METHOD FOR MAKING A DISPLAY WITH INTEGRATED TOUCHSCREEN

FIELD OF THE INVENTION

[0001] The present invention relates to a touch sensitive device with an electronically addressable display and methods for making such devices.

BACKGROUND OF THE INVENTION

[0002] Since their conception in the 1970's, touch sensitive displays have grown into one of the most popular forms of user interface in the computing world. Kiosks, machine controllers, and personal digital assistants (PDAs), are just a few of the common devices that utilize this technology. Touch sensitive displays can have discrete touch sensitive areas, for example, operated by switch mechanisms, or can have continuous touch sensing over the surface of the display, referred to herein as a "touchscreen." Touchscreens can detect multiple inputs over their entire surface, as compared to discrete touch sensitive devices, wherein each switch recognizes only a single input within the area of the switch. Touchscreens allow for higher resolution input recognition with simpler electronic circuitry than discrete touch sensitive devices. Touchscreen simplicity combined with display adaptability can be made to serve the function of a keyboard, mouse, pen, number pad, and many other input devices, all combined into a single unit. Today there are four most popular ways to make touchscreen displays: Resistive, Capacitive, Ultrasonic, and Infrared.

[0003] The resistive style consists of two clear conductors spaced apart by physical dots. When the assembly is depressed, the conductors touch and detectors determine the touch location by measuring the x and y resistance. This method is the least expensive and does not require a conductive stylus, but it suffers a reduction in optical transmission of up to 25%, providing a total transmittance of as low as 75%. Resistive touchscreens are typically manufactured independently of the final device for which they are used, as this is frequently the most cost effective manner for production. One way that this is accomplished is to coat two rolls or sheets of substrate material with a clear conductor, for example a sputter coated layer of Indium Tin Oxide (ITO), then screen print spacers and sensing electronics, and laminate the two substrates. In this manner, touchscreens can be made in an inexpensive, high-volume manner, then applied to any number of devices.

[0004] A second method for making a touchscreen is to use capacitive sensing. The capacitive style uses only one conductive layer arranged as the outermost layer of the device. Like in the resistive system, capacitive touchscreens can also be manufactured off-line, to be integrated later into the device. Capacitive touchscreens are advantageous because there is only one substrate, no spacers are required, and the optical transmissivity can be as much as 90%. Additionally, capacitive touchscreens can be easily fabricated integrally to the display by applying the conductive layer, for example, indium tin oxide (ITO), directly to the display front substrate. However, if this strategy is utilized, then special care must be taken with the handling of the display during fabrication, because there are functional layers on both sides of the substrate. This can quickly lead to significant handling problems, as ITO is notoriously prone to scratching. Additionally, once the assembly is formed, capacitive sensors are limited in that they require a conductive stylus, and the options for protective outer coatings on the conductive layer are very limited.

[0005] The final two popular methods for making a touchscreen, ultrasonic and infrared (IR) sensing, are very similar. Both styles use signal generators and receivers placed around the perimeter of the display. In the ultrasonic format, sonic waves are generated. In the IR format, infrared light beams are generated. In both, an array of beams or waves cover the surface of the display, and the sensors identify a touch location based on which beams are broken or what waves are bounced back. These systems cannot be integral to the display, and are rather separate components of a larger assembly. Their major advantage is that they do not require a conductive stylus and have no optical loss. However, given the large number of generators and sensors required, they are the most expensive of the options, and can be very sensitive to surface flatness. These issues make such touchscreens infeasible for use with inexpensive, flexible displays.

[0006] There are methods for allowing discrete touch input into a display device. The most common of these is a membrane switch. This is a method that is particularly popular with flexible displays, because it utilizes a series of individual electrical contacts, which are separated from complementary contacts by a gap. When the discrete contacts are depressed, they come in contact with their counterpart, completing a circuit. Although limited in their resolution, such sensors are simple to make and can be integrated into a flexible display. One example of this is in U.S. Pat. No. 6,751,898, where Heropoulos and Torma describe an electroluminescent display with integrated membrane switches. In their patent, they describe a device with at least one electrical contact, an insulator with holes corresponding to that contact, and a second conductor aligned to the first. When the display is depressed in the location of the contacts, a circuit is completed. This method is effective and inexpensive, but somewhat limited in overall application.

[0007] As was stated earlier, resistive and capacitive touchscreen display assemblies are typically created by manufacturing the display and touchscreen separately, then fastening or laminating the touchscreen to the front of the display. This method of assembly can be expensive, and the final product can be unnecessarily thick, especially if both display and touchscreen utilize glass substrates. It is possible to mitigate this effect by combining the back plane of the touchscreen and the front plane of the display. This is especially desirable in the capacitive system, as it reduces the touch-sensing portion of the display to a single layer of conductive material and the associated sensing electronics. However, the same limitations of capacitive touchscreens still apply. In addition, the conductive material must be transparent, and applied to the opposite side of the substrate from the display material. The fragility of many transparent conductors can make this a dangerous proposition, risking significant scratching during handling. This can be costly, as the transparent conductive materials are frequently expensive to make and deposit, with most requiring vacuum deposition in cleanroom environments. In addition, even the single layer of transparent conductor can cost around 10% of optical transparency in the view substrate. Resistive touchscreens may require less expensive electronics and can use non-conductive styluses, but they add an air gap, another