tive object. Further, the sensor provides reliable touch sensing through moisture, dirt or other contaminants on the touch screen surface.

[**0033**] The touch sensor of the present invention is particularly useful when combined with various types of data processing systems. The data processing systems incorporating the touch sensor of the present invention may include a display device enhanced by a transparent touch screen, for example. Such systems may be used in kiosks, ATMs, and a variety of point of sale devices. Further, desktop, handheld or laptop computer systems may incorporate a touch sensor of the present invention. The touch sensor may also be implemented in a personal data assistant (PDA) or a cell phone. Although the touch sensing device is described in combination with a microprocessor-based system, the touch sensing device may be combined with any logic-based system, if desired. The systems and methods of the present invention may be implemented with controller circuitry that uses a capacitively coupled connection to earth ground, or with a simplified controller that uses an internal low impedance reference.

[**0034**] In one embodiment, the touch sensor of the present invention includes two conductive layers disposed in a touch area and defining a gap between the two layers. A location of the touch input is determined by a change in capacitance between the two layers. The touch sensing method of the present invention includes deflecting a first conductive layer in the direction of a second conductive layer and detecting the location of the deflection. The basic operation of a touch sensor of the present invention is illustrated in **FIGS. 1A and 1B**. The touch sensor includes, at least, a top conductive layer **110** and a bottom conductive layer **120** separated by a gap **115**. The top and bottom conductive layers **110, 120** form the capacitor plates of the capacitive touch sensor **100**. Prior to a touch, the top and bottom conductive layers **110, 120** are typically positioned so that they are sufficiently separated, as shown in **FIG. 1A**. When touched with sufficient force, one conductive layer is locally deflected towards the other conductive layer, but is not brought into physical contact with the other layer. In the example shown in **FIG. 1B**, the top conductive layer **110** is deflected in the direction of the bottom conductive layer **120**. The deflection of the top conductive layer causes the distance between the conductive layers **110, 120** to decrease at the location of the touch, thereby changing the capacitance between the top and bottom conductive layers **110, 120** in a local area around the point of deflection. The change in capacitance is detectable by controller circuitry coupled to the touch sensor, and can be used to determine the location of the touch.

[**0035**] One particular embodiment of the invention is illustrated in **FIG. 2A**. The touch sensor **201** includes two multilayered structures **240, 245** separated by a gap **215**. The top structure **240** is preferably flexible and the bottom structure layer **245** may be flexible or rigid. The top and bottom structures **240, 245** may be composed of transparent materials. Transparent touch screens are suitable for placement over a display device such as a liquid crystal display (LCD), or cathode ray tube (CRT) to create an integrated touch screen/display.

[**0036**] The top structure **240** includes a supporting layer **205** and a first conductive layer **210** with an optional protective coating **212**. The components of the top structure **240** are preferably formed of flexible materials.

[**0037**] The bottom structure layer **245** may include a substrate **230** and a second conductive layer **220** that may also optionally be coated with a protective layer **218**. The top and bottom structures **240, 245** are separated by a gap layer **215**. Spacers **216** may be located within the gap **215** to maintain a predetermined distance between the top and bottom structures **240, 245**, for example a space in the range 5 μm to 500 μm. The spacers **216** may be formed, for example, by screen printing UV curable material onto the bottom protective layer **218** or conductive layer **220** in a pattern of appropriate dimensions. Adjacent spacers may be separated from each other by a distance of between 20 μm to 5 mm.

[**0038**] The top supporting layer **205** may be used as an insulator for the top conductive layer **210** to reduce the effect of external capacitance on the touch sensor **201**. External capacitance causes capacitive coupling between the touch sensor **201** and earth ground, and a resultant decrease in the signal to noise ratio of the touch location signal. Insulating the top conductive layer **210** with the top supporting layer **205** reduces the effect of external capacitance. The properties of the top supporting layer may be chosen to decrease capacitive coupling through the top supporting layer **205**. Capacitive coupling may be decreased, for example, by using a top supporting layer **205** with appropriate material properties or thickness. In some embodiments, the dielectric thickness of the top supporting layer **205** may be formed to be greater than the dielectric thickness between the first and second conductive layers **210, 220**. The dielectric thickness takes into account the actual thickness and the dielectric properties of the material over which the thickness is measured, and is proportional to the actual thickness multiplied by the relative permittivity of the material over which the thickness is measured. The dielectric thickness of the supporting layer **205** may be at least as thick as the minimum dielectric thickness between the deflected first conductive layer **210** and the second conductive layer **220**. This configuration may be used to reduce external capacitive effects so that a change in capacitance induced by the deflection of the top conductive layer **210** is predominant.

[**0039**] The conductive layers **210, 220** are typically composed of thin sheets of conductive material. The conductive layers **210, 220** may be made as thin as possible while maintaining durability and continuity. In applications requiring a transparent touch sensor, a transparent conductive oxide such as indium tin oxide (ITO) or antimony tin oxide (ATO) may be used to form the conductors **210, 220**. For example, the conductive layers **210, 220** may be comprised of ITO with a resistivity of approximately 10 to 50,000 ohms per square. In another example, the conductive layers **210, 220** may be comprised of ATO with a resistivity of approximately 10-50,000 ohms per square. The thickness of a conductive layer typically falls in the range 0.005 μm to 10 μm, although it may also have a thickness outside this range. Other transparent conductive materials may also be used for the conductive layers **210** and **220**, such as an electrically conductive polymer. Suitable conductive polymers include polypyrrole, polyaniline, polyacetylene, polythiophene, polyphenylene vinylene, polyphenylene sulfide, poly p-phenylene, and polyheterocycle vinylene. An exemplary conductive polymer is is poly (3,4-ethylenedioxythiophene), a substituted polythiophene, commonly referred to as PEDOT.