[0070] The microfluidic nozzle array devices disclosed herein are suitable for use in a number of different types of applications.

[0071] For purposes of illustration only, some of the exemplary applications will be disclosed with reference to the microfluidic nozzle array device **100** illustrated in FIGS. **4-5**; however, it will be understood that any of the devices disclosed herein can be used in place of device **100**.

[0072] The microfluidic nozzle array device **100** is particularly suited for use in nanospray/electrospray applications. Electrospray is the technique that enables a liquid sample to be vaporized and ionized for mass spectrometry analysis. The electrospray process takes place in ambient pressure. Conventional electrospray utilizes a capillary with a relatively large inside diameter (i.e., about 50 μm) to deliver the liquid sample to the entrance of the mass spectrometer. The liquid that is flowing out of the capillary is vaporized under the influence of an electric field generated by placing a high voltage (e.g., 4-5 KV) on a metallic conductor close to the capillary opening and a ground plane opposite the capillary opening, or vice versa. Dry nitrogen flows through concentric tubing to the capillary to help nebulize the liquid flowing out of the capillary. The flow of the liquid inside the capillary is driven generally by a pump, such as a syringe pump.

[0073] For the nozzle array of the present microfluidic device **100** to be used as individual nanospray sources, the reservoir **160** on the opposite side of the nozzle opening is filled with a sample to be sprayed. Before the spray, the reservoir has to be sealed so that the reservoir is liquid tight. In other words, the open end of reservoir **160** (i.e., the open first end **142** of the microfluidic channel **140**) must be sealed. The sealing of the open end of the reservoir **160** can be accomplished in a number of different ways that each provides a satisfactory liquid tight seal of the reservoir and permits the sample to be transported within the channel **140**. FIGS. **11-13**, illustrate a number of exemplary ways to provide the desired liquid tight seal of the reservoir.

[0074] For example, **FIG. 11** illustrates a first sealing technique in which the opening of the reservoir **160** (i.e., the first end **142** of the microfluidic channel **140**) is sealed with an elastic cover sheet **400**. The elastic cover sheet **400** is preferably in the form of an elastic polymeric cover sheet. In the microfluidic nozzle array device **100**, the polymeric cover sheet **400** is coupled to the reservoir wall **124** so that the polymeric cover sheet **400** extends completely across the open end of the reservoir **160**. A mechanical plunger **410** or the like can be used to apply a force to the polymeric cover sheet **400** to force the sample along the length of the microfluidic channel **140** and ultimately out of the nozzle opening (second end **144** of thee microfluidic channel **140**) in a continuous stream, generally indicated at **430**. The discharged continuous liquid stream of the sample is then vaporized under the influence of an electric field. The general direction of movement of the polymeric cover sheet **400** and the plunger **410** is illustrate by arrow **420**.

[0075] Another sealing technique is illustrated in **FIG. 12**. According to this technique, a movable sealing member **400** is provided and is formed of a sealing base **422** for sealing the opening of the reservoir and a rod or plunger **444** that is attached to the sealing base **442**. The dimensions of the sealing base **442** are greater than the dimensions of the open end of the reservoir **160** and therefore, the sealing base **442** seats against the reservoir wall **124** and completely extends across the open end of the reservoir **160**. The sealing base **442** is formed of a suitable elastic material to permit the sealing base to locally deform when a force is applied thereto. This elasticity permits the sealing base **442** to act as a temporary diaphragm that seals the reservoir as the sealing base **442** is directed into the reservoir **160** itself.

[0076] When the sealing base **442** is pushed downward in the direction toward the nozzle **170**, the sealing base **442** deforms as it is forced into the first end of the microfluidic channel **140** (which is also the entrance to the reservoir **160**). In the illustrated embodiment, the sealing base **442** includes a flange **446** that has a greater diameter than the diameter of the other portions of the sealing base and therefore, when the sealing base is inserted into the reservoir, the flange **446** intimately contacts the inner surface of the reservoir wall **124** and forms the liquid tight seal between the sealing base and the reservoir. As the sealing base **442** is inserted into the reservoir **160** and travels therein toward the nozzle, the sealing base **442** effectively forces the sample toward the second end **144** of the microfluidic channel **140**, causing the sample to be discharged through the nozzle opening defined thereat. There may be an air gap between the sample (e.g., a liquid) in the reservoir **160** and the sealing base **442** or a vent (not shown) can be incorporated into the sealing base **442** for air to be pushed out of the reservoir **160** when the sample is forced through the microfluidic device by the sealing base **442**. The vent can be fabricated using conventional vent technology in that the vent should permit air passage, while being impermeable to the flow of liquid so that the sample is prevented from flowing through the vent and out of the reservoir **160**.

[0077] It will be appreciated that the plunger **444** can either be manually operated or it can be part of an automated system including an actuator or the like which controls the movement of the plunger **444**. All of the plungers **444** can be linked to a common actuator or the link so that upon activation, the plungers **444** are all driven at the same time, resulting in the samples being concurrently transported through respective channels to respective nozzles.

[0078] Yet another sealing technique is illustrated with reference to **FIG. 13** in which a fluid carrying member **450** is provided. The member **450** has a hollow portion and is generally shaped to be complementary to the shape of the reservoir **160** to permit the member **450** to seat against the upper edge of the reservoir wall **124**. The member **450** includes a distal end **452** which initially is positioned proximate to the open end of the reservoir **160**. At the distal end **452**, a-gasket **460** is provided and in the illustrated embodiment, the gasket **460** is in the form of a sealing O-ring or the like. The gasket **460** serves to provide a seal between the distal end **452** and the reservoir wall **124** to prevent from escaping between this interface when the sample is transported in the following manner. Because the member **450** is at least partially hollow, the gasket **460** is disposed around the bore that extends through the member **450**.

[0079] In this embodiment, the sample is moved within the microfluidic channel **140** by conducting a fluid through the member **450** (more specifically, the bore thereof) to effectively force the sample through the microfluidic chan-