We Claim:

1. A sperm sorting system comprising:

a sample source;

a substrate;

at least one flow channel formed in the substrate, the flow channel having an inlet in fluid communication with the sample source, the flow channel further comprising an inspection region, a first outlet, and second outlet;

at least one diverting mechanism in communication with each of the at least one flow channels to selectively divert sperm in the at least one flow channel away from the first outlet;

an electromagnetic radiation source for illuminating sperm at the inspection region;

a detector aligned to measure sperm characteristics in the inspection region of the at least one flow channel;

an analyzer in communication with the detector to determine sperm characteristics;

a controller in communication with the analyzer for selectively activating the diverting mechanism based on measured sperm characteristics; and

a collection vessel in communication with the second outlet.

2. The system of claim 1, wherein the at least one flow channel comprises multiple flow channels formed on a microfluidic chip.

3. The system of claim 2, wherein the multiple flow channels comprises between 4 and 512 flow channels.

4. The system of claim 2, wherein either sperm characterized as viable X-chromosome bearing sperm or sperm characterized as viable Y-chromosome bearing sperm are deflected to the second outlet of each flow channel.

5. The system of claim 4, wherein the collection vessel comprises a common collection vessel in fluid communication with the second outlet of one or more flow channels.

6. The system of claim 1, wherein each flow channel further comprises a third outlet.

7. The system of claim 6, wherein the sperm cells characterized as viable X-chromosome bearing sperm are diverted to one of the second outlet or the third outlet and sperm characterized as viable Y-chromosome bearing sperm are diverted to other of the second outlet and the third outlet.

8 The system of claim 6, wherein each second outlet of the flow channels are connected to a first common collection vessel.

9. The system of claim 6, wherein each third outlet of the flow channels are connected to a second common collection vessel.

10. The system of claim 1, further comprising a passive collection vessel in communication with the first outlet.

11. The system of claim 1, further comprising a sheath source, and wherein the flow channel further comprises a sheath inlet in fluid communication with the sheath source.

12. The system of claim 11, further comprising a sheath fluid recycling system comprising:

a transport mechanism in fluid communication with the passive collection vessel;

a fluid path connecting the passive collection vessel to the sheath source; and

a particle concentrating device or a fluid removing system in the fluid path connecting the passive collection vessel to the sheath source.

13. The system of claim 1, wherein the at least one flow channel comprises multiple flow channels formed on a microfluidic chip and wherein at least a portion of the diverting mechanism is embedded within the microfluidic chip.

14. The system of claim 1, wherein the at least one flow channel comprises multiple flow channels formed on a microfluidic chip and wherein at least a portion of the diverting mechanism is positioned on the exterior of the microfluidic chip.

15. The system of claim 1, wherein the diverting mechanism comprises a side passage in fluid communication with the flow channel and in fluid communication a volume of fluid through a flexible interface.

16. The system of claim 15, wherein the fluid comprises one selected from the group consisting of: a gel, a liquid, and a gas.

17. The system of claim 15, further comprising an actuator contacting a portion of the flexible interface, wherein the actuator is in communication with the controller.

18. The system of claim 17, wherein the actuator is movable between a resting position and two or more activation positions while maintaining contact with the flexible interface.

19. The system of claim 18, further comprising a third outlet and wherein particles passively flow to the second outlet and wherein actuator movement between the resting position and the first active position diverts particles to the first outlet and wherein actuator movement between the resting position and the second active position diverts particles to a third outlet.

20. The system of claim 18, wherein the actuator is attached to the flexible interface.

21. The system of claim 18, wherein the actuator is preloaded onto the flexible interface.

22. The system of claim 15, further comprising a bimorph piezoelectric element.

23. The system of claim 22, wherein the bimorph piezoelectric element comprises the flexible interface.

24. The system of claim 22, wherein the bimorph piezoelectric element contacts the flexible interface.

25. The system of claim 22, wherein the bimorph piezoelectric element is configured for deflection in two directions to divert sperm in the flow channel two directions.

26. The system of claim 1, wherein the diverting mechanism comprises a transducer coupled to the flow channel.

27. The system of claim 26, wherein the transducer comprises an ultrasonic transducer for diverting particles in the flow channel.

28. The system of claim 27, wherein the ultrasonic transducer comprise an array of ultrasonic transducers and further comprising a driving element which times the activation of each transducer in the array to achieve the desired deflection.

29. The system of claim 28, comprising a second array of ultrasonic transducers, wherein each array of ultrasonic transducers is located on opposite sides of the flow channel.

30. The system of claim 28, wherein the array of ultrasonic transducers a configured to produce multiple standing waves.

31. The system of claim 28, wherein the array of ultrasonic transducers are configured to maintain the trajectory of a sperm cell in the flow path towards the first outlet, deflect the trajectory of a sperm cell in a flow path towards the second outlet, or deflect the trajectory of a sperm cell in a flow path towards a third outlet.

32. The system of claim 26, wherein the transducer is at least partially embedded in the substrate adjacent to the flow channel.

33. The system of claim 26, wherein the transducer is placed in contact with an exterior surface of the substrate.

34. The system of claim 1, further comprising one or more sources of electromagnetic radiation for deflecting sperm in the flow channel.

35. The system of claim 1, further comprising beam shaping optics for manipulating electromagnetic radiation produced from the electromagnetic radiation source to inspect sperm at each inspection region of the at least one flow channel.

36. The system of claim 35, wherein the at least one flow channel comprises a plurality of flow channels, and wherein the beam shaping optics comprise a beam splitting device for directing substantially equivalent beams to the inspection region of each of the plurality of flow channels.

37. The system of claim 36, wherein the beam splitting device comprises a reflective surface or refractive material for reflecting potions of the beam profile as beam segments or for dividing a beam intensity among beams having the same profile.

38. The system of claim 35, wherein the beam shaping optics further comprise a beam shaping optics for establishing a top hat beam profile.

39. The system of claim 1, wherein each flow channel has an associated reflective surface or an associated refractive element that redirects a side fluorescence produced by sperm in the flow channel.

40. The system of claim 39, wherein the associated reflective surface or associated refractive element redirects a side fluorescence in a direction substantially parallel to a first fluorescence.

41. The system of claim 39, wherein the first fluorescence comprises a forward fluorescence.

42. The system of claim 39, wherein the first fluorescence comprises a back fluorescence.

43. The system of claim 39, wherein the reflective surface is formed by a surface on the substrate.

44. The system of claim 39, wherein the reflective surface is formed by a surface of the flow channel.

45. The system of claim 39, wherein each flow channel is separated by a light blocking element.

46. The system of claim 39, wherein the reflective surface further comprises a reflective element embedded in the substrate.

47. The system of claim 39, wherein the reflective surface comprises an exterior surface of the substrate formed by cutaway portion adjacent to the inspection region, wherein the refractive index difference in the cutaway portion provides a reflective property.

48. The system of claim 47, wherein the cutaway portion provides a reflective surface at about 45 degrees relative to the surface of the substrate and/or the desired plane or orientation of the sperm.

49. The system of claim 47, further comprising a second reflective surface comprising a second exterior surface of the substrate formed by a second cutaway portion adjacent to the inspection region for producing a second side fluorescence.

50. The system of claim 1, wherein the detector comprises a forward fluorescence detector.

51. The system of claim 50, further comprising a first side fluorescence detector.

52. The system of claim 51, further comprising a second side fluorescence detector.

53. The system of claim 52, wherein the first and the second side fluorescence detectors are located about 90 degrees apart.

54. The system of claim 51, further comprising an array of first side fluorescence detectors of measuring a first side fluorescence value in each of a plurality of flow channels and an array of second side fluorescence detectors.

55. The system of claim 1, further comprising collection optics for collecting fluorescence from one or more flow channels.

56. The system of claim 55, wherein the collection optics comprise a single collection lens for collecting fluorescence from multiple channels.

57. The system of claim 55, further comprising an array of lens for collecting fluorescence from each flow channel.

58. The system of claim 55, further comprising a fiber array for collecting fluorescence from each flow channel.

59. The system of claim 55, further comprising epi-illumination forward collection optics.

60. The system of claim 59, further comprising a dichroic mirror positioned to reflect electromagnetic radiation from the electromagnetic radiation source onto the inspection region and through which fluorescence emissions in the back direction travel to a detector.

61. The system of claim 1, wherein the flow channel comprises fluid focusing features.

62. The system of claim 61, wherein the fluid focusing features of the flow channel further comprises: a core stream forming geometry.

63. The system of claim 62, wherein the core stream forming geometry further comprises:

a lateral fluid focusing region;

a first vertical fluid focusing component; and

a second vertical fluid focusing component.

64. The system of claim 63, wherein the first vertical fluid focusing component comprises a first vertical fluid focusing channel and the second vertical fluid focusing component comprises a second vertical fluid focusing channel.

65. The system of claim 64, wherein the first vertical fluid focusing channel and the second vertical fluid focusing channel are in communication with the flow channel in opposite vertical positions.

66. The system of claim 64, wherein the first vertical fluid focusing channel provides a first vertical influence and wherein the second vertical fluid focusing channel provides a second vertical influence in the opposite direction as the first vertical influence.

67. The system of claim 61, wherein the fluid focusing features of the flow channel further comprises: transducers for producing pressure waves in each flow channel.

68. The system of claim 67, wherein the at least one set of transducers are positioned symmetrically to each other with a surface perpendicular to the desired orientation of sperm.

69. The system of claim 68, further comprising a series of transducers for each flow channel.

70. The system of claim 69, wherein the series of transducers are configured to produce a standing pressure wave along the flow channel.

71. The system of claim 1, wherein the at least one flow channel comprises orienting features.

72. The system of claim 71, wherein the orienting features comprise an interior channel geometry dimensioned to orient sperm cells.

73. The system of claim 72, wherein the channel geometry further comprises a planar channel geometry.

74. The system of claim 72, wherein the channel geometry further comprises a nozzle geometry.

75. The system of claim 72, wherein the channel geometry further comprises one or more of the following channel features: a chevron, a gentle ramp, an abrupt ramp, a decompression-compression zone, a step, or one or more undulations.

76. The system of claim 71, wherein the orienting features further comprise: a magnet for producing a magnetic field in the orienting region of each flow channel.

77. The system of claim 1, wherein the flow channel further comprises a sheath inlet in fluid communication with the sheath source, and a sample inlet in fluid communication with the sample source, the sample inlet positioned within a sheath flow created by the sheath inlet to facilitate a co-axial flow of sheath and sample.

78. The system of claim 77, wherein the sample inlet comprises an inlet which is beveled, flattened, or has a rectangular cross-section.

79. The system of claim 77, wherein the flow channel comprises a first width and a first height at the sample inlet.

80. The system of claim 79, wherein the flow channel comprises a second width and a second height at a first transition point.

81. The system of claim 80, wherein the width of the flow channel is reduced between the sample inlet and the first transition point.

82. The system of claim 80, wherein the flow channel comprises a third width and a third height at a second transition point.

83. The system of claim 81, wherein the width remains constant between the first transition point and the second transition point and the height is reduced between the first transition point and the second transition point.

84. The system of claim 82, wherein the third height and the third width are maintained through the inspection region.

85. The system of claim 82, wherein the flow channel transitions from square cross section to a rectangular cross section.

86. The system of claim 82, wherein the flow channel transitions from a circular cross section to an elliptical cross section.

87. The system of claim 1, further comprising at least one mask.

88. The system of claim 87, wherein the at least one mask comprises an illumination mask positioned in the path of electromagnetic radiation directed to the inspection region.

89. The system of claim 88, wherein the illumination mask comprises a first region and a second region along the flow path.

90. The system of claim 89, wherein the first region provides an opening configured to produce a sufficient waveform pulse to differentiate viable X-chromosome bearing sperm from viable Y-chromosome bearing sperm, when orientated.

91. The system of claim 89, wherein the second region comprises a series of openings configured to produce a series of waveform pulses which differentiate oriented sperm cells from unoriented sperm cells.

92. The system of claim 89, wherein the second region comprises a series of openings with differing transverse profiles along the flow path.

93. The system of claim 89, wherein the second region comprises a first spaced pair of openings followed by a second spaced pair of openings, wherein the spacing is differed between the first pair of openings and the second pair of openings.

94. The system of claim 92, wherein the second region comprises a sequential series of openings along the flow path, each opening having a different transverse position along the flow path.

95. The system of claim 88, wherein the at least one mask comprises at least one detection mask.

96. The system of claim 95, wherein a first detection mask is place in the path of emitted forward fluorescence and a second detection mask is placed in the path of emitted side fluorescence.

97. The system of claim 96, wherein the first detection mask and the second detection masks have differing profiles of slits, and wherein each mask is in communication with the same detector.

98. The system of claim 97, wherein the analyzer is in communication with the detector and is configured to deconvolve a first waveform pulses representing the forward fluorescence and a second waveform pulse representing the side fluorescence based on the profile of slits in each of the first detection mask and the second detection mask.

99. The system of claim 87, wherein the mask is positioned in free space.

100. The system of claim 87, wherein the mask is located on the substrate.

101. The system of claim 1, wherein the detector comprises a first detector and the system further comprises a second detector.

102. The system of claim 101, wherein the first detector comprises an absorption detector and the second detector comprises a fluorescence detector.

103. The system of claim 102, further comprises a neutral density filter in the light path of the absorption detector.

104. A microfluidic chip for sorting sperm comprising:

a substrate;

a plurality of flow channels formed in the substrate, each flow channel comprising;

an inlet;

a fluid focusing region having an associated fluid focusing feature for aligning sperm cells within the flow channel;

a sperm orienting region having an associated sperm orienting feature for orienting sperm cells within the flow channel;

an inspection region at least partially downstream of the fluid focusing region and the sperm orienting region;

at least a first outlet and a second outlet; and

a diverting mechanism in communication with each flow channel.

105. The microfluidic chip of claim 104, wherein the fluid focusing features of the flow channel focusing region further comprises: a core stream forming geometry.

106. The microfluidic chip of claim 104, wherein the core stream forming geometry further comprises:

a lateral fluid focusing region;

a first vertical fluid focusing component; and

a second vertical fluid focusing component.

107. The microfluidic chip of claim 106, wherein the first vertical fluid focusing component comprises a vertical fluid focusing channel and the second vertical fluid focusing component comprises a second vertical fluid focusing channel.

108. The microfluidic chip of claim 107, wherein the first vertical fluid focusing channel and the second vertical fluid focusing channel are in communication with the fluid focusing region in opposite vertical positions.

109. The microfluidic chip of claim 107, wherein the first fluid vertical focusing channel provides a first vertical influence and wherein the second vertical fluid focusing channel provides a second vertical influence in the opposite direction as the first vertical influence.

110. The microfluidic chip of claim 104, wherein the fluid focusing feature of the fluid focusing region further comprises: ultrasonic transducers for producing pressure waves in the focusing region of each flow channel.

111. The microfluidic chip of claim 104, wherein the fluid focusing feature of the fluid focusing region further comprise an array of ultrasonic transducer for producing a standing pressure wave along the flow channel.

112. The microfluidic chip of claim 107, wherein the sperm orienting feature of the flow channel orienting region further comprises: a channel geometry.

113. The microfluidic chip of claim 112, wherein the channel geometry further comprises a planar channel geometry.

114. The microfluidic chip of claim 112, wherein the channel geometry further comprises a nozzle geometry.

115. The microfluidic chip of claim 112, wherein the channel geometry further comprises one or more of the following channel features: a chevron, a gentle ramp, a decompression-compression zone, an abrupt ramp, or a step.

116. The microfluidic chip of claim 104, wherein the sperm orienting features of the sperm orienting region further comprise: a magnet for producing a magnetic field in the orienting region of each flow channel.

117. The microfluidic chip of claim 104, wherein the sperm orienting features of the sperm orienting region further comprise an array of ultrasonic transducer for producing a standing pressure wave along the flow channel.

118. The microfluidic chip of claim 104, wherein the diverting mechanism comprises a bubble valve.

119. The microfluidic chip of claim 104, wherein the diverting mechanism comprises an array of ultrasonic transducers.

120. The microfluidic chip of claim 104, wherein each flow channel has an associated reflective surface or refractive element that redirects a side fluorescence produced by sperm in the flow channel.

121. The microfluidic chip of claim 120, wherein the associated reflective surface redirects a side fluorescence in a direction substantially parallel to a first fluorescence.

122. The microfluidic chip of claim 121, wherein the first fluorescence comprises a forward fluorescence.

123. The microfluidic chip of claim 121, wherein the first fluorescence comprises a back fluorescence.

124. The microfluidic chip of claim 121, wherein the reflective surface is formed as a surface on the substrate.

125. The microfluidic chip of claim 121, wherein the reflective surface is formed as a surface of the flow channel.

126. The microfluidic chip of claim 104, wherein the flow channel further comprises a sheath inlet in fluid communication with the sheath source, and wherein the sample inlet is positioned within a sheath flow created by the sheath inlet to facilitate a co-axial flow of sheath and sample.

127. The microfluidic chip of claim 126, wherein the sample inlet comprises a beveled inlet.

128. The microfluidic chip of claim 126, wherein the flow channel comprises a first width and a first height at the sample inlet.

129. The microfluidic chip of claim 128, wherein the flow channel comprises a second width and a second height at a first transition point.

130. The microfluidic chip of claim 129, wherein the width of the flow channel is reduced between the sample inlet and the first transition point.

131. The microfluidic chip of claim 129, wherein the flow channel comprises a third width and a third height at a second transition point.

132. The microfluidic chip of claim 131, wherein the width remains constant between the first transition point and the second transition point and the height is reduced between the first transition point and the second transition point.

133. The microfluidic chip of claim 132, wherein the third height and the third width are maintained through the inspection region.

134. The microfluidic chip of claim 132, wherein the fluid flow channel transitions from square cross section to a rectangular cross section.

135. The microfluidic chip of claim 132, wherein the flow channel transitions from a circular cross section to an elliptical cross section.

136. A method of sorting sperm comprising the steps of:

flowing sperm through a plurality of flow channels in a microfluidic chip;

orienting sperm within the plurality of flow channels;

flowing the oriented sperm through an inspection region in the flow channels;

interrogating sperm at the at least one inspection region to determine sperm characteristics;

differentiating oriented sperm from unoriented sperm in the flow channels;

selecting a subpopulation of oriented sperm based on the detected sperm characteristics; and

collecting the selected subpopulation of sperm in a collection vessel.

137. The method of claim 136, further comprising the steps of:

providing an electromagnetic radiation source;

manipulating electromagnetic radiation produced from the electromagnetic radiation source for inspecting multiple inspection regions.

138. The method of claim 137, wherein the step of manipulating electromagnetic radiation further comprises the steps of: splitting the electromagnetic radiation produced by the electromagnetic radiation source.

139. The method of claim 137, wherein the step of manipulating the electromagnetic radiation further comprises the step of: manipulating the shape of the beam profile of the electromagnetic radiation.

140. The method of claim 136, wherein the step of selecting a subpopulation of sperm based on the detected sperm characteristics further comprises the step of diverting the flow of a selected sperm within flow channel based on the detected sperm characteristics.

141. The method of claim 136, further comprising the step of differentiating oriented sperm from un-oriented sperm and excluding un-oriented sperm from selection.

142. The method of claim 136, further comprising the steps of:

generating a first signal with a forward fluorescence detector in response to emitted electromagnetic radiation of sperm at the inspection region, wherein the first signal comprises waveform pulses having detectable pulse characteristics.

143. The method of claim 142, further comprising the step of generating a second signal with a side fluorescence detector.

144. The method of claim 143, wherein the step of generating a second signal with a side fluorescence detector further comprises associating a reflective element with each flow channel for reflecting the side fluorescence outward and detecting the side fluorescence in parallel with a forward fluorescence.

145. The method of claim 144, further comprising the step of detecting the forward fluorescence through a first mask and the side fluorescence through a second mask.

146. The method of claim 145, further comprising the step of deconvolving a first waveform pulse and a second waveform pulse from signal produced by the detector.

147. The method of claim 146, wherein the deconvolved waveform pulse provide the sperm orientation.

148. The method of claim 136, further comprising the steps of generating a plurality of waveform pulses with a single detector in response to single sperm, wherein the plurality of waveform pulses provide orientation information about the sperm cell.

149. The method of claim 148, further comprising the step of measuring laser extinction to determine sperm orientation.

150. The method of claim 142, further comprising the steps of:

generating a second signal with a first side fluorescence detector, wherein the second signal comprises waveform pulses having detectable pulse characteristics; and

generating a third signal with a second side fluorescence detector, wherein the second signal comprises waveform pulses having detectable pulse characteristics.

151. The method of claim 150, wherein pulse characteristics of the second and third signals differentiated the orientation of sperm cells.

152. The method of claim 151, wherein the pulse characteristics are selected from the group consisting of: peak height, pulse width, pulse peak lag, pulse slope, pulse area, and combinations thereof.

153. The method of claim 150, further comprising the steps of comparing the pulse characteristics of the second signal to the pulse characteristics of the third signal to determine sperm orientation.

CLAIMS

1. A sperm sorting system comprising:

a substrate;

at least one flow channel formed in the substrate, the flow channel having a sample inlet that receives sample on a first plane, the flow channel further comprising: an inspection region, a first outlet, second outlet, and a core stream forming geometry, the core stream forming geometry further comprising: a lateral fluid focusing region on the same plane as the inlet, a first vertical fluid focusing component in fluid communication with the flow channel from a second plane above the plane of the sample inlet, and a second vertical fluid focusing component in fluid communication with the flow channel from a third plane below the plane of the sample inlet downstream of the first vertical focusing component in the flow channel;

at least one diverting mechanism in communication with the at least one flow channels to selectively divert sperm in the at least one flow channel away from the first outlet;

an electromagnetic radiation source for illuminating sperm at the inspection region;

a detector aligned to measure sperm characteristics in the inspection region of the at least one flow channel;

an analyzer in communication with the detector to determine sperm characteristics;

a controller in communication with the analyzer for selectively activating the diverting mechanism based on measured sperm characteristics; and

a collection vessel in communication with the second outlet.

2. The system of claim 1, wherein the at least one flow channel comprises multiple flow channels formed on a microfluidic chip.

3. The system of claim 2, wherein the multiple flow channels comprises between 4 and 512 flow channels.

4. The system of claim 2, wherein either sperm characterized as viable X-chromosome bearing sperm or sperm characterized as viable Y-chromosome bearing sperm are deflected to the second outlet of each flow channel.

5. The system of claim 4, wherein the collection vessel comprises a common collection vessel in fluid communication with the second outlet of multiple flow channels.

6. The system of claim 1, wherein each flow channel further comprises a third outlet.

7. The system of claim 6, wherein the sperm cells characterized as viable X-chromosome bearing sperm are diverted to one of the second outlet or the third outlet and sperm characterized as viable Y-chromosome bearing sperm are diverted to other of the second outlet and the third outlet.

8 The system of claim 6, wherein each second outlet of the flow channels are connected to a first common collection vessel.

9. The system of claim 6, wherein each third outlet of the flow channels are connected to a second common collection vessel.

10. The system of claim 1, further comprising a passive collection vessel in communication with the first outlet.

11. The system of claim 1, further comprising a sheath inlet that receives sheath fluid.

12. The system of claim 11, further comprising a sheath fluid recycling system comprising:

a transport mechanism in fluid communication with the passive collection vessel;

a fluid path providing fluid communication between the passive collection vessel and the sheath inlet source; and

a particle concentrating device or a fluid removing system in the fluid path connecting providing fluid communication between the passive collection vessel and the sheath inlet source.

13. The system of claim 1, wherein the at least one flow channel comprises multiple flow channels formed on a microfluidic chip and wherein at least a portion of the diverting mechanism is embedded within the microfluidic chip.

14. The system of claim 1, wherein the at least one flow channel comprises multiple flow channels formed on a microfluidic chip and wherein at least a portion of the diverting mechanism is positioned on the exterior of the microfluidic chip.

15. The system of claim 1, wherein the diverting mechanism comprises a side passage in fluid communication with the flow channel and in fluid communication with a volume of fluid through a flexible interface.

16. The system of claim 15, wherein the fluid comprises one selected from the group consisting of: a gel, a liquid, and a gas.

17. The system of claim 15, further comprising an actuator contacting a portion of the flexible interface, wherein the actuator is in communication with the controller.

18. The system of claim 17, wherein the actuator is movable between a resting position and two or more activation positions while maintaining contact with the flexible interface.

19. The system of claim 18, further comprising a third outlet and wherein particles passively flow to the second outlet and wherein actuator movement between the resting position and the first active position diverts particles to the first outlet and wherein

actuator movement between the resting position and the second active position diverts particles to a third outlet.

20. The system of claim 18, wherein the actuator is attached to the flexible interface.

21. The system of claim 18, wherein the actuator is preloaded onto the flexible interface.

22. The system of claim 15, further comprising a bimorph piezoelectric element.

23. The system of claim 22, wherein the bimorph piezoelectric element comprises the flexible interface.

24. The system of claim 22, wherein the bimorph piezoelectric element contacts the flexible interface.

25. The system of claim 22, wherein the bimorph piezoelectric element is configured for deflection in two directions to divert sperm in the flow channel two directions.

26. The system of claim 1, wherein the diverting mechanism comprises a transducer coupled to the flow channel.

27. The system of claim 26, wherein the transducer comprises an ultrasonic transducer for diverting particles in the flow channel.

28. The system of claim 27, wherein the ultrasonic transducer comprise an array of ultrasonic transducers and further comprising a driving element which times the activation of each transducer in the array to achieve the desired deflection.

29. The system of claim 28, comprising a second array of ultrasonic transducers, wherein each array of ultrasonic transducers is located on opposite sides of the flow channel.

30. The system of claim 28, wherein the array of ultrasonic transducers a configured to produce multiple standing waves.

31. The system of claim 28, wherein the array of ultrasonic transducers are configured to maintain the trajectory of a sperm cell in the flow path towards the first outlet, deflect the trajectory of a sperm cell in a flow path towards the second outlet, or deflect the trajectory of a sperm cell in a flow path towards a third outlet.

32. The system of claim 26, wherein the transducer is at least partially embedded in the substrate adjacent to the flow channel.

33. The system of claim 26, wherein the transducer is placed in contact with an exterior surface of the substrate.

34. The system of claim 1, further comprising one or more sources of electromagnetic radiation for deflecting sperm in the flow channel.

35. The system of claim 1, further comprising beam shaping optics for manipulating electromagnetic radiation produced from the electromagnetic radiation source to inspect sperm at each inspection region of the at least one flow channel.

36. The system of claim 35, wherein the at least one flow channel comprises a plurality of flow channels, and wherein the beam shaping optics comprise a beam splitting device for directing substantially equivalent beams to the inspection region of each of the plurality of flow channels.

37. The system of claim 36, wherein the beam splitting device comprises a reflective surface or refractive material for reflecting potions of the beam profile as beam segments or for dividing a beam intensity among beams having the same profile.

38. The system of claim 35, wherein the beam shaping optics further comprise a beam shaping optics for establishing a top hat beam profile.

39. The system of claim 1, wherein each flow channel has an associated reflective surface or an associated refractive element that redirects a side fluorescence produced by sperm in the flow channel.

40. The system of claim 39, wherein the associated reflective surface or associated refractive element redirects a 90 degree side fluorescence into an optical path which is spatially separated from a first fluorescence and which is substantially parallel to the first fluorescence, so the 90 degree side fluorescence and the first fluorescence are collected by separate detectors.

41. The system of claim 39, wherein the first fluorescence comprises a forward fluorescence.

42. The system of claim 39, wherein the first fluorescence comprises a back fluorescence.

43. The system of claim 39, wherein the reflective surface is formed by a surface on the substrate.

44. The system of claim 39, wherein the reflective surface is formed by a surface of the flow channel.

45. The system of claim 39, wherein each flow channel is separated by a light blocking element.

46. The system of claim 39, wherein the reflective surface further comprises a reflective element embedded in the substrate.

47. The system of claim 39, wherein the reflective surface comprises an exterior surface of the substrate formed by cutaway portion adjacent to the inspection region, wherein the refractive index difference in the cutaway portion provides a reflective property.

48. The system of claim 47, wherein the cutaway portion provides a reflective surface at about 45 degrees relative to the surface of the substrate and/or the desired plane or orientation of the sperm.

49. The system of claim 47, further comprising a second reflective surface comprising a second exterior surface of the substrate formed by a second cutaway portion adjacent to the inspection region for producing a second side fluorescence.

50. The system of claim 1, wherein the detector comprises a forward fluorescence detector.

51. The system of claim 50, further comprising a first side fluorescence detector.

52. The system of claim 51, further comprising a second side fluorescence detector.

53. The system of claim 52, wherein the first and the second side fluorescence detectors are located about 90 degrees apart.

54. The system of claim 51, further comprising an array of first side fluorescence detectors of measuring a first side fluorescence value in each of a plurality of flow channels and an array of second side fluorescence detectors.

55. The system of claim 1, further comprising collection optics for collecting fluorescence from one or more flow channels.

56. The system of claim 55, wherein the collection optics comprise a single collection lens for collecting fluorescence from multiple channels.

57. The system of claim 55, further comprising an array of lens for collecting fluorescence from each flow channel.

58. The system of claim 55, further comprising a fiber array for collecting fluorescence from each flow channel.

59. The system of claim 55, further comprising epi-illumination forward collection optics.

60. The system of claim 59, further comprising a dichroic mirror positioned to reflect electromagnetic radiation from the electromagnetic radiation source onto the inspection region and through which fluorescence emissions in the back direction travel to a detector.

61. The system of claim 1, wherein the first vertical fluid focusing component comprises a first vertical fluid focusing channel and the second vertical fluid focusing component comprises a second vertical fluid focusing channel.

62. The system of claim 61, wherein the first vertical fluid focusing channel and the second vertical fluid focusing channel are in communication with the flow channel in opposite vertical positions.

63. The system of claim 61, wherein the first vertical fluid focusing channel provides a first vertical influence and wherein the second vertical fluid focusing channel provides a second vertical influence in the opposite direction as the first vertical influence.

64. The system of claim 1 further comprising a series of transducers configured to produce a standing pressure wave along the flow channel.

65. The system of claim 1, wherein the at least one flow channel comprises orienting features.

66. The system of claim 65, wherein the orienting features comprise an interior channel geometry dimensioned to orient sperm cells.

67. The system of claim 66, wherein the channel geometry further comprises a planar channel geometry.

68. The system of claim 66, wherein the channel geometry further comprises a nozzle geometry.

69. The system of claim 66, wherein the channel geometry further comprises one or more of the following channel features: a chevron, a gentle ramp, an abrupt ramp, a decompression-compression zone, a step, or one or more undulations.

70. The system of claim 65, wherein the orienting features further comprise: a magnet for producing a magnetic field in the orienting region of each flow channel.

71. The system of claim 1, wherein the flow channel further comprises a sheath inlet that receives sheath fluid, wherein the sample inlet is in fluid communication with the sample source, the sample inlet positioned within a sheath flow created by the sheath inlet to facilitate a co-axial flow of sheath and sample.

72. The system of claim 71, wherein the sample inlet comprises an inlet which is beveled, flattened, or has a rectangular cross-section.

73. The system of claim 71, wherein the flow channel comprises a first width and a first height at the sample inlet.

74. The system of claim 73, wherein the flow channel comprises a second width and a second height at a first transition point.

75. The system of claim 74, wherein the width of the flow channel is reduced between the sample inlet and the first transition point.

76. The system of claim 74, wherein the flow channel comprises a third width and a third height at a second transition point.

77. The system of claim 75, wherein the width remains constant between the first transition point and the second transition point and the height is reduced between the first transition point and the second transition point.

78. The system of claim 76, wherein the third height and the third width are maintained through the inspection region.

79. The system of claim 76, wherein the flow channel transitions from square cross section to a rectangular cross section.

80. The system of claim 76, wherein the flow channel transitions from a circular cross section to an elliptical cross section.

81. The system of claim 1, further comprising at least one mask.

82. The system of claim 81, wherein the at least one mask comprises an illumination mask positioned in the path of electromagnetic radiation directed to the inspection region.

83. The system of claim 82, wherein the illumination mask comprises a first region and a second region along the flow path.

84. The system of claim 83, wherein the first region provides an opening configured to produce a sufficient waveform pulse to differentiate viable X-chromosome bearing sperm from viable Y-chromosome bearing sperm, when orientated.

85. The system of claim 83, wherein the second region comprises a series of openings configured to produce a series of waveform pulses which differentiate oriented sperm cells from unoriented sperm cells.

86. The system of claim 83, wherein the second region comprises a series of openings with differing transverse profiles along the flow path.

87. The system of claim 83, wherein the second region comprises a first spaced pair of openings followed by a second spaced pair of openings, wherein the spacing is differed between the first pair of openings and the second pair of openings.

88. The system of claim 86, wherein the second region comprises a sequential series of openings along the flow path, each opening having a different transverse position along the flow path.

89. The system of claim 82, wherein the at least one mask comprises at least one detection mask.

90. The system of claim 89, wherein a first detection mask is place in the path of emitted forward fluorescence and a second detection mask is placed in the path of emitted side fluorescence.

91. The system of claim 90, wherein the first detection mask and the second detection masks have differing profiles of slits, and wherein each mask is in communication with the same detector.

92. The system of claim 91, wherein the analyzer is in communication with the detector and is configured to deconvolve a first waveform pulses representing the forward fluorescence and a second waveform pulse representing the side fluorescence based on the profile of slits in each of the first detection mask and the second detection mask.

93. The system of claim 81, wherein the mask is positioned in free space.

94. The system of claim 81, wherein the mask is located on the substrate.

95. The system of claim 1, wherein the detector comprises a first detector and the system further comprises a second detector.

96. The system of claim 96, wherein the first detector comprises an absorption detector and the second detector comprises a fluorescence detector.

97. The system of claim 96, further comprises a neutral density filter in the light path of the absorption detector.

98. A microfluidic chip for sorting sperm comprising:

a substrate;

a plurality of flow channels formed in the substrate, each flow channel comprising;

a sample inlet on a first plane;

a fluid focusing region having a lateral fluid focusing region, a first vertical fluid focusing channel in fluid communication with the flow channel at a first location and a second vertical fluid focusing channel in fluid communication with the flow channel at a second location, the lateral

fluid focusing region being on the same plane as the sample inlet, wherein one of the first vertical fluid focusing channel or the second vertical fluid focusing channel is in fluid communication with the flow channel from a second plane above the plane of the sample inlet and the other is in fluid communication with the flow channel from a third plane below the plane of the sample inlet, and wherein the second location is down stream of the first location on the flow channel;

a sperm orienting region having channel geometry that orients sperm cells within the flow channel;

an inspection region at least partially downstream of the fluid focusing region and the sperm orienting region;

at least a first outlet and a second outlet; and

a diverting mechanism in communication with each flow channel downstream of the fluid focusing region and the sperm orienting region and upstream of the at least first outlet and second outlet.

99. The microfluidic chip of claim 98, wherein the first fluid vertical fluid focusing channel provides a first vertical influence and wherein the second vertical fluid focusing channel provides a second vertical influence in the opposite direction as the first vertical influence.

100. The microfluidic chip of claim 104, wherein the fluid focusing region further comprises: ultrasonic transducers for producing pressure waves in the focusing region of each flow channel.

101. The microfluidic chip of claim 104, wherein the fluid focusing region further comprises an array of ultrasonic transducer for producing a standing pressure wave along the flow channel.

102. The microfluidic chip of claim 104, wherein the channel geometry further comprises a planar channel geometry.

103. The microfluidic chip of claim 104, wherein the channel geometry further comprises a nozzle geometry on the interior of the channel.

104. The microfluidic chip of claim 104, wherein the channel geometry further comprises one or more of the following channel features: a chevron, a gentle ramp, a decompression-compression zone, an abrupt ramp, or a step.

105. The microfluidic chip of claim 104, wherein the diverting mechanism comprises a bubble valve.

106. The microfluidic chip of claim 104, wherein the diverting mechanism comprises an array of ultrasonic transducers.

107. The microfluidic chip of claim 104, wherein each flow channel has an associated reflective surface or refractive element that redirects a side fluorescence produced by sperm in the flow channel.

108. The microfluidic chip of claim 107, wherein the associated reflective surface redirects a 90 degree side fluorescence into an optical path which is spatially separated from a first fluorescence and which is substantially parallel to the first fluorescence, so the 90 degree side fluorescence and the first fluorescence are collected by separate detectors.

109. The microfluidic chip of claim 108, wherein the first fluorescence comprises a forward fluorescence.

110. The microfluidic chip of claim 108, wherein the first fluorescence comprises a back fluorescence.

111. The microfluidic chip of claim 108, wherein the reflective surface is formed as a surface on the substrate.

112. The microfluidic chip of claim 108, wherein the reflective surface is formed as a surface of the flow channel.

113. The microfluidic chip of claim 98, wherein the flow channel further comprises a sheath inlet in fluid communication with the sheath source, and wherein the sample inlet is positioned within a sheath flow created by the sheath inlet to facilitate a co-axial flow of sheath and sample.

114. The microfluidic chip of claim 113, wherein the flow channel comprises a first width and a first height at the sample inlet.

115. The microfluidic chip of claim 114, wherein the flow channel comprises a second width and a second height at a first transition point.

116. The microfluidic chip of claim 115, wherein the width of the flow channel is reduced between the sample inlet and the first transition point.

117. The microfluidic chip of claim 115, wherein the flow channel comprises a third width and a third height at a second transition point.

118. The microfluidic chip of claim 117, wherein the width remains constant between the first transition point and the second transition point and the height is reduced between the first transition point and the second transition point.

119. The microfluidic chip of claim 118, wherein the third height and the third width are maintained through the inspection region.

120. The microfluidic chip of claim 118, wherein the fluid flow channel transitions from a square cross section to a non-square rectangular cross section.

121. The microfluidic chip of claim 132, wherein the flow channel transitions from a circular cross section to a non-circular, an elliptical cross section.

122. A method of sorting sperm comprising the steps of:

flowing sperm through a plurality of flow channels in a microfluidic chip;

orienting sperm within the plurality of flow channels;

flowing the oriented sperm through an inspection region in the flow channels;

interrogating sperm at the at least one inspection region to determine sperm characteristics;

differentiating oriented sperm from unoriented sperm in the flow channels;

selecting a subpopulation of oriented sperm based on the detected sperm characteristics; and

collecting the selected subpopulation of sperm in a collection vessel.

123. The method of claim 122, further comprising the steps of:

providing an electromagnetic radiation source;

manipulating electromagnetic radiation produced from the electromagnetic radiation source for inspecting multiple inspection regions.

124. The method of claim 123, wherein the step of manipulating electromagnetic radiation further comprises the steps of: splitting the electromagnetic radiation produced by the electromagnetic radiation source.

125. The method of claim 123, wherein the step of manipulating the electromagnetic radiation further comprises the step of: manipulating the shape of the beam profile of the electromagnetic radiation.

126. The method of claim 122, wherein the step of selecting a subpopulation of sperm based on the detected sperm characteristics further comprises the step of diverting the flow of a selected sperm within flow channel based on the detected sperm characteristics.

127. The method of claim 122, further comprising the step of differentiating oriented sperm from un-oriented sperm and excluding un-oriented sperm from selection.

128. The method of claim 122, further comprising the steps of:

generating a first signal with a forward fluorescence detector in response to emitted electromagnetic radiation of sperm at the inspection region, wherein the first signal comprises waveform pulses having detectable pulse characteristics.

129. The method of claim 128, further comprising the step of generating a second signal with a side fluorescence detector.

130. The method of claim 129, wherein the step of generating a second signal with a side fluorescence detector further comprises associating a reflective element with each flow channel for reflecting the side florescence outward and detecting the side fluorescence in parallel with a forward fluorescence.

131. The method of claim 130, further comprising the step of detecting the forward fluorescence through a first mask and the side fluorescence through a second mask.

132. The method of claim 131, further comprising the step of deconvolving

generating a signal with a fluorescence detector in response to emitted electromagnetic radiation of sperm at the inspection region, wherein the signal embeds first waveform pulses having detectable pulse characteristics and second waveform pulses having detectable pulse characteristics; and

a first waveform pulse and a second waveform pulse from signals produced by the detector.

133. The method of claim 132, wherein the deconvolved waveform pulse and second waveform pulses provide information on the sperm orientation within the flow channel.

134. The method of claim 122, further comprising the steps of generating a plurality of waveform pulses with a single detector in response to single sperm, wherein the plurality of waveform pulses provide orientation information about the sperm cell.

135. The method of claim 134, further comprising the step of measuring laser extinction to determine sperm orientation.

136. The method of claim 128, further comprising the steps of:

generating a second signal with a first side fluorescence detector, wherein the second signal comprises waveform pulses having detectable pulse characteristics; and

generating a third signal with a second side fluorescence detector, wherein the second signal comprises waveform pulses having detectable pulse characteristics.

137. The method of claim 136, wherein pulse characteristics of the second and third signals differentiated the orientation of sperm cells.

138. The method of claim 137, wherein the pulse characteristics are selected from the group consisting of: peak height, pulse width, pulse peak lag, pulse slope, pulse area, and combinations thereof.

139. The method of claim 136, further comprising the steps of comparing the pulse characteristics of the second signal to the pulse characteristics of the third signal to determine sperm orientation.