Advancements in Touch Panel Modules through Atmel XSense® and 0.4 mm Corning® Gorilla® Glass

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Abstract: The Drive for Thinner and Lighter Touch Sensor Sub-systems

Since 2011 the average smartphone and tablet device thickness (z-height) has decreased by approximately 20%. Though there are practical sizes and form factors for mobile devices, the central design goal for mobile devices is to be sleek...thin...lightweight.

Advancements in semiconductors, electronic packaging, memory capacity, RF communication components, and display modules have enabled industrial designers to substantially increase the density of features and functions within the shrinking volume of a mobile device. Obviously, the choice of structural materials plays an important role in reducing the thickness and weight; designers have also identified the battery pack, liquid crystal display module (LCDM), and touch panel module (TPM) as opportunities to drive excess weight and thickness out of the device. Designers are leveraging the significant improvements in increased energy density of lithium ion batteries and can comfortably reduce the power pack’s z-height without compromising battery life. Developments in thinner TFT glass substrates have also helped reduce the z-height of modern-day LCDMs. Interestingly, the touch panel module (cover glass and capacitive touch sensor) can also afford industrial designers volume reduction by decreasing the glass substrate thickness. Still there are misconceptions about the reliability of a thinner cover glass substrate and its utility with capacitive touch sensors made using transparent conductors, such as ITO or other metal oxides. Novel, flexible touch circuit designs and processes developed by Atmel, in addition to advancements in thin, chemically-strengthened glass by Corning can be readily combined to very effectively address concerns about electrical and mechanical functionality of new wafer-thin TPMs. We will describe the respective key product attributes of Atmel’s XSense® film-based, capacitive touch sensor, 0.4 mm Corning® Gorilla® Glass, and their reciprocal influence to reduce the z-height and weight in touch-enabled displays...all while greatly improving the electrical functionality of the touch module above the state-of-the-art projected capacitive touch (PCT) circuit designs, such as one-glass sensor (OGS) or bi-layered Indium-Tin Oxide (ITO) films.

Challenges with Reducing Weight and Size
Borders and Touch Sensor Signal Tracking

To some extent, the touch display’s dimensional outline is governed by the touch panel because the signal traces for the capacitive touch sensor occupy a significant portion of the border. The predominant technology used in today’s capacitive touch sensors is ITO (Indium Tin Oxide) due to its optical transparency. However ITO has a significant shortcoming in its high sheet resistance ranging from 50 to 340 Ω/sq. Because of this, the electrodes in the touch sensor matrix have a relatively high resistance and must therefore use redundant sensor traces (“double-connected”) to ensure satisfactory touch sensor performance. While the primary role of cover lens on the touch module is to provide a physical user interface, it is also burdened with the task of masking these wide electrical conduits. Consider for example the display glass for typical 10.1” tablet illustrated in Figure 2; almost 1/3 of the cover lens surface area is occupied by the border bezel area. As a result, system designers must make the system frame wider to accommodate the larger lens even if the extra space is not actually needed for
the rest of the device. Thus, this superfluous area adds weight and cost to the system without any direct functional benefit to the end user.

By reducing the borders by 1 cm on each side of a 10.1” tablet, touch surface space utilization could improve from 67% to over 80%. At the same time the weight of the touch sensor could be reduced by almost 20% (assuming the same glass thickness) and the system frame size and weight will also be reduced accordingly. In addition to “double-connected” sensor tracking, the signal tracks for GFF sensors are silkscreen printed and are generally limited to 100um pitch (50µm width, 50µm gap) with a 300µm alignment tolerance. This silkscreen process used to make ITO film sensors results in wider tracks, wider contact bars, and when combined with the need to double-connect the electrodes all add up to greatly increase the size of the sensor border. Because of this, ITO-based glass-film-film (GFF) sensors generally have the widest sensor borders of the touch sensors most commonly used.

However there are emerging views in light of new cover glass design elements and process technologies which challenge this accepted position on the manufacturability and electrical design of OGS circuitry. Notably, while OGS sensors permit very fine sensor track and bond pad pitches on rigid glass sensor substrates, the circuitry relies on a combination of double routing, wide connection bars, and wide lens cut tolerances. These design elements unfortunately conspire to create wider overall border widths for OGS even though the track pitch by itself may be somewhat narrower.

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Given its scaled economy OGS manufacturing practices are considered by most industry experts as a good process for moderately priced, high performance touch panel modules.
XSense® Enables Narrow Sensor Borders

To meet the need for narrow touch sensor borders, there are new technologies coming to market that provide low sheet resistance and very tight alignment tolerances to reduce the amount of space needed for sensor tracking along the edges. XSense® is a copper-based metal mesh that has a sheet resistance of <10 Ω/sq, far lower than other touch sensor materials. This low sheet resistance permits single-connected sensor track routing even on larger touch sensors and vastly reduces the amount of space occupied by tracking by cutting the number required in half compared to ITO. Additionally, XSense® tracking is currently 30% slimmer than ITO silver tracking with a 70µm pitch (30µm track, 40µm gap) and will be moving to an even finer 40µm pitch shortly. XSense®-based industrial designs are targeting narrow bezel form factors and are able to achieve a total border width space of less than 5mm between the LCD active area and the edge of the cover lens. With such narrow border form factors, it will be possible to place larger displays in smaller system frames to make maximum use of usable display area while minimizing the size and weight of the surrounding system. For example, it will be possible to place a 12.5” diagonal display in a frame that would have been used for an 11.6” display in earlier generations.

As a result of the more precise manufacturing process and its more favorable electrical properties, XSense® metal mesh touch sensor technology can help drive product designs that provide larger screens in smaller overall form factors without sacrificing touch performance.

Thickness Reduction and Retained Strength of Thin Corning® Gorilla® Glass Lenses

Consider the various embodiments of the touch sensor stacks in Figure 5. These variants are comprised of a combination of cover glass, thin polymeric film (50-100 µm), optically clear adhesive (OCA) (~25 µm), and a patterned conductive layer (<1 µm). Though not to scale in Figure 5, it is apparent that the cover lens is the largest contributor to thickness in the touch sensor stack. There are two key concerns over reducing the thickness of the cover lens: durability and multi-touch performance. Corning® Gorilla® Glass product suite features the industry’s thinnest and most durable chemically-strengthened cover glass. Corning’s fusion draw infrastructure is capable of producing wide sheets of glass (>3m) at thicknesses less than the width of a human hair with very fine thickness tolerances. To date the thinnest Corning® Gorilla® Glass 3 product is available at 0.4 mm.

This immoderately thin glass possesses the same properties (thermal, chemical, optical, and physical) as the more common thicker sheets of Corning® Gorilla® Glass 3. Additionally, this ultra-thin Corning® Gorilla® Glass can be chemically strengthened to compressive stress values greater than 0.8 GPa to depths greater than 35 µm. More importantly, this thinner substrate also exhibits Corning’s proprietary NDR™ and retained strength attributes consumers and OEMs value. These features mitigate damage from scratches and chips while exhibiting high retained strength after damage is imparted to the surface. When compared to the common 0.7 mm lens thickness this thinner Corning® Gorilla® Glass product can
substantially reduce the Z-height of the touch sensor module by 43% without compromising the mechanical reliability of the glass. Various methods to vet the native damage resistance of 0.4 mm GG3 are illustrated in Table 2.

### Table 2. Array of Scratch and Indentation Damage

<table>
<thead>
<tr>
<th></th>
<th>SLG 0.7 mm CS = 586 MPa DOL = 9 mm</th>
<th>0.4 mm GG3 with NDR™ CS = 858 MPa DOL = 45 mm</th>
<th>GG3 0.4 mm CS = 856 MPa DOL = 39 mm</th>
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<tbody>
<tr>
<td><strong>Vickers Indentation Damage</strong></td>
<td></td>
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<td></td>
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<tr>
<td>0.6 kg load applied</td>
<td>2320</td>
<td></td>
<td></td>
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<tr>
<td>8 kg load applied</td>
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<tr>
<td><strong>Knoop Scratch Damage</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 N load applied</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7.0 N load applied</td>
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Here, diamond tools (Knoop or Vickers) are used to impart damage to the surface under well-defined loads. As the load increases, a damage threshold is defined at the onset of lateral cracking within the glass. These first two methods, scratch and indentation damage thresholds on 0.4 mm Corning® Gorilla® Glass and 0.7 mm chemically-strengthened soda-lime glass (SLG), are benchmarked in the micrographs in Table 1. While damage resistance from sharp contact is important to Corning® Gorilla® Glass, the extrinsic retained-strength has proven indispensable to OEMs and their end-users. Hence, the third method used to characterize the retained strength after damage was derived from the ASTM standard C1499. In this context, the glass is purposefully damaged using a diamond scribe or silicon carbide grit and biaxially loaded per the C1499 standard until the sample yields to the applied stress. Table 3 summarizes the metrics used to vet the durability of cover glass, including the four-point bend modulus of rupture. Here, the 0.4 mm Corning® Gorilla® Glass is compared to thicker glass specimens, including Corning glass compositions which predate Corning® Gorilla® Glass 3. As evidenced in this table, the 0.4 mm Corning® Gorilla® Glass 3 outperforms thicker chemically-strengthened soda-lime glass and rivals its predecessors, thereby validating the toughness and durability of this form factor.

### Advancements in Electrical Performance Enabled by XSense®

In addition to mechanical strength, there are electrical performance issues with thin cover lenses seen mostly in an effect called re-transmission, or sometimes referred to as "ghosting".

![Figure 6. Multi-Touch Re-Transmission (Ghosting) Effect](image-url)
Re-transmission occurs most often when the device is in a floating electrical state, such as when it is unplugged and sitting on a desktop. When the user applies two or more touches to the screen, the pulses from one sensor line transmit a small amount of charge through a user’s fingers depositing it onto another electrode as shown in Figure 6. This extra charge results in an effect known as “anti-touch” and can be seen as a large negative touch signal.

When an area that is experiencing anti-touch coincides with a real touch, the signals cancel each other out and the SNR (signal to noise ratio) is substantially reduced. If the anti-touch signal is large enough, this can result in touch detection failure. With ITO-based touch sensors such as GFF or GF2 co-planar sensors as the cover lens thickness is reduced, the amplitude of the anti-touch false signals increases resulting in a substantial reduction of SNR and worsening multi-touch performance.

OGS-based touch modules also utilize ITO as their sensor matrix material, and much like GFF and other ITO-based film sensors are also susceptible to multi-touch, retransmission issues. Though very mature, the OGS manufacturing process has encountered challenges to make significant advancements to increase the conductivity of ITO or to lower the modulus of the conductive oxide to enable larger touch or contoured touch panels. As a result, OGS touch panels will be limited to flat module designs less than 13 diagonal-inches. However, the combination of XSense® metal mesh sensor material and Corning® Gorilla® Glass effectively addresses multi-touch retransmission issues while without compromising reliability, performance, and design flexibility. The high dielectric constant ($\varepsilon_r \approx 9$ @ 200 KHz < $f < 1$MHz) of Corning® Gorilla® Glass paired with Atmel XSense® unique sensor design vastly reduce anti-touch from retransmission.

**Figure 7.** Anti-Touch resulting from Re-Transmission (Ghosting) on ITO

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**Figure 8.** XSense® Re-Transmission on 0.4mm Corning® Gorilla® Glass

This combination of properties delivers SNR levels that were previously unattainable on a touch panel with a thin 0.4mm cover lens. Furthermore, the ambient process temperatures of the XSense®-to-Corning® Gorilla® Glass lamination procedure expands the selection of decorative lens border colors beyond carbon black inks. Finally, the sheet resistance (<10 $\Omega$/sq) of the sensor matrix for XSense® is unaffected by the film’s intrinsic flexibility; as a result, XSense® can be easily applied to curved or contoured cover glass surfaces with small bend radii.
Conclusion: Design Challenges are Surmountable

Advancements in metal mesh touch sensor technologies, film substrates, deposition processes, glass composition, and glass forming processes have made it possible to substantially reduce the overall sensor stack and not compromise performance. Corning has been a perennial industry leader in the manufacture of strengthened glass for consumer electronics applications and is now innovating with ever-thinner cover lenses with 0.4 mm Corning® Gorilla® Glass 3. This latest product provides unmatched optical clarity coupled with the durability that the consumer device industry demands. To further reduce the thickness of the sensor stack, XSense® is only a single layer of 50µm film with the transmitter and receiver sensor circuit patterns deposited on either side. This configuration not only greatly improves TX/RX electrode alignment tolerances, but when used in conjunction with the thin cover lens XSense® helps reduce the sensor stack by approximately 32% compared to the 0.7 mm OGS configuration. Because XSense® metal mesh sensor technology has more uniform touch surface coverage than ITO, the unwanted stray charge that causes large anti-touch signals is substantially reduced. As a result, even with very thin cover lenses, multi-touch performance with XSense® is not significantly affected by re-transmission. New technologies from Corning and Atmel are enabling industrial design engineers to push mobile device design aesthetics to new heights; XSense® and 0.4 mm Corning® Gorilla® Glass are facilitating new designs by virtue of their properties that permit use of tighter mechanical dimensions than ever before without compromising the mechanical and electrical performance required by the CE industry. Ultimately, these products allow device manufacturers to create products that are ever more portable and aesthetically attractive to lure fickle consumers. Style is as important as function and the touch module is not only the primary point of interaction with the user, but is often the sub-system around which the rest of the device is designed. Fortunately, XSense® and Corning® Gorilla® Glass can help system designers meet the market demand to create consumer devices that are ever lighter with sleeker lines.

For more information:
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