

CLAIMS

What we claim is:

1. A method of manufacturing a multi-material fiber comprising at least one electrically-connectable device, the method comprising the steps of:

positioning each electrically-connectable device within a corresponding pocket provided in a preform material;

positioning a first electrical conductor longitudinally within a first conduit provided in the preform material; and

drawing the multi-material fiber by causing the preform material to flow, such that the first electrical conductor extends within the multi-material fiber along a longitudinal axis thereof and makes an electrical contact with a first electrode located on each electrically-connectable device,

wherein, at least one of (i) a metallurgical bond is formed between the first electrical conductor and the first electrode while drawing the multi-material fiber or (ii) after drawing the multi-material fiber, the first electrical conductor is located substantially along a neutral axis of the multi-material fiber.

2. The method of claim 1 further comprising positioning a second electrical conductor longitudinally within a second conduit provided in the preform material.

3. The method of claim 2, wherein drawing the multi-material fiber by causing the preform material to flow further causes the second electrical conductor to extend within the multi-material fiber along the longitudinal axis thereof and to make an electrical contact with a second electrode located on each electrically-connectable device.

4. The method of claim 3, wherein a metallurgical bond is formed between the second electrical conductor and the second electrode while drawing the multi-material fiber.

5. The method of claim 3, wherein, after drawing the multi-material fiber, the second electrical conductor is located substantially along the neutral axis of the multi-material fiber.

6. The method of claim 1, wherein positioning the first electrical conductor comprises positioning a copper alloy wire within the first conduit.

7. The method of claim 6, wherein the copper alloy wire comprises a silver coating.

8. The method of claim 1 further comprising depositing a bonding material on the first electrode prior to drawing the multi-material fiber.
9. The method of claim 8, wherein the bonding material comprises a metal alloy material.
10. The method of claim 9, wherein the metal alloy material comprises tin and bismuth.
11. The method of claim 8, wherein a melting point of the bonding material substantially matches a glass transition temperature of the preform material.
12. The method of claim 8, wherein depositing the bonding material on the first electrode utilizes a hot press device.
13. The method of claim 1 further comprising controlling an aspect ratio of the drawn multi-material fiber.
14. The method of claim 13, wherein the controlled aspect ratio is between about 1.1:1 and about 2.7:1.
15. The method of claim 13, wherein controlling the aspect ratio comprises adding sidewalls to the drawn multi-material fiber.
16. The method of claim 1 further comprising overcoating the drawn multi-material fiber.
17. The method of claim 16, wherein the drawn multi-material fiber is overcoated with a thermoplastic elastomer material.
18. The method of claim 1 further comprising positioning a support wire longitudinally within an additional conduit in the preform material to provide mechanical stability to each electrically-connectable device.
19. The method of claim 18, wherein positioning the support wire comprises positioning the support wire within the additional conduit such that, after the multi-material fiber is drawn, the support wire contacts each electrically-connectable device without making electrical contact with the first electrical conductor or the first electrode.
20. The method of claim 1 further comprising positioning at least one outer wire longitudinally within a corresponding conduit in the preform material.

21. The method of claim 20, wherein positioning the at least one outer wire comprises positioning each outer wire so that, after drawing the multi-material fiber, each outer wire is located substantially along the neutral axis of the drawn multi-material fiber.
22. The method of claim 1 further comprising interlacing the drawn multi-material fiber with a plurality of additional fibers to form a textile.
23. The method of claim 22 further comprising adding rigidity to the textile.
24. The method of claim 23, wherein adding rigidity to the textile comprises at least one of:
- adding tubing to the textile;
 - adding a plurality of stiffeners to the textile;
 - adding a backing to the textile; or
 - adding a ribbon-cable backing to the textile.
25. The method of claim 22 further comprising at least one of:
- wrapping the drawn multi-material fiber with an overwrap prior to the interlacing; or
 - producing a composite yarn comprising at least one of a high modulus mono-filament yarn, a high strength mono-filament yarn, a high modulus multi-filament yarn, or a high strength multi-filament yarn placed in parallel with the drawn multi-material fiber; and
 - overwrapping the composite yarn with at least one of similar or other textile yarns.
26. The method of claim 25, wherein the overwrap comprises a plurality of high tensile strength fibers.
27. The method of claim 26, wherein the high tensile strength fibers comprise one or more of aramids, dyneema, or basalt fibers.
28. A textile comprising:
- (i) at least one multi-material fiber comprising:
 - a cladding material;
 - an electrically-connectable device disposed within the cladding material; and
 - a first electrical conductor disposed within the cladding material and in electrical communication with a first electrode on the electrically-connectable device;and
 - (ii) a plurality of additional fibers interlaced with the multi-material fiber,

wherein, at least one of (i) the first electrical conductor is in electrical communication with the first electrode via a first metallurgical bond that comprises a bonding material having a melting temperature that substantially matches a glass transition temperature of the cladding material or (ii) the first electrical conductor is located substantially along a neutral axis of the multi-material fiber.

29. The textile of claim 28, wherein the multi-material fiber further comprises a second electrical conductor disposed within the cladding material and in electrical communication with a second electrode on the electrically-connectable device.

30. The textile of claim 29, wherein the second electrical conductor is in electrical communication with the second electrode via a second metallurgical bond that comprises a bonding material having a melting temperature that substantially matches the glass transition temperature of the cladding material.

31. The textile of claim 29, wherein the second electrical conductor is located substantially along the neutral axis of the multi-material fiber.

32. The textile of claim 28, wherein the cladding material is selected from the group consisting of a thermoplastic material, a thermoplastic elastomer, and glass.

33. The textile of claim 28, wherein the electrically-connectable device is selected from the group consisting of a light-emitting diode, a light-emitting device, a microphone, an inertial measurement unit, an interposer, an interconnect device, a temperature sensor, a light-responsive device, a photodetector, and a photodiode.

34. The textile of claim 28, wherein the bonding material comprises a metal alloy material.

35. The textile of claim 34, wherein the metal alloy material comprises a solder made of tin and bismuth.

36. The textile of claim 28, wherein the first electrical conductor is selected from the group consisting of a copper wire, a copper wire comprising a silver coating, a tungsten wire, a high tension wire, and an extra high tension wire.

37. The textile of claim 28, wherein the multi-material fiber has an aspect ratio between about 1.1:1 and about 2.7:1.
38. The textile of claim 28, wherein the multi-material fiber comprises an overcoating.
39. The textile of claim 38, wherein the overcoating comprises a thermoplastic elastomer material.
40. The textile of claim 28, wherein the multi-material fiber comprises an overwrap.
41. The textile of claim 40, wherein the overwrap comprises a plurality of high tensile strength fibers.
42. The textile of claim 41, wherein the high tensile strength fibers comprise one or more of aramids, dyneema, or basalt fibers.
43. The textile of claim 28, wherein the multi-material fiber further comprises a support wire to provide mechanical stability to the device.
44. The textile of claim 28, wherein the multi-material fiber further comprises at least one outer wire.
45. The textile of claim 44, wherein the outer wire is located substantially along the neutral axis of the multi-material fiber.
46. The textile of claim 44, wherein the outer wire comprises one or more of a wire made from aramid, dyneema, or tungsten.
47. A method of manufacturing a multi-material fiber comprising at least one electrically-connectable device, the method comprising the steps of:
 fabricating a core portion of a composite preform, the core portion comprising:
 a core material;
 at least one electrically-connectable device; and
 at least one electrical conductor in electrical communication with the electrically-connectable device;
 encasing the core portion within an outer sheath portion to form the composite preform; and
 thermally drawing the composite preform.

48. The method of claim 47, wherein the core portion and the outer sheath portion are manufactured from different materials having substantially similar glass transition temperatures.
49. The method of claim 47, wherein the core portion is manufactured from a thermoplastic and the outer sheath portion is manufactured from a thermoplastic elastomer.
50. The method of claim 49, wherein the core portion is manufactured from a cyclic olefin copolymer (COC) and the outer sheath portion is manufactured from an elastomeric-cyclic olefin copolymer (e-COC).
51. The method of claim 47, wherein fabricating the core portion comprises:
providing a plurality of layers of the core material;
forming a slot in at least two of the layers;
forming a pocket in a third layer;
positioning a first electrical conductor in a first slot in a first layer;
positioning a second electrical conductor in a second slot in a second layer;
positioning the electrically-connectable device in the pocket in the third layer; and
consolidating the first, second, and third layers to form the core portion.
52. The method of claim 51, wherein the third layer is disposed between the first and second layers.
53. The method of claim 51, wherein the consolidating comprises using a hot press device.
54. The method of claim 47, wherein encasing the core portion comprises:
placing the core portion between first and second clam shell portions of the outer sheath portion; and
consolidating the core portion, the first clam shell portion, and the second clam shell portion.
55. The method of claim 54, wherein the consolidating comprises using a hot press device.
56. The method of claim 47 further comprising interlacing the drawn multi-material fiber with a plurality of additional fibers to form a textile.

57. A textile comprising:
- (i) at least one multi-material fiber comprising:
 - a composite material;
 - an electrically-connectable device disposed within the composite material; and
 - at least one electrical conductor disposed within the composite material and in electrical communication with the electrically-connectable device; and
 - (ii) a plurality of additional fibers interlaced with the multi-material fiber,
- wherein the composite material comprises a first preform material having a first glass transition temperature and a second preform material encasing the first preform material, the second preform material having a second glass transition temperature substantially similar to the first glass transition temperature.
58. The textile of claim 57, wherein the electrically-connectable device and the at least one electrical conductor are disposed in the first preform material.
59. A method of manufacturing a multi-material fiber comprising at least one electrically-connectable device, the method comprising the steps of:
- thermally drawing a core preform, comprising a first material, at a first temperature to produce a first drawn fiber, the first drawn fiber comprising:
 - at least one electrically-connectable device; and
 - at least one electrical conductor in electrical communication with the electrically-connectable device;
 - inserting the first drawn fiber within a hollow portion of a second preform to form a composite preform, the second preform comprising a second material that differs from the first material; and
 - thermally drawing the composite preform at a second temperature to provide the multi-material fiber.
60. The method of claim 59, wherein a glass transition temperature of the second preform is less than a glass transition temperature of the core preform.
61. The method of claim 59, wherein the second temperature is less than a glass transition temperature of the core preform.
62. The method of claim 59, wherein the second preform comprises an elastomeric-cyclic olefin copolymer (e-COC).

63. The method of claim 59 further comprising interlacing the multi-material fiber with a plurality of additional fibers to form a textile.
64. A textile comprising:
- (i) at least one multi-material fiber comprising:
 - a composite material;
 - an electrically-connectable device disposed within the composite material; and
 - at least one electrical conductor disposed within the composite material and in electrical communication with the electrically-connectable device; and
 - (ii) a plurality of additional fibers interlaced with the multi-material fiber,
- wherein the composite material comprises a first preform material having a first glass transition temperature and a second preform material encasing the first preform material, the second preform material having a second glass transition temperature less than the first glass transition temperature.
65. The textile of claim 64, wherein the electrically-connectable device and the at least one electrical conductor are disposed in the first preform material.
66. A method of manufacturing a multi-material fiber comprising at least one electrically-connectable device, the method comprising the steps of:
- positioning a plurality of electrical conductors longitudinally within corresponding conduits provided in a preform material;
 - drawing the multi-material fiber by causing the preform material to flow;
 - creating at least one pocket in the drawn multi-material fiber to expose the electrical conductors;
 - electrically coupling at least one of an interconnector or an interposer to the exposed electrical conductors within the pocket;
 - positioning an electrically-connectable device outside of the pocket;
 - electrically coupling the electrically-connectable device to at least one of the interconnector or the interposer; and
 - encapsulating the electrically-connectable device and at least one of the interconnector or the interposer.
67. The method of claim 66, wherein the electrically-connectable device is selected from the group consisting of a light-emitting diode, a light-emitting device, a microphone, an

inertial measurement unit, a temperature sensor, a light-responsive device, a photodetector, and a photodiode.

68. A textile comprising:

(i) at least one multi-material fiber comprising:

a cladding material;

at least one of an interconnector or an interposer;

an electrically-connectable device disposed outside of the cladding material;

and

a plurality of electrical conductors disposed within the cladding material and in electrical communication with at least one of the interconnector or the interposer;

and

(ii) a plurality of additional fibers interlaced with the multi-material fiber,

wherein the electrically-connectable device and at least one of the interconnector or the interposer are encapsulated by a material.

69. The textile of claim 68, wherein the electrically-connectable device is selected from the group consisting of a light-emitting diode, a light-emitting device, a microphone, an inertial measurement unit, a temperature sensor, a light-responsive device, a photodetector, and a photodiode.