[0017] While resistive touch sensors often employ spacer dots, structures other than dots, which are typically realized as hemispherical shapes, can be used as spacers in the spacer array disposed across the touch-sensitive area of a touch sensor according to the present invention. For example, the spacer array can include dots, spheres, elongated shapes, lines, and any other suitable shape. A spacer array can include spacers of all one shape, size, or distribution, or can includes spacers having different shapes, sizes, or distributions. Without loss of generality, spacers in the spacer array may be referred to as spacer dots or simply as spacers in this document.

[0018] **FIG. 1** schematically shows a touch sensor **1000** that includes a movable first layer **1010** spaced apart from a second layer **1020**. Spacers **1030** are disposed between and bonded to each of the first layer **1010** and the second layer **1020**. Spacers **1030** are disposed in a touch-sensitive area of the sensor **1000**. A touch input to a touch surface in the touch-sensitive area causes first layer **1010** to be moved toward second layer **1020**. Spacers, including double-bonded spacers **1030** and optional single-bonded spacers (not shown), encourage the deformation of first layer **1010** under the touch to occur locally. The size, shape, and distribution of the various spacers determines the amount of force and area of force required to cause a movement sufficient to result in a detectable signal. The deformation of first layer **1010** due to the touch brings the first layer **1010** and the second layer **1020** either into contact or into closer proximity. First layer **1010** and second layer **1020** are typically provided with resistive elements such as a resistive layer covering the touch-sensitive area. The resistive elements can be biased so that a touch input results in a detectable signal that can be used to determine the location of the touch. By touch or touch input, it is meant that a touch implement such as a finger, stylus, or other suitable object is used to apply pressure to the touch surface in the touch-sensitive area of the touch sensor.

[0019] The materials of the first layer **1010** and second layer **1020** can be selected so that a display (not shown) can be viewed through the touch sensor **1000**. The gap between the first layer **1010** and second layer **1020** can optionally be filled with a deformable material such as a liquid or an elastomer. The filler material can also be selected so that a display can be viewed through the sensor **1000**. The presence of a gap filler can produce improved optics by eliminating the air gap between the layers, thereby reducing reflections that can limit light throughput. The present invention may be particularly suited to applications where a flowable gap filler material is used. When a flowable gap filler is used, the gap filler in the touched area is pushed into the surrounding areas, which can cause the movable first layer to be pushed away from the second layer in an annulus around the touched area. This may form air pockets, leading to bubble formation that detracts from viewability through the sensor. The presence of double-bonded spacers may help prevent this by containing excessive motion of the movable first layer away from the second layer.

[0020] In conventional resistive touch sensors, the spacer dots are typically made of a rigid material such as an acrylic. In the present invention, the spacers disposed in the touch-sensitive area of the touch sensor can be rigid or deformable. For example, it may be desirable to include double-bonded spacers that are sufficiently deformable to be somewhat yielding under touch forces but that return to their rest state upon removal of the touch force. Elastomers such as silicone elastomers can be used as deformable spacer materials.

[0021] To exemplify some aspects of the present invention, and without loss of generality, there is shown in **FIG. 2 a** 4-wire resistive touch sensor **10** including a top sheet **12**, which may be made of, for example, polyethylene terephthalate (PET), and a substrate **14**, which may be made of, for example, glass. A resistive coating **16** is applied to topsheet **12** and another resistive coating **18** is applied to substrate **14** in facing relationship to one another. The resistive coatings may be made of any suitable resistive material, particularly transparent conductive oxides such as indium tin oxide (ITO), tin oxide (TO), or antimony tin oxide (ATO) for applications where it is desirable for touch sensor **10** to be transparent. Topsheet **12** and substrate **14** may have thicknesses of about 0.03 to 0.5 mm and 0.5 to 5 mm respectively, for example.

[0022] Touch sensor **10** is shown to be generally rectangular and the materials are indicated to be transparent so the sensor can be used as a touch screen overlay on a display device such as an LCD or CRT screen. The present invention also applies to whiteboards, touchpads, and other touch sensor devices that are not transparent. Also, although **FIG. 2** shows a 4-wire resistive touch sensor, the present invention applies equally well to any resistive touch sensor that includes a topsheet with a resistive layer spaced apart from a substrate with a resistive layer and spacer dots disposed between the resistive layers. Other resistive touch sensor types include 5-wire and 8-wire, the constructions of which are well known to those of ordinary skill in the art.

[0023] Referring back to **FIG. 2**, electrodes **20** may be printed or otherwise disposed on substrate **14** for applying voltages and sensing signals. Electrodes **21** may be printed or otherwise disposed on topsheet **12** for applying voltages and sensing signals. The sensed signals result from a touch input of sufficient force to bring the resistive coatings **16** and **18** into electrical contact. Information gathered from sensing these signals can be used to determine the location of the touch.

[0024] An adhesive medium **22** is conventionally applied along the periphery between topsheet **12** and substrate **14** to form a seal. The seal protects the inside of the sensor from contaminants, and also provides a support on which the topsheet can be pulled taut and to which the topsheet may be bonded to help reduce topsheet sag, buckle, and bubble effects. In the present invention, an adhesive border or periphery may still be desirable to seal the gap between the top sheet and substrate **14** to prevent contamination.

[0025] The gap between the resistive coatings **16** and **18** is maintained by spacers **24** disposed over the touch-sensitive area of the sensor. Spacers **24** may be arranged in any regular or random array, although they are shown in **FIG. 2** to be arranged in an array of rows and columns. Spacers may be rounded, squared or elongated, and may form lines across the touch-sensitive area. The spacers may be formed from any suitable material such as an acrylic material, and can be formed conventionally by screen printing, offset printing, stenciling, photolithography, and the like. Spacers can also be formed by ink jet printing as disclosed in co-owned U.S. patent application Ser. No. 10/017,268, the disclosure of which is wholly incorporated into this document. Spacers