FIG.**1** may be provided. The outer surface layer **121** may be the outer-most layer, or the furthest away from the user's skin. The next inward layer toward the skin may be the reservoir layer **122**, and the next inward layer may be the pump member **123**. The next inward layer towards the user's skin, and in some examples the final layer (the layer closest to the user's skin), may be the toxel layer **124**.

[0016] The outer surface layer **121** may comprise a material such as rubber or latex. In some examples, conductivity enhancers may be provided on the outer surface layer **121**, such as, for example, lithium salts, or silicone nitride particles alone or in combination with silicone carbide whisker, or other suitable materials. The material included in the construction of the outer surface layer **121** may be selected and configured so that the outer surface layer **121** may be sealed to protect the interior components from exposure to, e.g., liquids, moisture, dirt, and dust, which may potentially cause damage to the tactile display device **100**. The outer surface layer **121** may be grounded and configured to absorb a current so that a resistance may be tolerated by the tactile display device **100** where such resistance may not interfere with the operation of the tactile display device **100**.

[0017] In some examples, the outer surface layer **121** may include wires **127** or other electrical conductors, fiber-optic cables, nano-tubes or other types of conduits or channels **163**, **164**, **165** that may be configured to carry signals **125**. The wires **127** may be configured to carry signals **125** from a receiver (not shown) to facilitate selectively forming the bubbles **143**, **144**, **145** that may communicate touch data to a user of the tactile display device **100**. The wires **127** may be bundled, grouped, individually disposed or otherwise configured.

[0018] The outer surface layer **121** may include various types of patterning, in some examples. Patterning may be based on, for example, construction of the tactile display device **100**, mobility of the user of the display device **100**, and/or decorative preferences. In some examples, patterning may be used to provide for the wires **127** to connect to the actuators (not shown in FIG. **1**, see **173** and **175** of FIG. **2**). Patterning may be configured to correspond to patterning that may be included in the other layers **122**, **123**, **124**, including patterning of the toxels **130**, **131**, **132**, **133**, **134**, **135**, **136**, **137**, **138**, **139**.

[0019] The reservoir layer **122** may comprise or may include a porous cloth and/or a reservoir that may be created by texturing the side of the outer surface layer **121** that is closest to the user's skin. The reservoir layer **122** may be configured to contain the liquid **126**. Various types and configurations of porous cloth may be used in the construction of the reservoir layer **122** so that liquid **126** may be contained therein. The reservoir layer **122** and the material used in its contraction may be selected based upon, for example, its absorption capacity, and chemical and mechanical properties. In some implementations, the reservoir layer **122** or material from which it is constructed may be selected so that the reservoir layer **122** does not chemically react with liquid **126** or any other element of the tactile display device **100** that may potentially come into contact with the material from which the porous cloth may be constructed. The reservoir layer **122** may be configured to allow the liquid **126** to flow from the reservoir layer **122** to activate some or all of the toxels in the toxel layer and thereby communicate touch data to the user of the tactile display device **100**. The liquid **126** may contain ions in a solvent including silanol groups, and the channels may be made of silica (SiO_2), for example.

[0020] In the example depicted in FIG. **1**, the pump member **123** may comprise a silica mat layer configured for pumping the fluid **126** electro-osmotically in response to a signal. An electric field may be applied across pump member **123** to cause the fluid to be pumped in an electro-osmotic fashion into bubble cavities **153**, **154**, **155**. Flow of the fluid into the bubble cavities **153**, **154**, **155**, which may be constructed of an elastic material, causes bubbles **153**, **154**, **155** to form and the bubble cavities **153**, **154**, **155** to expand. Some examples may be configured so that when an electric field is no longer applied across the pump member **123** (e.g., the potential difference is set to zero), the elastic force of the material from which the bubbles **143**, **144**, **145** are constructed forces the fluid **126** from the bubble cavities **153**, **154**, **155** back to the reservoir layer **122**. Accordingly, the bubbles **143**, **144**, **145** deflate, thereby ceasing the communication of touch data to the user.

[0021] Toxel layer **124** may be the next layer towards the skin. In some examples, toxel later **124** may be the final inner-most layer and may be in contact with a user's skin. In some examples, toxel layer **124** may be patterned, for example with ribs, stripes, circular patterns, repeating patterns, random patterns, patterns that increase or decrease in size according to placement, or any other pattern or combination of patterns. Toxel layer **124** patterns may be based on the configurations of the pump member **123**, and/or the applications with which the tactile display device **100** may be used, or other considerations. Toxel layer **124** may be arranged so as to provide electrodes on the back of the pump member **123**. A voltage adjustment may be used to alter the potential of the pump member, such that when a negative voltage is applied across the pump member **123**, a dual layer structure forms as silanol layers to provide for a surface layer to the silica, and cations stream down the space within the silanol layer carrying the solvent with them. Examples using this pump mechanism may be configured to provide flow rates in the range of multiple millimeters per second and/or on scales of about 200 μm per second, for example.

[0022] FIG. **2** depicts an enlarged view of the tactile display device of FIG. **1**, also arranged in accordance with the present disclosure. As depicted, an actuation layer **128** may be included and may comprise a plurality of actuators **173**, **174**, **175**, which may be comprised in a pattern of electrodes. Electrode patterns may be dictated by the type of device used, for example, a glove device may have closely spaced electrodes to permit for a greater number of toxels to be activated in the hands, which are relatively sensitive, whereas a device that is worn on the legs may have more spread out electrodes. The pattern of electrodes may also be dictated or influenced by the intended application for the tactile display. For instance, if the tactile device is used with a computer baseball game, a circular, densely packed configuration of electrodes may be used on an arm portion of a shirt-like tactile display, in order to simulate the vibrations that course down a batters arm, as she hits the baseball. The tactile display device **100** may comprise a plurality of toxel portions **183**, **184**, **185** sensitively drivable by the fluid **126** for causing the toxels **133**, **134**, **135** to be displayed. The actuators **173**, **174**, **175** may be patterned on an elastomer at the actuation layer **128**, such that the toxels **133**, **134**, **135** may form bubbles **143**, **144**, **145** using the pump member **123**. Accordingly, an electrode layer **129** may be formed on the actuation layer **128**. In some