an inner ring wall section and a plurality of longitudinal structures and encaging said longitudinal structures in between said outer ring wall section and said inner ring wall section to form longitudinal holes and providing said at least one slot extending through the outer ring wall section and intersecting at least one of said longitudinal holes.

18. The method of claim 17, wherein said outer ring wall section is an outer hollow cane and said inner ring wall section is an inner hollow cane, preferably said outer hollow cane has an outer surface forming an outer preform element surface and said method comprises performing said at least one slot extending from the outer preform element surface and intersecting said longitudinal hole(s).

19. The method of claim 17 or claim 18, wherein said encaging of said at least one longitudinal structure in between said outer ring wall section and said inner ring wall section comprises assembling said outer ring wall section and said inner ring wall section with said longitudinal structures in between and at least partly fusing said outer ring wall section and said inner ring wall section together via said longitudinal structures.

20. The method of any one of claims 17-18, wherein said assembling comprises arranging said inner wall section with its outer surface of said inner ring wall to face an inner surface of said outer ring wall and arranging said longitudinal structures between said outer surface of said inner ring wall and said inner surface of said outer ring wall.

21. The method of any one of claims 17-20, wherein the inner and outer ring wall sections are hollow canes and the assembling comprises inserting said inner ring wall section into said outer ring wall section and arranging a plurality of said longitudinal structures between said inner ring wall section and said outer ring wall section.

22. The method of any one of claims 17-21, wherein the method comprises arranging said longitudinal structures in a side by side configuration to surround said inner ring wall section, to form at least one ring of longitudinal structures, such as two rings of longitudinal structures, such as three rings of longitudinal structures.

23. The method of any one of claims 17-22, wherein one or more of said plurality of longitudinal structures are hollow tubes with said longitudinal holes and/or said longitudinal holes are longitudinal interspace holes between said longitudinal structures, wherein said least one slot is provided to intersects at least one of said holes of said hollow tubes and/or at least one of said interspace holes, preferably all of said longitudinal structures are hollow tubes optionally including one or more tubes with a plurality of longitudinal holes substantially parallel to the center axis of the preform ring element.

24. The method of claim 22 or claim 23, wherein the ring of longitudinal structures is arranged in a configuration where said respective longitudinal structures are in contact with adjacent longitudinal structures along their lengths.

25. The method of claim 22 or claim 23, wherein the ring of longitudinal structures is arranged in a configuration where said respective longitudinal

structures are not in contact with adjacent longitudinal structures thereby forming said longitudinal holes in the form of interspace longitudinal holes, preferably the method comprises arranging a distance arrangement at two or more positions along the length of the preform ring element for controlling the distance between the longitudinal structures.

26. The method of any one of claims 17-25, wherein said at least one slot is provided by a radially inwards cut through the outer ring wall section, wherein the radially inwards cut is substantially perpendicular to the center axis.

27. The method of any one of claims 17-25, wherein the method further comprises closing said intersected holes at a position from the first end of the preform to the intersection, such as at the first end of the preform and/or at the intersection towards the first end of the preform and/or at an additional slot intersecting the holes, said intersected holes are preferably closed by collapsing and/or by filling a solid material into the holes.

28. A method of producing a microstructured optical fiber, the method comprising assembling a preform, and drawing the preform assembly to a microstructured optical fiber, wherein the assembling of the preform comprises providing a preform element according to any one of the claims 1-10 and assembling it with at least one additional preform element.

29. The fiber production method of claim 28, wherein said preform element is a preform center element which is assembled with an additional preform ring element and/or an overcladding tube or wherein said preform element is a preform ring element which is assembled with an additional preform center element and optionally an overcladding tube.

30. The fiber production method of claim 29 wherein the method comprises providing a preform center element with a length and a first and a second end, and arranging the ring shaped wall to surround said preform center element to form a preform ring element- preform center interface, wherein the preform

assembly has a first end section comprising said first end of said preform center element and said first end of said preform ring element.

31. The fiber production method of any one of claims 28-30, wherein at least one of said elements interface(s) is subjected to a reduced pressure during at least a part of the drawing of the preform assembly to a microstructured optical fiber, preferably at least one of said preform element - overcladding tube interface and said preform ring element-preform center interface is/are subjected to a reduced pressure during at least a part of the drawing of the preform assembly to a microstructured optical fiber, wherein said preform element - overcladding tube interface is selected from a preform center element - overcladding tube interface and a preform ring element - overcladding tube interface.

32. The fiber production method of any one of claims 28-31, wherein the preform center element comprises at least one hole extending along its length, said method comprising subjecting said at least one hole of said preform center element to a preform center controlled pressure during the drawing, preferably the preform center element is according to any one of claims 1-17 and the controlled pressure is applied via the slot of the preform center element.

33. The fiber production method of any one of claims 30-32, wherein the method comprises subjecting said longitudinal holes of said preform ring element to a preform ring element controlled pressure during the drawing, wherein said preform ring element controlled pressure is controlled independently of at least one other controlled pressure during the drawing, such as said preform center controlled pressure.

34. The fiber production method of any one of claims 28-33, wherein said first end of said preform center element and said first end of said overcladding tube are sequentially offset at said preform end section, such that said end section of said preform center element protrudes beyond the end of said overcladding tube.

35. The fiber production method of any one of claims 29-34, wherein said first end of said additional preform center element, said first end of said preform ring element and said first end of said overcladding tube are sequentially offset at said preform end section, such that said end section of said preform ring element protrudes beyond the end of said overcladding tube and preferably such that an end section of said additional preform center element protrudes beyond the end of said preform ring element.

36. The fiber production method of any one of claims 30-35, wherein said first end of said preform center element, said first end of said additional preform ring element and said first end of said overcladding tube are sequentially offset at said preform end section, such that said end section of said additional preform ring element protrudes beyond the end of said overcladding tube and preferably such that an end section of said preform center element protrudes beyond the end of said additional preform ring element.

37. The fiber production method of any one of claims 27-36, wherein said one or more pressure controls are provided by enclosing said end section of said preform assembly by a pressure control cap comprising two or more pressure control sections and applying seals to seal off independently pressure controlled holes, comprising at least a pair of slot seals on opposite sides of said slot of said preform element, preferably said intersected holes of said preform element are closed at a position from said first end of the preform to said slot intersection towards the first end and said pair of slot seals forms annular seals against the outer preform element surface of said end section of said preform element.

38. A method of forming an optical fiber comprising:

- forming an optical fiber preform assembly comprising at least one interface void and comprising a plurality of longitudinal holes and one or more longitudinally extending voids; and

- drawing the optical fiber preform assembly into the optical fiber while pressuring at least one of the holes through a radially inwardly extending slot in the preform assembly and while evacuating said at least one interface void,

wherein the method is according to any one of the claims 28-37.

39. The fiber production method of claim 38, wherein the method comprises drawing the optical fiber, such that the at least one interface void is closed in the drawn fiber.