CLAIMS

What is claimed is:

1. A method of forming a flow cell, comprising:

applying a first adhesive to a substrate, wherein a top surface of the substrate comprises electrical contacts;

orienting a package on the first adhesive, the package comprising a die wherein a top surface of the die comprises an active surface and electrical contact points and surfaces adjacent to the active surface on at least two opposing sides of the active surface form fanout regions for utilization in a fluidic path of the flow cell;

connecting the electrical contacts on the top surface of the substrate to electrical contact points on the die;

applying a second adhesive to a part of the package; and

attaching a lid to the second adhesive, wherein the attaching defines a fluidic flow-cell cavity below the lid and above a surface comprising the active surface and the fanout regions.

2. The method of claim 1, further comprising:

forming the package, the forming the package comprising:

orienting the die on the first adhesive; and

forming the fanout regions by orienting one or more support pieces on the first adhesive adjacent to at least two sides of the die, wherein the fanout regions comprise a portion of a top surface of the support pieces.

3. The method of claim 2, wherein the one or more support pieces comprise two support pieces, and wherein the orienting the one or more support pieces on the first adhesive adjacent to

the at least two sides of the die comprises placing two support pieces adjacent to the die on opposing sides of the die.

4. The method of claim 2, wherein the one or more support pieces comprise one support piece, wherein the one support piece comprises a cutout, and wherein the orienting the one or more support pieces on the first adhesive adjacent to the at least two sides of the die comprises orienting the one support piece such that the die and electrical contacts are within the cutout.

5. The method of claim 1, wherein the package comprises a cured electronic molded compound (EMC) material molded around portions of the die, wherein a portion of the EMC material comprises the fanout regions.

6. A flow cell, comprising:

a substrate comprising electrical contacts on a top surface, wherein the electrical contacts on the top surface of the substrate are connected to electrical contact points on a top surface of a die;

a first cured adhesive, wherein the first cured adhesive is joined to a package, the package comprising:

the die, wherein the top surface of the die further comprises an active surface; and

fanout regions comprising surfaces adjacent at least two opposing sides of the active surface, the fanout regions at least partially defining a fluidic path of the flow cell;

a second cured adhesive, wherein the second cured adhesive joins a portion of a top surface of the package to a lid defining a fluidic flow-cell cavity below the lid and above a surface comprising the active surface and the fanout regions; and

the lid.

7. The flow cell of claim 6, wherein the package further comprises:

one or more support pieces adjacent to the at least two opposing sides of the active surface of the die, wherein the one or more support pieces comprise the fanout regions.

8. The flow cell of claim 7, wherein the one or more support pieces comprise two support pieces oriented on the at least two opposing sides of the active surface of the die.

9. The flow cell of claim 7, wherein the one or more support pieces comprise one support piece, wherein the one support piece comprises a cutout, wherein the die and the electrical contacts on the top surface of the substrate are oriented within the cutout.

10. The flow cell of claim 6, wherein the package further comprises:

a cured electronic molded compound (EMC) material molded around portions of the die;

a portion of the EMC material forming EMC material surfaces adjacent to the active surface on the at least two opposing sides of the active surface; and

a portion of the EMC material surfaces comprise the fanout regions.

11. The method of any one of claims 1-4, wherein the forming the fanout regions further comprises: dispensing a material to fill gaps between the one or more support pieces and the die.

12. The method of any one of claims 1-4, wherein the one or more support pieces comprise a material selected from the group consisting of: glass, silicon, and ceramic.

13. The method of claim 1, wherein the package comprises a cured electronic molded compound (EMC) material molded around portions of the die, and a layer deposited on the EMC material surfaces adjacent to the active surface on the at least two opposing sides of the active surface, and the fanout regions comprise portions of the layer.

14. The method of claim 13, further comprising:

forming the package, wherein the forming the package comprises:

curing the EMC material around portions of the die.

15. The method of claim 14, wherein forming the package further comprises:

planarizing the EMC material surfaces adjacent to the active surface.

16. The method of claim 15, wherein the planarizing comprises:

depositing the layer on a surface comprising the top surface of the die and the EMC material surfaces adjacent to the active surface;

opening the layer on the active surface; and

curing the layer.

17. The method of claim 16, wherein the layer comprises a photoresist.

18. The method of claim 16, wherein a technique for opening the layer is selected from the group consisting of: lithography and lithography plus lift-off.

19. The method of any of claims 4 or 13-18, wherein the package further comprises vias embedded in the EMC material.

20. The method of claim 19, wherein forming the package further comprises:

prior to the curing of the EMC material around portions of the die, embedding the vias in the EMC material.

21. The method of claim 19 or 20, wherein the vias are comprised of an electrically conductive material.

22. The method of claim 21, wherein the electrically conductive material is selected from the group consisting of: copper, gold, tungsten, and aluminum.

23. The method of any of claims 19-22, wherein the vias extend through the EMC material from a surface of the die opposing the active surface in a direction opposing the active surface.

24. The method of any one of claims 1-5 or 11-24, wherein connecting the electrical contacts on the top surface of the substrate to the electrical contact points on the die, comprises wire-bonding the electrical contacts to the electrical contact points.

25. The method of claim 24, further comprising: encasing the wire-bonded connections with an epoxy.

26. The method of any one of claims 1-5 or 11-25, further comprising: curing the first adhesive and the second adhesive.

27. The method of claim 26, wherein the curing is selected from the group consisting of: thermally curing and ultraviolet (UV) curing.

28. The method of any one of claims 1-5 or 11-27, wherein the substrate is a printed circuit board.

29. The method of any one of claims 1-5 or 11-28, wherein the substrate comprises a material selected from the group consisting of: a glass-reinforced epoxy laminate material, FR4, and co-fired ceramic sheets.

30. The method of any one of claims 1-5 or 11-29, wherein the substrate further comprises electrical contacts on a bottom surface of the substrate, wherein the electrical contacts on a bottom surface of the substrate are electrically coupled to the electrical contacts on the top surface of the substrate by vias formed through the substrate.

31. The method of any one of claims 1-5 or 11-30, further comprising:

forming a heating element in the substrate.

32. The method of claim 31, wherein forming the heating element comprises:

placing one or more resistors on one or more of the top surface of the substrate and the bottom surface of the substrate; and

coupling the one or more resistors, via the vias, to a metal plane in the substrate.

33. The method of claim 31, wherein the heating element comprises a long wound metal trace, and wherein forming the heating element comprises:

forming the heating element in the substrate to function as a resistive heater.

34. The method of any one of the claims 1-5 or 11-33, wherein applying the second adhesive further comprises applying the second adhesive to a portion of the die.

35. The method of any one of claims 1-5 or 11-34, wherein the die is a complementary metal–oxide–semiconductor.

36. The method any one of claims 1-5 or 11-34, wherein the lid comprises two apertures and each aperture defines one of an inlet or an outlet fluidic port.

37. The method of any one of claims 1-5 or 11-34, wherein the active surface of the die comprises nanowells.

38. The flow cell of claim 6, wherein the package comprises:

a cured electronic molded compound (EMC) material molded around portions of the die;

a layer deposited on the EMC material surfaces adjacent to the active surface on the at least two opposing sides of the active surface, wherein the fanout regions comprise portions of the layer.

39. The flow cell of claim 10 or claim 38, wherein the package further comprises vias embedded in the EMC material.

40. The flow cell of any one of claims 7-9, wherein the one or more support pieces comprise a material selected from the group consisting of: glass, silicon, and ceramic.

41. The flow cell of any one of claims 6-10 or 38-40, wherein the substrate further comprises electrical contacts on a bottom surface of the substrate, wherein the electrical contacts on a bottom surface of the substrate are electrically coupled to the electrical contacts on the top surface of the substrate by vias formed through the substrate.

42. The flow cell of any one of claims 6-10 or 38-41, the substrate further comprising a heating element.

43. The flow cell of claim 42, the heating element comprising:

one or more resistors on one or more of the top surface of the substrate and the bottom surface of the substrate;

a metal plane in the substrate; and

vias through the substrate coupling the one or more resistors to the metal plane in the substrate.

44. The flow cell of claim 42, the heating element comprising: a long wound metal trace in the substrate to function as a resistive heater.

45. The flow cell of any one of claims 6-10 or 38-44, wherein the lid comprises two apertures and each aperture defines one of an inlet or an outlet fluidic port.

46. The flow cell of any one of claims 6-10 or 38-45, wherein the top surface of the die comprises nanowells.

47. The flow cell any one of claims 6-10 or 38-46, wherein the substrate is a printed circuit board.

48. The flow cell of any one of claims 6-10 or 38-47, wherein the substrate comprises a material selected from the group consisting of: a glass-reinforced epoxy laminate material, FR4, and co-fired ceramic sheets.

49. The flow cell of any one of claims 6-10 or 38-48, wherein the die is a complementary metal–oxide–semiconductor.

50. A method of forming a flow cell, comprising:

applying a first adhesive to a substrate, wherein a top surface of the substrate comprises electrical contacts;

orienting a die on the first adhesive, wherein a top surface of the die comprises an active surface and electrical contact points;

forming fanout regions for utilization in a fluidic path of the flow cell, wherein the forming the fanout regions comprises orienting one or more support pieces on the first adhesive adjacent to at least two sides of the die, wherein a portion of a top surface of the support pieces on the at least two sides of the die comprise the fanout regions;

connecting the electrical contacts on the top surface of the substrate to electrical contact points on the die;

applying a second adhesive to a portion of the one or more support pieces; and

attaching a lid to the second adhesive, wherein the attaching defines a fluidic flow-cell cavity below the lid and above a surface comprising the active surface and the fanout regions.

51. The method of claim 50, wherein the one or more support pieces comprise two support pieces, and wherein orienting the one or more support pieces on the first adhesive adjacent to the at least two sides of the die comprises placing two support pieces adjacent on opposing sides of the die.

52. The method of claim 50, wherein the one or more support pieces comprise one support piece, wherein the one support piece comprises a cutout, and wherein orienting the one or more support pieces on the first adhesive adjacent to the at least two sides of the die comprises orienting the one support piece such that the die and electrical contacts are within the cutout.

53. The method of any one of claims 50-52, wherein the lid comprises two apertures and each aperture defines one of an inlet or an outlet fluidic port.

54. The method of any one of claims 50-53, wherein the active surface of the die comprises nanowells.

55. The method of any of one of claims 50-54, wherein the forming the fanout regions further comprises: dispensing a material to fill gaps between the one or more support pieces and the die.

56. The method of any one of claims 50-55, wherein connecting the electrical contacts on the top surface of the substrate to the electrical contact points on the die, comprises wire-bonding the electrical contacts to the electrical contact points.

57. The method of claim 56, further comprising: securing the wire-bonded connections with an epoxy.

58. The method of any one of claims 50-57, further comprising: curing the first adhesive and the second adhesive.

59. The method of claim 58, wherein the curing is selected from the group consisting of: thermally curing and ultraviolet (UV) curing.

60. The method of any one of claims 50-59, wherein the substrate is a printed circuit board.

61. The method of any one of claims 50-60, wherein the substrate comprises a material selected from the group consisting of: a glass-reinforced epoxy laminate material, FR4, and co-fired ceramic sheets.

62. The method of any one of claims 50-61, wherein the one or more support pieces comprise a material selected from the group consisting of: glass, silicon, and ceramic.

63. The method of any one of claims 50-62, wherein the substrate further comprises electrical contacts on a bottom surface of the substrate, wherein the electrical contacts on a bottom surface of the substrate are electrically coupled to the electrical contacts on the top surface of the substrate by vias formed through the substrate.

64. The method of any one of claims 50-63, further comprising:

forming a heating element in the substrate.

65. The method of claim 64, wherein forming the heating element comprises:

placing one or more resistors on one or more of the top surface of the substrate and the bottom surface of the substrate; and

coupling the one or more resistors, via the vias, to a metal plane in the substrate.

66. The method of claim 64, wherein forming the heating element comprises:

implementing a long wound metal trace in the substrate to function as a resistive heater.

67. The method of any one or claims 64-66, further comprising:

utilizing the heating element to heat the substrate.

68. The method of any one of claims 50-67, wherein the die is a complementary metal–oxide–semiconductor.

69. The method of any one of the claims 50-68, wherein applying the second adhesive further comprises applying the second adhesive to a portion of the die.

70. A flow cell, comprising:

a substrate comprising electrical contacts on a top surface, wherein the electrical contacts on the top surface of the substrate are connected to electrical contact points on a top surface of a die;

a first cured adhesive, wherein the first cured adhesive joins the die and one or more support pieces adjacent to at least two sides of the die, to the substrate, wherein at least a portion of the top surface of the die and at least a portion of a top surface of the one or more support pieces, form a surface that is utilized in a fluidic path of the flow cell;

a second cured adhesive, wherein the second cured adhesive joins areas of the one or more support pieces and areas of the top surface of the die proximate to the surface that is utilized in the fluidic path of the flow cell, to a lid; and

the lid, wherein a fluidic flow-cell cavity is defined above the surface that is utilized in the fluidic path of the flow cell and below the lid.

71. The flow cell of claim 70, wherein the one or more support pieces comprise two support pieces oriented on opposing sides of the die.

72. The flow cell of claim 70, wherein the one or more support pieces comprise one support piece, wherein the one support piece comprises a cutout, wherein the die and the electrical contacts on the top surface of the substrate are oriented within the cutout.

73. The flow cell of any one of claims 70-72, wherein the lid comprises two apertures and each aperture defines one of an inlet or an outlet fluidic port.

74. The flow cell of any one of claims 70-73, wherein the top surface of the die comprises nanowells.

75. The flow cell of any one of claims 70-74, wherein the substrate is a printed circuit board.

76. The flow cell of any one of claims 70-73, wherein the substrate comprises a material selected from the group consisting of: a glass-reinforced epoxy laminate material, FR4, and co-fired ceramic sheets.

77. The flow cell of any one of claims 70-76, wherein the one or more support pieces comprise a material selected from the group consisting of: glass, silicon, and ceramic.

78. The flow cell of any one of claims 70-77, wherein the substrate further comprises electrical contacts on a bottom surface of the substrate, wherein the electrical contacts on a bottom surface of the substrate are electrically coupled to the electrical contacts on the top surface of the substrate by vias formed through the substrate.

79. The flow cell of any one of claims 70-78, the substrate further comprising a heating element.

80. The flow cell of claim 79, the heating element comprising:

one or more resistors on one or more of the top surface of the substrate and the bottom surface of the substrate;

a metal plane in the substrate; and

vias through the substrate coupling the one or more resistors to the metal plane in the substrate.

81. The flow cell of claim 79, the heating element comprising: a long wound metal trace in the substrate to function as a resistive heater.

82. The flow cell of any one of claims 70-81, wherein the die is a complementary metal–oxide–semiconductor.

83. A method of forming a flow cell, comprising:

applying a first adhesive to a substrate, wherein a top surface of the substrate comprises electrical contacts;

orienting a die on the first adhesive, wherein a top surface of the die comprises an active surface and electrical contact points;

forming fanout regions for utilization in a fluidic path of the flow cell, wherein the forming of the fanout regions comprises:

orienting two support pieces on the first adhesive on opposing sides of the die, each of the two support pieces adjacent to the die, wherein the top surface of the die and top surfaces of the two support pieces form an upper surface; and

dispensing a material to fill gaps between the two support pieces and the die;

connecting the electrical contacts on the top surface of the substrate to electrical contact points on the die;

applying a second adhesive to a portion of the one or more support pieces and a portion of the die; and

attaching a lid to the second adhesive, wherein the attaching defines a fluidic flow-cell cavity below the lid and above the upper surface.

84. A method of forming a flow cell, comprising:

applying a first adhesive to a substrate, wherein a top surface of the substrate comprises electrical contacts;

orienting a die on the first adhesive, wherein a top surface of the die comprises an active surface and electrical contact points;

forming fanout regions for utilization in a fluidic path of the flow cell, wherein the forming the fanout regions comprises:

orienting a support piece on the first adhesive, wherein the support piece comprises a cutout, and wherein the orienting comprises placing the support piece on the first adhesive such that the die and electrical contacts are positioned within the cutout, wherein the fanout regions comprise portions of a top surface of the support piece on opposing sides of the die, and wherein the portions of the top surface and the active surface form an upper surface;

connecting the electrical contacts on the top surface of the substrate to electrical contact points on the die with bond wires; and

dispensing a second adhesive into the cutout such that the second adhesive fills spaces in the cutout between the die and the support piece and encapsulates the bond wires;

applying a third adhesive to a portion of the support piece and a portion of the die; and

attaching a lid to the third adhesive, wherein the attaching defines a fluidic flow-cell cavity below the lid and above the upper surface.

85. A method of forming a flow cell, comprising:

applying a first adhesive to a substrate, wherein a top surface of the substrate comprises electrical contacts;

orienting a package comprising a cured electronic molded compound (EMC) material molded around portions of a die, wherein a top surface of the die comprises an active surface and electrical contact points, and a portion of the EMC material forms EMC material surfaces adjacent to the active surface on at least two opposing sides of the active surface;

connecting the electrical contacts on the top surface of the substrate to electrical contact points on the die;

applying a second adhesive to a portion of a top surface of the package; and

attaching a lid to the second adhesive, wherein the attaching defines a fluidic flow-cell cavity below the lid and above a surface comprising the active surface and fanout regions for utilization in a fluidic path of the flow cell, the fanout regions comprising another portion of the top surface of the package.

86. The method of claim 85, wherein the fanout regions are comprised of the EMC material surfaces adjacent to the active surface on the at least two opposing sides of the active surface.

87. The method of claim 85, wherein the package further comprises a layer deposited on the EMC material surfaces adjacent to the active surface on the at least two opposing sides of the active surface, and the fanout regions comprise portions of the layer deposited on the EMC material surfaces adjacent to the active surface on the at least two opposing sides of the active surface.

88. The method of any one of claims 85-87, wherein the lid comprises two apertures and each aperture defines one of an inlet or an outlet fluidic port.

89. The method of any one of claims 85-88, wherein the active surface of the die comprises nanowells.

90. The method of any one of claims 85-89, wherein connecting the electrical contacts on the top surface of the substrate to the electrical contact points on the die comprises wire-bonding the electrical contacts to the electrical contact points.

91. The method of claim 90, further comprising: securing the wire-bonded connections with an epoxy.

92. The method of any one of claims 85-91, further comprising: curing the first adhesive and the second adhesive.

93. The method of claim 92, wherein the curing is selected from the group consisting of: thermally curing and ultraviolet (UV) curing.

94. The method of any one of claims 85-93, wherein the substrate is a printed circuit board.

95. The method of any one of claims 85-94, wherein the substrate comprises a material selected from the group consisting of: a glass-reinforced epoxy laminate material, FR4, and co-fired ceramic sheets.

96. The method of any one of claims 85-95, wherein the substrate further comprises electrical contacts on a bottom surface of the substrate, wherein the electrical contacts on a bottom surface of the substrate are electrically coupled to the electrical contacts on the top surface of the substrate by vias formed through the substrate.

97. The method of any one of claims 85-96, further comprising:

forming a heating element in the substrate.

98. The method of claim 97, wherein forming the heating element comprises:

placing one or more resistors on one or more of the top surface of the substrate and the bottom surface of the substrate; and

coupling the one or more resistors, via the vias, to a metal plane in the substrate.

99. The method of claim 97, wherein forming the heating element comprises:

implementing a long wound metal trace in the substrate to function as a resistive heater.

100. The method of any one or claims 97-99, further comprising:

utilizing the heating element to heat the substrate.

101. The method of any one of claims 85-100, wherein the die is a complementary metal–oxide–semiconductor.

102. The method of claim 85, further comprising:

forming the package, wherein forming the package comprises:

curing the EMC material around portions of the die.

103. The method of claim 102, wherein forming the package further comprises:

planarizing the EMC material surfaces adjacent to the active surface.

104. The method of claim 103, wherein the planarizing comprises:

depositing the layer on a package surface comprising the top surface of the die and the EMC material surfaces adjacent to the active surface;

opening the layer on the active surface; and

curing the layer.

105. The method of claim 104, wherein the layer comprises a photoresist.

106. The method of claim 104, wherein a technique for opening the layer is selected from the group consisting of: lithography and lithography plus lift-off.

107. The method of any of claims 85-106, wherein the package further comprises vias embedded in the EMC material.

108. The method of claim 107, wherein forming the package further comprises:

prior to the curing of the EMC material around portions of the die, embedding the vias in the EMC material.

109. The method of claim 107 or 108, wherein the vias are comprised of an electrically conductive material.

110. The method of claim 109, wherein the electrically conductive material is selected from the group consisting of: copper, gold, tungsten, and aluminum.

111. The method of any of claims 107-109, wherein the vias extend through the EMC material from a surface of the die opposing the active surface in a direction opposing the active surface.

112. A flow cell, comprising:

a substrate comprising electrical contacts on a top surface, wherein the electrical contacts on the top surface of the substrate are connected to electrical contact points on a top surface of a die;

a first cured adhesive, wherein the first cured adhesive joins a package comprising a cured electronic molded compound (EMC) material molded around portions of a die, wherein a top surface of the die is exposed and comprises an active surface and the electrical contact points, and a portion of the EMC material forms EMC material surfaces adjacent to the active surface on at least two opposing sides of the active surface, wherein a portion of the EMC material surfaces comprise fanout regions for utilization in a fluidic path;

a second cured adhesive, wherein the second cured adhesive joins a portion of a top surface of the package to a lid defining a fluidic flow-cell cavity below the lid and above a surface comprising the active surface and the fanout regions; and

the lid.

113. The flow cell of claim 112, wherein the package further comprises vias embedded in the EMC material.

114. The flow cell of claim 112 or claim 113, wherein the lid comprises two apertures and each aperture defines one of an inlet or an outlet fluidic port.

115. The flow cell of any one of claims 112-114, wherein the top surface of the die comprises nanowells.

116. The flow cell of any one of claims 112-115, wherein the substrate is a printed circuit board, and wherein the die is a complementary metal–oxide–semiconductor.

117. The flow cell of any one of claims 112-116, wherein the substrate comprises a material selected from the group consisting of: a glass-reinforced epoxy laminate material, FR4, and co-fired ceramic sheets.

118. The flow cell of any one of claims 112-117, wherein the substrate further comprises electrical contacts on a bottom surface of the substrate, wherein the electrical contacts on a bottom surface of the substrate are electrically coupled to the electrical contacts on the top surface of the substrate by vias formed through the substrate.

119. The flow cell of any one of claims 112-118, the substrate further comprising a heating element.

120. The flow cell of claim 119, the heating element comprising:

one or more resistors on one or more of the top surface of the substrate and the bottom surface of the substrate;

a metal plane in the substrate; and

vias through the substrate coupling the one or more resistors to the metal plane in the substrate.

121. The flow cell of claim 119, the heating element comprising: a long wound metal trace in the substrate to function as a resistive heater.

122. A flow cell, comprising:

a substrate comprising electrical contacts on a top surface, wherein the electrical contacts on the top surface of the substrate are connected to electrical contact points on a top surface of a die;

a first cured adhesive, wherein the first cured adhesive joins a package comprising a cured electronic molded compound (EMC) material molded around portions of the die, wherein a top surface of the die is exposed and comprises an active surface and the electrical contact points, and a portion of the EMC material forms EMC material surfaces adjacent to the active surface on at least two opposing sides of the active surface, wherein a layer is planarizing the EMC material surfaces, wherein a portion of the EMC material surfaces planarized by the layer comprise fanout regions for utilization in a fluidic path;

a second cured adhesive, wherein the second cured adhesive joins a portion of a top surface of the package to a lid defining a fluidic flow-cell cavity below the lid and above a surface comprising the active surface and the fanout regions; and

the lid.

123. The flow cell of claim 122, wherein the package further comprises vias embedded in the EMC material.

124. The flow cell of claim 122 or claim 123, wherein the lid comprises two apertures and each aperture defines one of an inlet or an outlet fluidic port.

125. The flow cell of any one of claims 122-124, wherein the top surface of the die comprises nanowells.

126. The flow cell of any one of claims 122-125, wherein the substrate is a printed circuit board.

127. The flow cell of any one of claims 122-126, wherein the substrate comprises a material selected from the group consisting of: a glass-reinforced epoxy laminate material, FR4, and co-fired ceramic sheets.

128. The flow cell of any one of claims 122-127, wherein the substrate further comprises electrical contacts on a bottom surface of the substrate, wherein the electrical contacts on a bottom surface of the substrate are electrically coupled to the electrical contacts on the top surface of the substrate by vias formed through the substrate.

129. The flow cell of any one of claims 122-128, the substrate further comprising a heating element.

130. The flow cell of claim 129, the heating element comprising:

one or more resistors on one or more of the top surface of the substrate and the bottom surface of the substrate;

a metal plane in the substrate; and

vias through the substrate coupling the one or more resistors to the metal plane in the substrate.

131. The flow cell of claim 129, the heating element comprising: a long wound metal trace in the substrate to function as a resistive heater.

132. The flow cell of any one of claims 122-131, wherein the die is a complementary metal–oxide–semiconductor.