Property of Cover Glass in Capacitive Touch Screen
Corning Incorporated

Founded:
1851

Headquarters:
Corning, New York

Employees:
Approximately 25,000 worldwide

2007 Sales:
$5.86 Billion

Fortune 500 Rank:
417

• Corning is the world leader in specialty glass and ceramics.

• We create and make keystone components that enable high-technology systems for consumer electronics, mobile emissions control, telecommunications and life sciences.

• We succeed through sustained investment in R&D, over 150 years of materials science and process engineering knowledge, and a distinctive collaborative culture.
## Corning market segments and additional operations

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<th>Life Sciences</th>
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<td>Telecom Components</td>
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<td>Specialty Glass</td>
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**Gorilla™ Glass**

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A culture of innovation

- Glass envelope for Thomas Edison’s light bulb (1879)
- Heat-resistant Pyrex® glass (1915)
- Processes for mass producing the television bulb (1934)
- Fusion draw process (1947)
- Ceramic substrates for automotive catalytic converters (1952)
- First low-loss optical fiber (1960)
- High-throughput label-free screening platform for drug discovery (1970)
- AMLCD glass for computers and large screen TVs (1972)
- Glass ceramics (1972)
- Dow Corning silicones (1984)
- Ceramic substrates for automotive catalytic converters (2006)
- Ceramic substrates for automotive catalytic converters (2006)
- AMLCD glass for computers and large screen TVs (2006)
Capacitive Touch Screen Structure
Current Tech

Surface Capacitive is currently the 2nd largest technology

• How it works
  – ITO conducts a continuous electrical current across the sensor
  – Finger touch alters the capacitance field
  – The resulting distortion is measured by circuits at each corner of the screen

• Advantages: durability

• Disadvantages: requires finger touch

• Applications: retail, game/entertainment, industrial/financial

Source: 3M
Projected Capacitive becomes more popular due to iPhone, and can be used for both small and large panels

- **How it works**
  - Consists of a sensor grid of micro-fine wires laminated between two layers of protective glass
  - Touch location calculated from changing electrical characteristics of the sensor grid
  - Can be installed behind other materials, e.g. vandal-resistant glass
  - Finger does not have to be in physical contact

- **Advantages:** durability, environmental tolerance
- **Disadvantage:** high cost
- **Applications:** mobile phone, retail

Source: Elo
Design Considerations
for
Cover Glass
Typical glass surface damage from “used” devices

Scratches

Scratch with Lateral Cracks

Impacts

~ 20 micron depth

~ 40 micron depth
Surface damages cause glass failure

Summary of Failure Analysis of Broken Devices (Fieldreturned and drop tested):

- **Major** cause of fracture – **Impact damage**
  - Sharp impacts create flaws that cause failure
    - Keys, pens, gravel, etc.

- Second major cause - **Scratch-related damage**
  - Fracture initiated from a flaw within the scratch

- Over-stress alone does not cause failure
  - Strengthened glass deflects substantially before failure
    - Devices do not have room for so much deflection
    - Failure stresses are never reached

![Impact event](image1)
- Origin
- Depth of damage 15 µm

![Scratch event](image2)
- Depth of scratch 25-40 µm
Design considerations

- Define “Design strength”
- Strength of brittle materials represented by Weibull statistics
  - Select low (1%?) probability of failure strength
  - Apply a factor of safety
- Strength of glass decreases when damaged
  - In-use strength measured by Abraded Strength
  - Abrasion per ASTM C158
- Input requirements from failure-mode analysis
Requirements for glass in mobile devices

1. Tight Strength distributions
2. High retained (abraded) strength
3. Increased resistance to impact damage
4. Greater resistance to scratching
Gorilla™ Glass
What is Corning Gorilla™ Glass?

• Alumino-silicate thin sheet glass
  – Capable of high strength and reliability when chemically tempered with an ion-exchange process

• Formed using Corning’s proprietary fusion draw process
  – Highest quality of as-drawn glass sheets in the world
  – Thickness 0.7 mm – 2.0 mm as drawn

• Corning glass is ideal for display cover windows
  – Touch screens
  – Mobile phones
  – Other mobile electronic devices
Key benefits

- Glass designed for deep, protective, ion-exchange layer
- High strength and reliability
- Ability to sustain impacts without damage
- Retains high strength after use and abuse
- Pristine glass sheet surface
- Scalable sheet sizes for optimal throughput
Gorilla™ Glass combines unique capabilities

Proprietary fusion forming process: superior surface, scalability, reliability

Innovative glass composition optimized for chemical tempering

Gorilla Glass
Fusion-formed for a pristine surface

Roughness Measurement Results

<table>
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<th>Area 1</th>
<th>Area 2</th>
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<tbody>
<tr>
<td>RMS</td>
<td>0.29 nm</td>
<td>1.46 nm</td>
</tr>
<tr>
<td>Ra</td>
<td>0.23 nm</td>
<td>1.13 nm</td>
</tr>
<tr>
<td>Z-Range</td>
<td>4.23 nm</td>
<td>33.7 nm</td>
</tr>
</tbody>
</table>
What properties of glass provide these requirements?

- Flaws, damages and scratches on the surface reduce strength
- Enveloping compression layer of Gorilla™ Glass provides tight strength distributions
Gorilla™ Glass – ideally suited for protective covers for mobile displays

- **Highest degree of chemical strengthening**
- Tightest strength distribution
- Highly tolerant to in-use damage (high retained strength)
- Highest impact resistance
- Highest resistance to scratch
The ion-exchange process

KNO₃ bath

Glass surface

O₂
Si
Al
Na: 0.97Å
K: 1.33Å
What is chemical strengthening?

- Compressive stress and depth of layer (DOL) define the characteristics of chemical strengthening.

- Stress equilibrium will induce a tensile stress in the center of the sheet.

- Overcoming the compressive stress at the crack tip is necessary to initiate failure.
Gorilla™ Glass has the highest depth of layer (DOL)

- Degree of chemical strengthening is the development of the desired level of compressive stress (CS) over desired DOL
- Gorilla Glass can achieve DOL greater than typical damages/flaws depth
- Gorilla glass is designed for lower stress relaxation, higher DOL and high CS
Gorilla™ Glass has the highest CS at given DOL

- The predicted CS at 15 um and 25 um DOL is shown
- At deeper DOL, compressive stresses are significantly lower for the soda-lime glasses
Gorilla™ Glass – ideally suited for protective covers for mobile displays

- Highest degree of chemical strengthening

- **Tightest strength distribution**

- Highly tolerant to in-use damage

- Highest impact resistance

- Highest resistance to scratch
Gorilla™ Glass has tighter strength distribution

- Gorilla Glass shows the highest overall strength

Note: Edge strength is measured using 4-pt bend test
Gorilla™ Glass – ideally suited for protective covers for mobile displays

- Highest degree of chemical strengthening
- Tightest strength distribution
- **Highly tolerant to in-use damage**
  - Highest impact resistance
  - Highest resistance to scratch
Flaws induced during in-service life

- “In Use Flaws” can be simulated by abrading the surface
  - ASTM C158

- Measure strength after increasing levels of abrasion of glass surface
  - Ring-on-ring test method

Gorilla™  Soda Lime
Gorilla™ Glass retains significant strength after use

Higher “In Use” Strength

- “Contact force factor” combines abrasion pressure with grit diameter
- A deeper DOL protects the glass surface from in-use damage

![Graph showing relationship between contact force factor and strength (MPa)]
High retained strength is directly related to DOL

![Graph showing the relationship between DOL and strength with various samples labeled as IG3, Corning 18, Corning 31, Corning 45, and Corning 57. The graph includes data points indicating strength values for unabraded and abraded conditions.](image-url)
Gorilla™ Glass – ideally suited for protective covers for mobile displays

- Highest degree of chemical strengthening
- Tightest strength distribution
- Highly tolerant to in-use damage
- **Highest damage resistance**
- Highest resistance to scratch
Gorilla™ has increased resistance to impact damage

IOX Gorilla Glass

Indentation Flaw ‘A’ @ 4500 g - Corning

4500 g load

Vickers indenter: \( a = 68.00^\circ \)

IOX Soda Lime

Indentation Flaw ‘A’ @ 1500 g - Soda Lime

1500 g load
Gorilla™ Glass can bear up to 6X more load

Gorilla glass withstands 6X higher loads before radial cracks form
- Sharp object impact
Gorilla™ Glass is more resistant to lateral cracking

No lateral cracks were initiated in Gorilla glass for loads up to 6500 grams.
Gorilla™ Glass is more resistant to chipping

Gorilla glass inhibits formation of chips associated with indentation
Gorilla™ Glass – ideally suited for protective covers for mobile displays

- Highest degree of chemical strengthening
- Tightest strength distribution
- Highly tolerant to in-use damage
- Highest impact resistance
- **Highest resistance to scratch**
Gorilla™ Glass shows minimum collateral damage after scratch event
Gorilla™ Glass is designed for mobile devices

Optimal Mobile Device Performance

- Deepest Depth of Layer
- Maximum Surface Compressive Stress
- Highest Damage Tolerance
- Tightest Strength Distribution
- Minimum collateral Damage after scratch event
- Greatest Retained Strength

Optimal Mobile Device Performance
Thank You