Conductive-Polymer Developments in Resistive-Touch-Panel Technology

One of the biggest drawbacks to resistive-touch-panel devices is the brittle nature of the ITO coating. An alternative coating made of conductive polymers, which promises to hold up much better in rugged conditions, is discussed here.

by Bruce DeVisser

TOUCH SCREENS are becoming the most prevalent man–machine interface in the computing world, with their uses ranging from handheld computing to industrial controls and a variety of other growing markets and applications. All methods of touch input, regardless of the underlying technology, simplify accurate and efficient user input.

Of all the existing touch technologies, resistive touch panels (Fig. 1) are by far the most common type in use today. They accept input from virtually any means – such as a gloved or bare finger, a stylus, an edge of a credit card, *etc.* – and they are the least expensive to produce. Furthermore, with recent advances in materials technology, resistive touch panels have been able to expand into ever-more-demanding applications, especially rugged environments such as the booming mobile-device market, automotive and avionics use requiring high optical as well as environmental performance, and industrial environments where high-performance requirements are becoming standard – while maintaining the cost-effectiveness for which they are known.

The Problems with ITO

Despite their widespread use, resistive touch panels do have an inherent weakness: the use of indium tin oxide (ITO), a conductive ceramic substance that is deposited in a micro-thin layer on a soft plastic film called polyethylene terephthalate (PET), which is then used to detect touch input in conjunction with a similar layer on a hard, inflexible substrate counterpoised below the film. This ITO/PET layer degrades from repeated touch impact, due to the flexing of the PET material into a radiused curve from the user's finger or, in the more severe case, by a stylus such as used with PDAs and similar devices. This flexing into a curved shape causes microscopic cracks to occur in the brittle ITO material as shown in Fig. 2, initially creating spots of poor or no contact and eventually spreading out to disable functionality over larger areas.

An interesting phenomenon that occurs with heavy stylus use is the requirement for increased pressure at a developing failure spot, typically at a location that requires repetitive touches, such as a response box ("Tap OK to Proceed"). Initial ITO wear causes poor contact, so more pressure is exerted by the user, which increases the rate of wear. This vicious cycle escalates until catastrophic failure occurs. Naturally, OEMs and end users have a strong desire to see a countermeasure developed to mitigate this problem as well as other similar wear factors.

The application of ITO into a resistive touch device also requires a high-vacuum deposition process that is complex, environmentally unfriendly, and expensive. For many years, there has been a need and a desire to develop a flexible, transparent touch con-

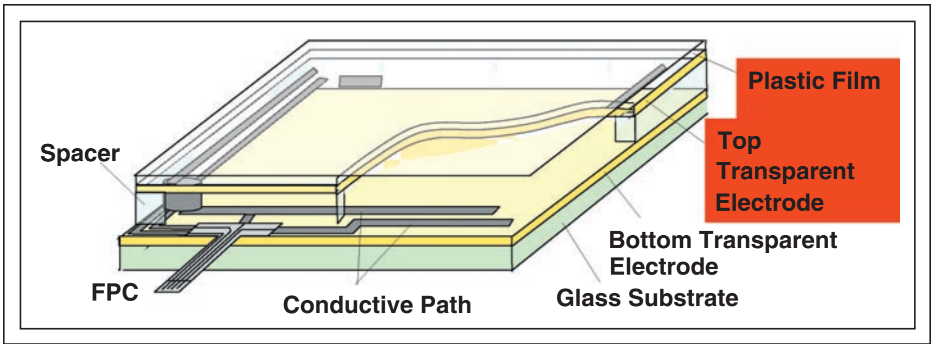

Fig. 1: *A structural cross section of a typical resistive touch panel.*

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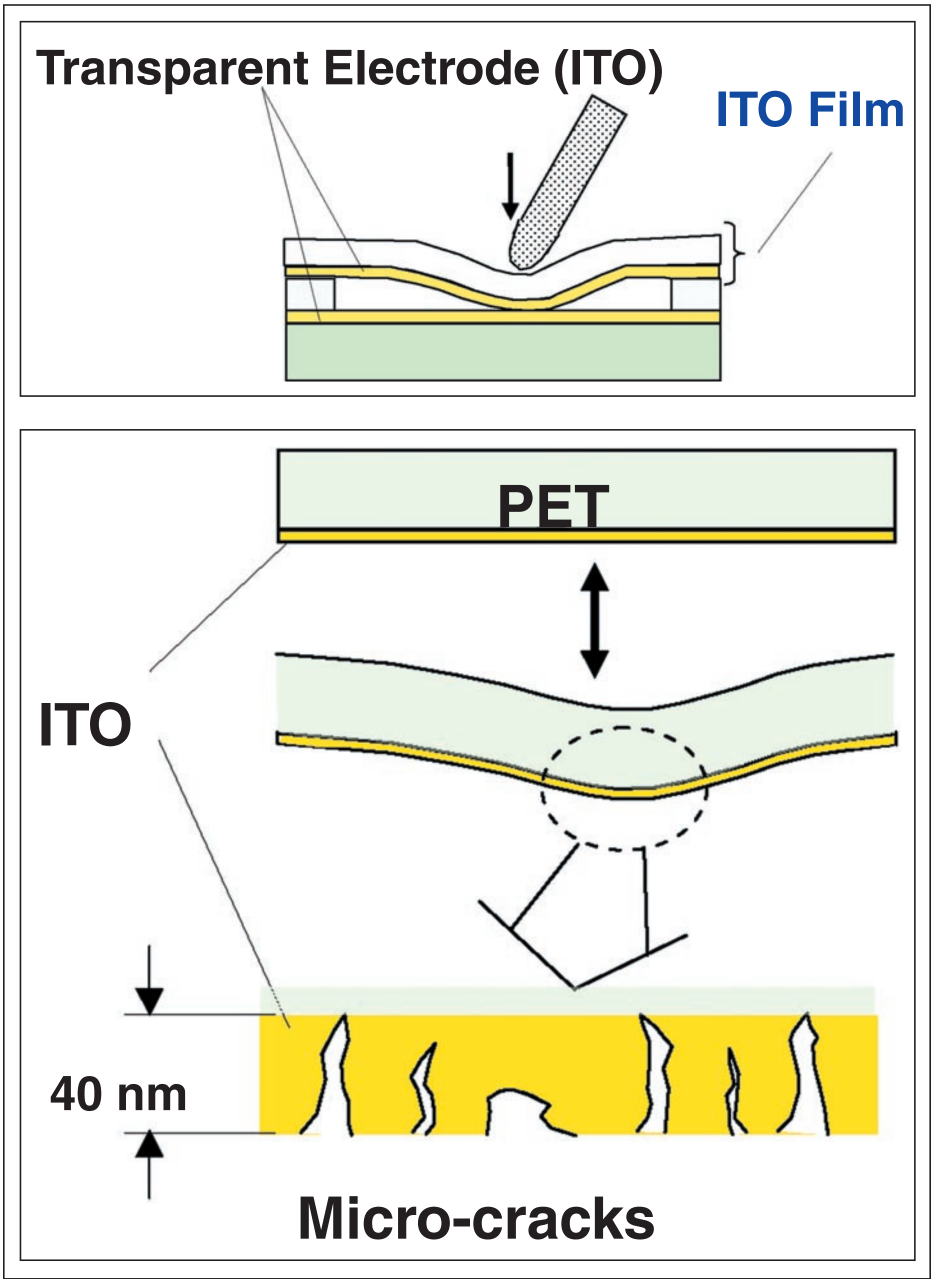

Fig. 2: Micro-cracking of ITO due to use of stylus.

ductor that would provide a more durable touch surface and be relatively easy to apply to plastic substrates. These features would increase the life of the resistive touch panel, allowing it to be used in more-rugged applications than current resistive touch panels.

Conductive Polymers

Organic chemistry has long held promise as a potential source of the desired material. Conductive polymers have been researched for more than 10 years as a possible solution, primarily due to their inherent flexibility as a plastic substance. Along the way, many basic materials challenges have been met and overcome. However, it was not until three scientists collaborating on a project discovered how to orient the molecular structure by the addition of selected impurities that it became possible to reliably achieve a uniform resistance and current flow across an area. Such was the significance of their discovery that they were awarded the Nobel Prize for Chemistry in 2000.[1]

Developing the conductive polymer material was a formidable undertaking, and using it to make a touch panel has not been an easy task either. Early on, it was discovered that these polymers were conductive, and that variations in the conductivity were possible by varying the volume of the material, much the same as with any conductive substance, but no one understood how to control this property with any degree of consistency. Early experiments with constant width and varying thickness produced analogous results, but these results were not able to be reproduced in a reliable manner, and the electrical resistance of the polymer was significantly higher than is desirable for touch-panel use, on the order of 3.5 kΩ per square unit of area. It was also noted that the optical transmissivity was much less than ITO coatings of similar thickness, so reducing the coating thickness of the polymer became an obvious requirement.

Further research revealed that the randomness of the material's molecular pattern was the problem, and efforts were undertaken to bring order to the structure. After a significant investment of time, an additive material with a rod-like molecular structure was dis-

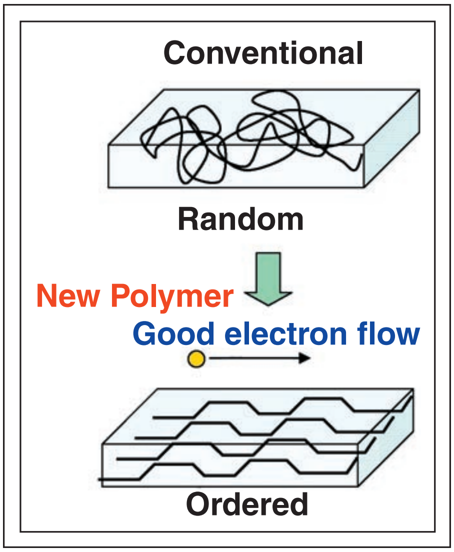

Fig. 3: Development of conductive polymer from unordered to ordered structure to produce proper electron flow.

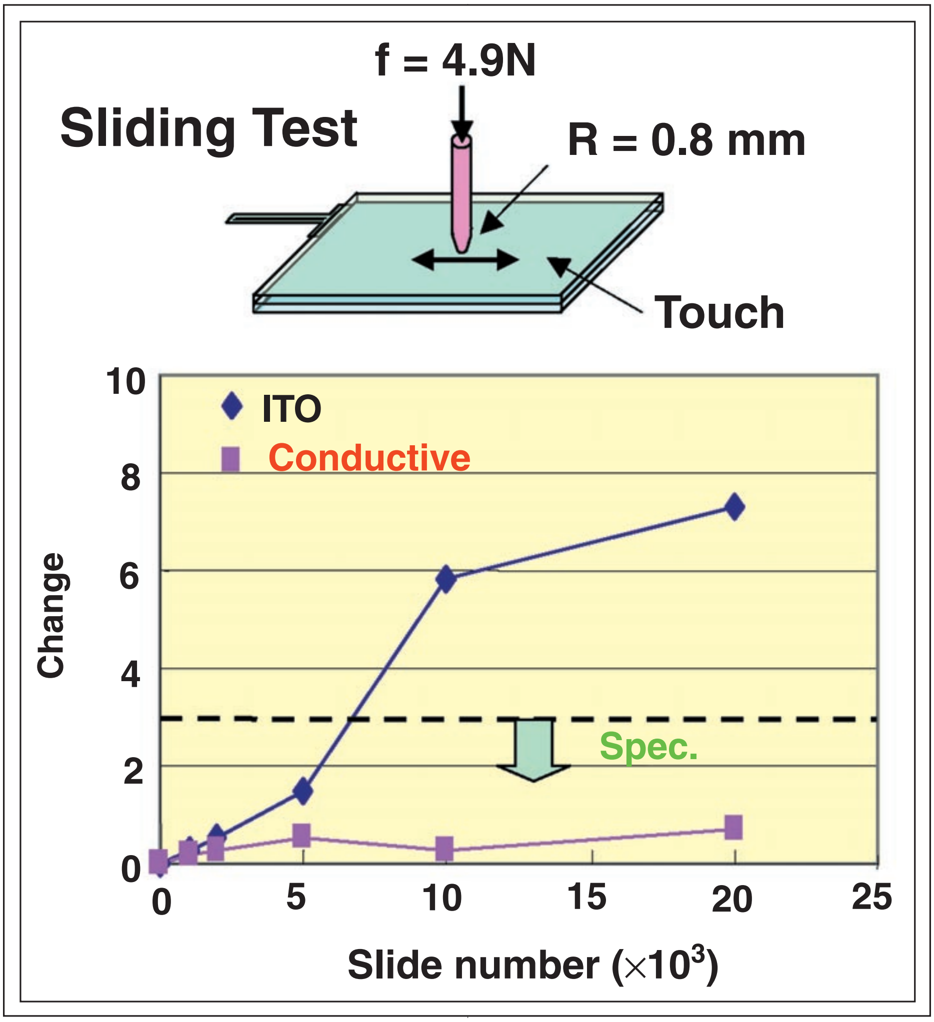

Fig. 4: *By performing a severe 35mm sliding test, a conductive-polymer touch panel demonstrated a lifetime that was five times greater than that for an ITO touch panel.*

covered that, when properly mixed in, caused the polymer molecules to become ordered (or aligned), increasing conductivity to more than twice previous levels (Fig. 3). With this improvement, a much thinner layer of polymer material, with lower resistance, could be achieved. Further development refined the use of this additive to create a high level of molecular consistency from batch to batch, opening the door to practical usage at a product level.

The next challenge was to develop the means and methods for applying the polymer to a flexible plastic-film surface. This polymer can be placed into solution using a water-based solvent, which then enables a simplified manufacturing process using roll coating, a well-understood process technology. Like any material, the polymer material has certain unique properties, one of which is the high alkalinity of the material in solution, and this must be considered in the process and equipment designs. This manufacturing process also provides environmental advantages, as the roll-coated PET film eliminates the large, expensive equipment and harsh chemicals associated with ITO vacuum deposition onto PET film.

Another major challenge was to create a constant polymer film thickness such that the end product has consistent electrical resistance and optical transmissivity values from batch to batch. This requires making the polymer layer thin enough that reasonable transparency is achieved, while simultaneously minimizing the electrical resistance that increases as the coating becomes thinner, an inversely proportional relationship. We strongly desire to achieve the same or better optical transmissivity as ITO across the 400–700-nm band of the visible spectrum, and to concurrently achieve less than 800 Ω per square unit area of electrical resistance, with the improvement of these key specification areas a continuing goal.

The continuing development by Fujitsu Laboratories, in partnership with Fujitsu Components, Ltd. in Japan, has resulted in an organic, conductive polymer material that can be readily applied to a PET film substrate. With this highly functional PET film, a robust resistive touch panel can be constructed at a cost only slightly greater than that of current ITO-based panels.

The inherent flexibility of the polymer is much less susceptible to damage when the PET film is flexed, even when a stylus creates a small radius bend in the PET film (Fig. 4). Clear evidence of this difference is provided in the accompanying scanning electron microscopy (SEM) images of material surface condition at the conclusion of wear testing – the ITO is clearly damaged, whereas the polymer material shows virtually no wear (Fig. 5).

When combined with a standard ITO-coated glass substrate, the resulting resistive-touch-panel structure has about 1% less transmissivity across the 400–700-nm portion of the spectrum, similar resistance per square unit area, and more than five times the operational life, when compared to a panel made with traditional ITO-coated PET film and ITO-coated glass. Another beneficial feature is that the transparent yellowish hue normally visible with ITO-coated PET film becomes a transparent blue-gray with the polymer-coated PET film, which tends to enhance LCD color image appearance.

While the combined achievements to date are very significant, development efforts will continue towards even higher-performance materials and products. Eventually, touch panels will be fabricated by using conductive polymer-coated glass substrates. However, the durability of ITO-coated glass is quite good, so the need for replacement is not nearly as great as for ITO-coated PET film.

Conductive-polymer panels have been demonstrated publicly for more than a year,

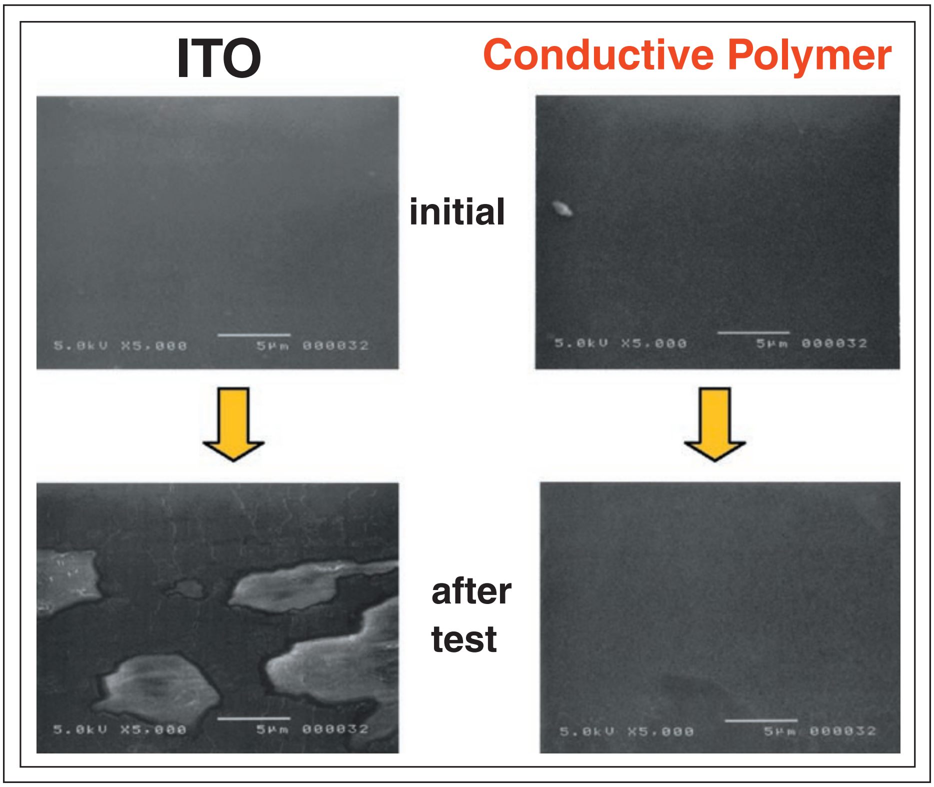

Fig. 5: *Scanning electron microscopy (SEM) photographs of ITO versus polymer wear. The conductive polymer shows no damage after 2×10^5 slides.*

and they are now in the final test phase prior to commencement of production. The current plan is to begin general sampling and customer field experience phases by January 2007, with the goal of full production by mid-2007.

References

[1]October 10, 2000. Alan J. Heeger, University of California, Santa Barbara, CA; Alan G. MacDiarmid, University of Pennsylvania, Philadelphia, PA; and Hideki Shirakawa, University of Tsukuba, Japan. ■