High Accuracy Single Layer Touch Sensors Roll to Roll Processed on Plastic Substrates

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Abstract

We present a metal mesh touch sensor fabricated by roll to roll printing on a thin flexible plastic substrate. High transparency and conductivity of the single layer device facilitate large sensor sizes and high accuracy. Due to mutual capacitance sensing the screen supports multi touch operation. Precision measurements performed on a xyz linear stage equipped with a metal test finger provide data for linearity and point accuracy of the touch sensor. The point accuracy is further analyzed statistically and shows a typical deviation of 0.46mm for a 3 inch x 2 inch one layer touchscreen.

Introduction

The capacitive touchscreen market is strongly growing since the iphone came up in 2007 and nowadays touch is integrated in numerous applications [1]. Common touch technologies are self-capacitance and mutual capacitance, differing rather in the way of operation than in their hardware. Both technologies are based on an x-y-pattern of conductive material that forms intersections. Self-capacitance sensors measure the capacitance of each column and row separately against a common potential e.g. ground. A finger touch changes this capacitance by introducing the additional capacitance of the body. Drawback of this technique is the emergence of ghost points in for example two-touch applications, since two activated rows and columns give four intersection points and the controller cannot decide which coordinates belong together.

Instead of sensing each row and column individually, mutual capacitance measures the capacitance between a row and a column at each intersection point, thus a row and a column at once. Since each intersection is sensed individually this method avoids ghost points. Although, addressing all intersection points takes more time than addressing all rows and columns, which slows down the response time, mutual capacitance allows for higher resolution and is less sensitive to electromagnetic interference (EMI) [2]. Furthermore most recent touch-technology developments include the possibility of multi touch which indicates a trend to mutual capacitance applications.

Most common touchscreen hardware technology is based on ITO coated glass panels, but also ITO on film becomes important for flexible solutions. Although ITO presents one of the best compromises between high transparency and low resistivity, its application in larger thin film flexible devices is sophisticated. This results from the brittleness of ITO layers of higher thickness, which are required to gain conductivities high enough for large screens. This brittleness makes the ITO layer prone to cracks upon bending.

In this paper we present a 3 inch x 2 inch single layer touchscreen based on a metal mesh which is roll to roll processed on plastic film (PolyTC) [3]. As illustrated in Fig. 1 the metal layer can be printed with a resolution of 10µm [4], which is below the resolving power of the human eye and thus appears transparent. Afterwards contact enhancements and a protection layer is coated on top of the metal mesh. The completed mutual capacitance sensor supports multi touch applications, is bendable and compatible with conventional image processing controllers [5].

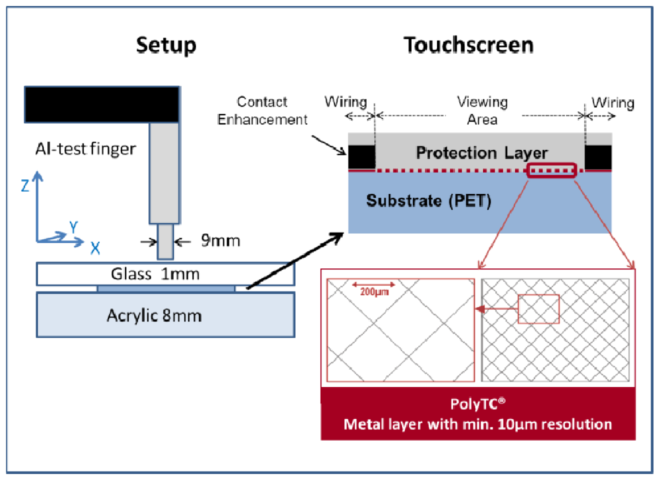

Figure 1. Setup for accuracy measurements: Illustrated are the xyz-stage with metal test finger and a cross section of the metal mesh touchscreen based on PolyTC [3]

Measurement Procedure

We applied a xyz-stage (Movetec Wacht GmbH) equipped with a 9mm aluminum test-finger for scanning (see Fig. 1). The touchscreen is placed on an 8mm thick acrylic sheet mounted on the table of the stage. For scanning a thin protection glass sheet (thickness = 1mm) is fixed on top of the screen and the test-finger is adjusted approximately 0.1 – 0.5mm above the protection glass. During the test procedure the finger sweeps the screen step by step in x-direction without lift off in z-direction. At the end of each row the finger moves back to the start and shifts in y-direction to the next row. The touchscreen controller is synchronized to the stage and starts data recording 0.5s after the test-finger approaches a particular position.

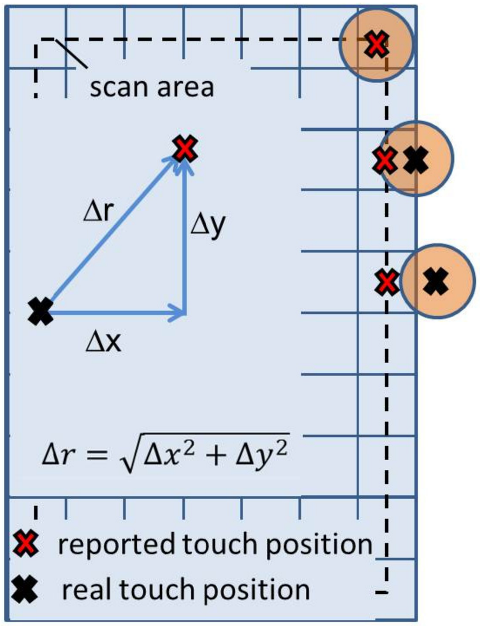

Figure 2. *Schematic representation of the touchscreen with sensor fields and reduced area of scanning. The outmost position of the center of the test finger during the scan is indicated by the dashed line. The circular patches illustrate finger touches at the edge of the screen and how the real touch position deviates from the one reported from the sensor. If the touch position stays entirely in the screen, as indicated by the upper patch, edge effects are small and reported and real touch position coincide within the accuracy of the sensor. The arrows show how the accuracy is determined from the measured x and y data.*

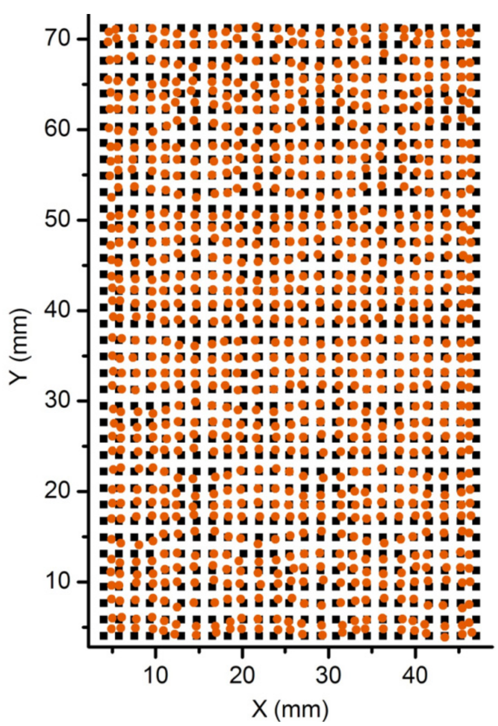

Figure 3. *Comparison of the test finger positions (black squares) and touchscreen reported positions from the controller.*

Edge Correction

As illustrated in Fig. 2 the accuracy of a touchscreen is remarkably reduced at the edges due to the lack of sensor fields. A finger touch in the center region of the screen usually activates signals of numerous buttons that can be interpolated to give a precise position. However, in close vicinity to the border interpolation becomes impossible in the direction perpendicular to the edge and the position determination becomes inaccurate. Edge effects can be avoided if the test-finger stays entirely within the touch panel as indicated by the upper circular patch in Fig. 2. Hence, the scan area (dashed line in Fig. 2) is reduced by 4mm with respect to the edges, which is approximately the radius of the test-finger. As indicated in Fig. 2 the absolute accuracy Δr is determined by the deviation in x and y direction between the xyz-stage test-finger position (x_{stage}, y_{stage}) and the position reported from the touchscreen controller (x_{contr}, y_{contr}) with $\Delta x = x_{contr} - x_{stage}$ and $\Delta y = y_{contr} - y_{stage}$.

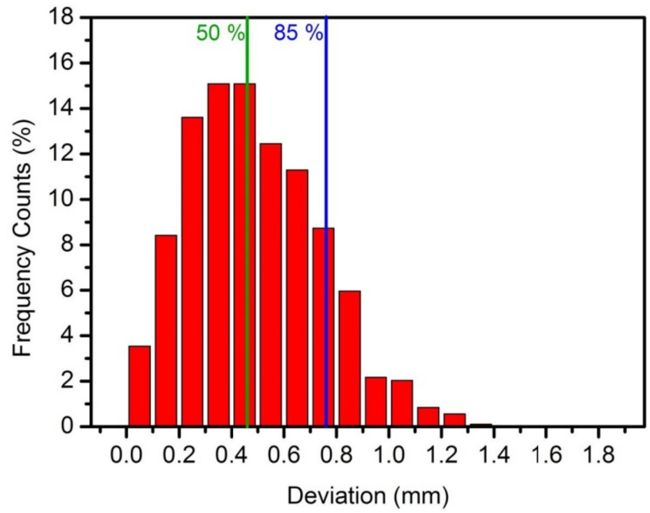

Figure 4. *Statistics of accuracy measurements Δr of the data presented in Fig. 5. The green and blue markers indicate the upper accuracy limit of 50% and 85% of all data points.*

Results

Fig. 3 shows the test-finger position (black squares) in comparison to the position reported by the touchscreen controller (orange dots). The data of 25 x 38 points in x- and y-direction respectively were recorded across the screen. This corresponds to a point to point distance of 1.72mm in x- and 1.77mm in y-direction. Half of the reported data points match the finger position within 0.46mm deviation (see Fig. 4). Precision deteriorates slightly close to the borders of the screen and some wavy features appear mostly at the top and the bottom of the screen. The statistics in Fig. 4 contain data collected from three comparable measurements for enhanced reliability. 85% of the reported points show a deviation less than 0.76mm. The typical accuracy of the screen can be expressed through the median of the statistical data, which yields 0.46mm. The absolute accuracy is illustrated in the color plot in Fig. 5. It stays below 1.4mm for the entire scan area. The x- and y-linearity, depicted in Fig. 6 and 7 respectively, reflects the typical accuracy of the screen. Obviously the linearity in x-direction is slightly enhanced as compared to the one in y-direction.

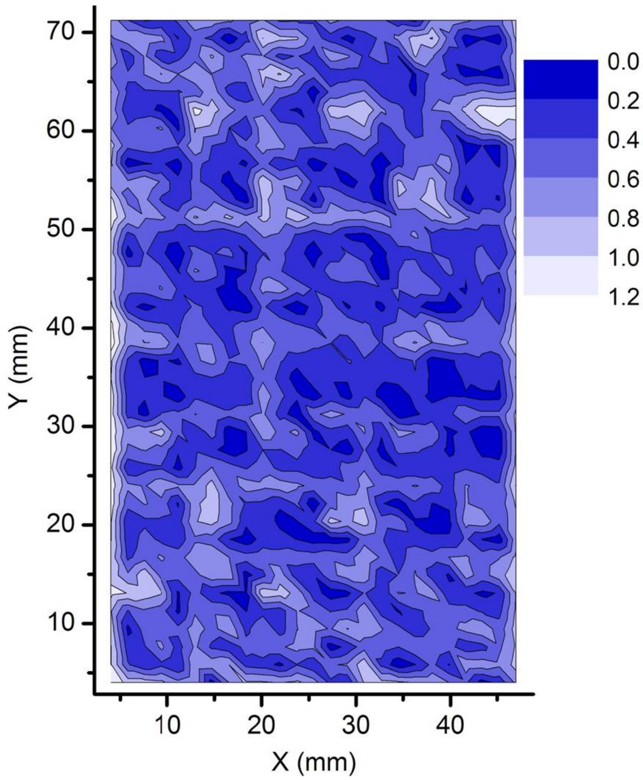

Figure 5. *Color plot of the absolute accuracy Δr (mm) as defined in Fig.2*

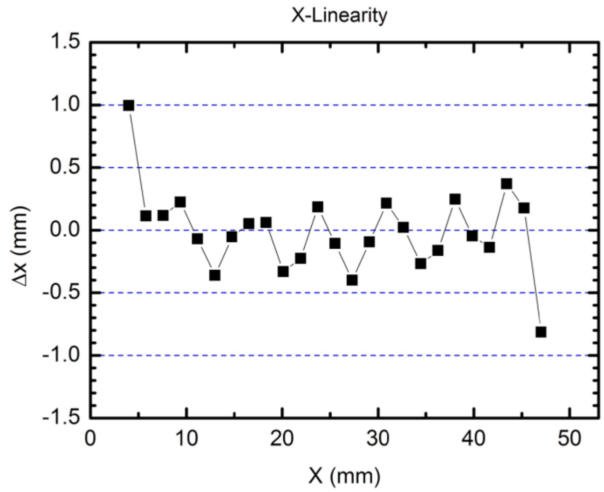

Figure 6. *X-Linearity at the center of the screen (at Y = 40.3 mm)*

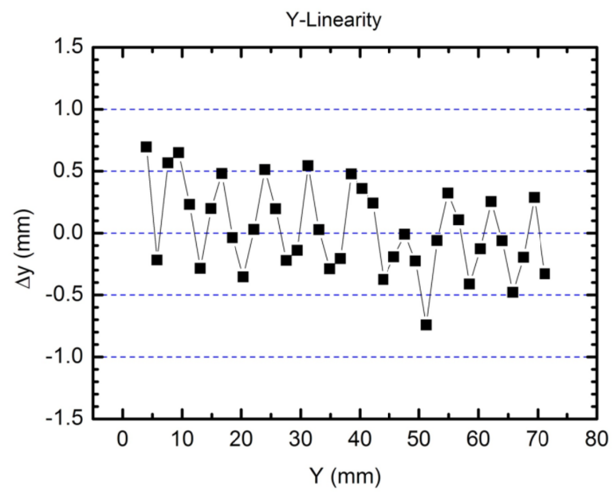

Figure 7. *Y-Linearity at the center of the screen (X = 25.5 mm)*

Conclusions

We presented a metal mesh touch sensor roll to roll printed on plastic film, as a possible replacement for ITO touchscreens. Performance measurements with a xyz stage show a typical accuracy of 0.46mm for the single layer sensor and a maximum deviation of 1.4mm. The sensor based on PolyTC is bendable without the risk of cracks and offers the possibility to produce large screens with a high conductivity metal mesh. Multi touch operation is facilitated due to mutual capacitance sensing. Furthermore, the accuracy of the presented one layer sensor can be significantly enhanced by introducing a second layer to the sensor.

References

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Author Biography

Sebastian Schaefer studied physics at "Freie Universität Berlin", where he received a doctorial grade for his work on "spin-dependent processes in organic devices" in Dr. Harneit´s spintronics group in 2010. The same year he joined the group of Prof. D. Neher at "Universität Potsdam" working on inorganic/organic hybrid solar cells. Since 2012 he works as research scientist at PolyIC.

Dietmar Zipperer studied physics at the University of York, UK and the University of Erlangen-Nuremberg, Germany, where he received a PhD for his work on polymer rectifiers in 2004. He has worked for Siemens Corporate Technology, Erlangen, before he joined PolyIC at the formation of the company. He works as senior research scientist on the electrical characterization of printed electronics.