DETAILED DESCRIPTION

[0019] The following description is presented to enable any person skilled in the art to make and use the invention as claimed and is provided in the context of the particular examples discussed below (touch pad input devices for personal computer systems), variations of which will be readily apparent to those skilled in the art. Accordingly, the claims appended hereto are not intended to be limited by the disclosed embodiments, but are to be accorded their widest scope consistent with the principles and features disclosed herein. By way of example only, force imaging systems in accordance with the invention are equally applicable to electronic devices other than personal computer systems such as computer workstations, mobile phones, hand-held digital assistants and digital control panels for various machinery and systems (mechanical, electrical and electronic).

[0020] Referring to FIG. **1**, the general concept of a force detector in accordance with the invention is illustrated as it may be embodied in touch pad device **100**. As illustrated, force detector **100** comprises cosmetic layer **105**, sense layer **110** (including conductive paths **115** and electrical connector **120**), dielectric spring layer **125** (including spatially offset raised structures **130**), drive layer **135** (including conductive paths **140** and electrical connector **145**) and base or support **150**. (It will be understood by those of ordinary skill in the art that connectors **120** and **145** provide unique connections for each conductive trace on layers **110** and **135** respectively.)

[0021] Cosmetic layer **105** acts to protect other elements of the system from ambient conditions (e.g., dust and moisture) and, further, provides a surface through which users interact with detector **100**. Conductive paths **115** on sense layer **110** are arranged so that they overlap conductive paths **140** on drive layer **135**, thereby forming capacitors whose plates (conductive paths **115** and **140**) are separated by sense layer substrate **110**, dielectric spring layer **125** and raised structures **130**. Dielectric spring layer **125** and raised structures **130** together create a mechanism by which sense layer **110**'s conductive paths **115** are brought into closer proximity to drive layer **135**'s conductive paths **140** when a force is applied to cosmetic layer **105**. It will be recognized that this change in separation causes the mutual capacitance between sense layer and drive layer conductive paths (**115** and **140**) to change (increase)—a change indicative of the amount, intensity or strength of the force applied to cosmetic layer **105**. Base or support layer **150** provides structural integrity for force detector **100**.

[0022] Referring to FIG. **2**A, a cross-sectional view of force detector **100** is shown in its unloaded or "no force" state. In this state, the mutual capacitance between sense layer **110** and drive layer **135** conductive paths (**115** and **140**) results in a steady-state or quiescent capacitance signal (as measured via connectors **120** and **145** in FIG. **1**). Referring to FIG. **2**B, when external force **200** is applied to cosmetic layer **105**, dielectric spring layer **125** is deformed so that sense layer **110** moves closer to drive layer **135**. This, in turn, results in a change (increase) in the mutual capacitance between the sense and drive layers—a change that is approximately monotonically related to the distance between the two and, therefore, to the intensity or strength of applied force **200**. More specifically, during operation traces **140** (on drive layer **135**) are electrically stimulated one at a time and the mutual capacitance associated with the stimulated trace and each of traces **115** (on sense layer **110**) is measured. In this way an image of the strength or intensity of force **200** applied to cosmetic layer **105** is obtained. As previously noted, this change in mutual capacitance may be determined though appropriate circuitry.

[0023] Referring to FIG. **3**, a block diagram of force imaging system **300** utilizing force detector touch pad **100** is shown. As illustrated, force imaging system **300** comprises force detector **100** coupled to touch pad controller **305** through connectors **120** (for sense signals **310**) and **145** (for drive signals **315**). Touch pad controller **305**, in turn, periodically sends signals to host processor **320** that represent the (spatial) distribution of force applied to detector **100**. Host processor **320** may interpret the force information to perform specified command and control actions (e.g., select an object displayed on display unit **325**).

[0024] Referring to FIG. **4**, during operation drive circuit **400** in touch pad controller **305** sends ("drives" a current through drive signals **315** and connector **145** to each of the plurality of drive layer conductive paths **140** (see FIG. **1**) in turn. Because of capacitive coupling, some of this current is carried through to each of the plurality of sense layer conductive paths **115** (see FIG. **1**). Sensing circuits **405** (e.g., charge amplifiers) detect the analog signal from sense signals **310** (via connector **120**) and send them to analysis circuit **410**. One function of analysis circuit **410** is to convert the detected analog capacitance values to digital form (e.g., through A-to-D converters). Another function of analysis circuit is to queue up a plurality of digitized capacitance values for transmission to host processor **320** (see FIG. **3**). Yet another function of analysis circuit is to control drive circuit **400** and, perhaps, to dynamically adjust operation of sense circuits **405** (e.g., such as by changing the threshold value at which a "change" in capacitance is detected). One embodiment of controller **305** suitable for use in the present invention is described in US patent application entitled "Multipoint Touch Screen Controller," Ser. No. 10/999,999 by Steve Hotelling, Christoph Krah and Brian Huppi, filed 15 Mar. 2006 and which is hereby incorporated in its entirety.

[0025] In another embodiment, a force detector in accordance with the invention is combined with a capacitive location detector to create a touch pad device that provides both location and force detection. Referring to FIG. **5**, combined location and force detector **500** comprises cosmetic layer **505**, circuit board or substrate **510** (including a first plurality of conductive drive paths **515** on a first surface and a plurality of sense paths **520** on a second surface), dielectric spring layer **525** (including alternating, or spatially offset, raised structures **530**), drive layer **535** (including a second plurality of conductive drive paths) and base or support **540**. In one embodiment, conductive drive paths **515** and **535** are laid down on substrate **510** and support **540** respectively to form rows and sense conductive paths are laid down on substrate **510** to form columns. Accordingly, during operation first drive paths **515** are driven (one at a time) during a first time period and, during this same time, sense paths **520** are interrogated to obtain an image representing the location of one or more cosmetic layer touches. Similarly, second drive paths **535** are driven (one at a time) during a second time period and, during this same time,