160, which is defined at the first end 142 of the microfluidic device 140, is therefore formed above the planar surface 126.

[0045] The second end 144 of the microfluidic channel 140 is formed in a protrusion 170 that extends outwardly from the second face 130. As with the prior embodiment, the protrusion 170 preferably has a tapered shape (inward taper) such that it forms a generally conical structure with the open second end 144 being formed at an apex of the conical structure. The tapered protrusion 170 therefore acts as a nozzle that can discharge a sample that is loaded into the microfluidic channel 140 (e.g., in the reservoir 160). The nozzle 170 is therefore part of the microfluidic channel structure since the microfluidic channel 140 is formed therethrough and terminates at the nozzle opening.

[0046] The second face 130 is also not substantially planar but rather includes a second perimeter wall 132 that extends at least partially around a perimeter of the second face 130. The second face 130 does contain a floor 134 that is substantially planar. Between the second perimeter wall 132, one or more nozzle base sections 180 are formed with the number of nozzle base sections 180 being equal to the number of microfluidic channels 140. The nozzle base sections 180 are integrally formed with and extend outwardly from the floor 134 and in the illustrated embodiment, each nozzle base section 180 has a generally annular shape. However, the shape of the nozzle base section 180 is not limited to an annular shape and instead can have any number of shapes, including a conical shape or a tapered shape or any other regular or irregular shape. According to one embodiment, a plane that contains the upper edge of the second perimeter wall 132 generally cuts through the interface between the nozzle base section 180 and the nozzle 170. The nozzle 170 therefore extends beyond the upper edge of the second perimeter wall 132. According to one embodiment, the diameter of the reservoir 160 is about equal to the outside diameter of the nozzle base section 180; and therefore, an outside diameter of the reservoir wall 124 is greater than the outside diameter of the nozzle base section 180.

[0047] The specific configurations of the nozzle 170 and the microfluidic channel 140 are best shown in FIG. 5. As illustrated, the first end 142 of the microfluidic channel 140 is in the form of the reservoir 160. A distal end of the reservoir 160 has an inwardly tapered construction that leads to an intermediate channel section 146. A substantial length of the intermediate channel section 146 is formed in the nozzle base section 180. The intermediate channel section 146 also has a tapered construction in that it tapers inwardly toward the nozzle 170 defined at the second end 144 of the microfluidic channel 140. Thus, the dimensions of the microfluidic channel 140 are greatest at the first end 142 and are at a minimum at a tip portion 172 of the nozzle 170. In one embodiment, the microfluidic feature formed in the device 100 beginning with the reservoir 160 and terminating with the nozzle 170 is generally cylindrical in shape along its length. According to one exemplary embodiment, the open second end 144 of the microfluidic channel 140 formed at the tip portion 172 has an inside diameter equal to or less than 100 $\mu$m, preferably equal to or less than 50 $\mu$m and more preferably, equal to or less than 20 $\mu$m; and an outside diameter of the nozzle, as measured at a tip portion thereof, is less than about 150 $\mu$m and preferably is equal to or less than about 100 $\mu$m, and more preferably equal to or less than 50 $\mu$m. The inside diameter of the microfluidic channel 140 varies along its length due to its tapered construction. For example, the inside diameter of the microfluidic channel 140 opens gradually in a direction away from the nozzle 170 to about several hundred $\mu$m as the microfluidic channel 140 traverses through the thickness of the substrate body 110 and eventually, the microfluidic channel 140 is formed to a diameter of about 1.5 mm to define the reservoir 160. The length of the microfluidic channel 140 can be tailored in view of the construction details of the microfluidic device 100 and the potential applications of the device 100. In one example, the length of the microfluidic channel 140 is about 3 mm; however, this will vary depending upon the thickness of the device 100, the amount of sample that is to be loaded into the device, etc.

[0048] As with the first embodiment, the microfluidic channel 140 is formed in a substantially perpendicular manner in the substrate body 110 since the microfluidic channel 140 is formed substantially perpendicular to both the first and second faces 120, 130. While, the nozzle 170 extends beyond a plane containing the distal edge of the second perimeter wall 132, the distal end of the reservoir wall 124 preferably lies within the same plane that contains the distal edge of the first perimeter wall 122. This orientation permits a cover (e.g., thin polymeric cover sheet) or seal member to be disposed across the distal edge of the first perimeter wall 122 and the distal ends of the reservoir wall 124 to effectively seal the sample material within the reservoir 160, as will be described hereinafter.

[0049] One will appreciate that one of the advantages of the device 100 is that it is formed as a one piece construction in contrast to conventional devices which have multiple layers bonded together. In these conventional devices, the microfluidic channel is closed by the bonding of one layer over another layer. In other words, two separate layers are needed to define the complete channel. Because the present device 100 is injection-molded, separate bonded layers are not required.

[0050] It will be understood that the present configurations that are illustrated herein with reference to FIGS. 1-5 are merely exemplary in nature and are intended to merely convey exemplary embodiments. Various modifications can be performed to the microfluidic devices depending upon a number of different considerations, including manufacturing considerations. For example, the nozzle structures do not necessarily have to have conical shapes; however, for ease of manufacturing, a conical shape or the like is generally preferred.

[0051] According to another aspect of the present application, various manufacturing methods are disclosed herein for manufacturing the microfluidic array devices illustrated in FIGS. 1-5. In general terms, exemplary manufacturing processes disclosed herein permit microfluidic nozzle array devices to be manufactured having microscale nozzle dimensions (e.g., a nozzle tip opening having a diameter equal to or less than 100 $\mu$m, preferably equal to or less than 50 $\mu$m and more preferably, equal to or less than 20 $\mu$m; and an outside diameter of the nozzle, as measured at a tip portion thereof, is less than about 150 $\mu$m and preferably is equal to or less than about 100 $\mu$m, and more preferably equal to or less than 50 $\mu$m) and also the present microfluidic array devices are particularly suited to inexpensive fabrica-