Trends and applications of Nanotechnology on automotive glass. 
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1. Trends in automotive glass
2. Applications that use Nanotechnology
   - Glazings using soft coatings, examples
   - Glazings using hard coatings, examples
TRENDS IN AUTOMOTIVE GLASS

Are defined by:
- Regulations for greenhouse emissions.
- Car designers.
- Client requirements.

AUTOMOTIVE GLASS

- Safety
- Comfort
- Green value
- Aesthetics
Safety is a critical issue for automotive glass

Reduce occupant ejection

Handle interaction with water

Increase the field of view

Burglary prevention

Improve driver attention
Use windshield as a display for Advanced Driver Assistance

- Alert the driver from potential problems
- Better driving, avoid collisions and accidents

- Strict control of glass shape is important for the performance of the glass as display, but also in aesthetics.
Automotive glass plays a key role in aesthetics of cars

- Lower angles of installation
- Windshield extended into the roof
- Wrap around corners
- Complex bends
Complex shapes of glass bring new challenges to the glass industry

Complex curvatures cause distortions in glass leading to deflections of straight lines, this is a cause of product rejection!

Tolerance of glass shape and size are very important for other applications for improved driver comfort & safety.
Nanotechnology is mainly used to improve driver comfort.

- Cooler temperature at cabin + deicing
- Less road noise
- Allow communication systems
- Privacy glass
Regulations for greenhouse emissions are driving the growth of nanotechnology applications as solar control coatings.
Applications of nanotechnology in automotive glass

Automotive coatings

Soft coatings
- Need to be protected (mechanically and/or chemically).
- Used for laminated glazings (between 2 glass plies).
  - Windshields.
  - Laminated windows.
- Technology highly developed.
- Products already at high end market

Hard coatings
- Can be used at outdoor applications.
- Difficult penetration in the OEM because:
  - When lifetime product is lower than 10 years.
  - Reapplying is required.
  - Each client has different wear requirements.
- Products has better acceptance when it is sell apart and user apply it.
NANOTECHNOLOGY APPLICATIONS: Solar control

The solar control coatings are the most important for automotive

- Reduce the temperature inside the cabin.
- Reduce heat load
- Decrease fuel consumption.
- Visible light transmittance > 70%

Soft coating in a laminated product
NANOTECHNOLOGY APPLICATIONS: Solar control

**Sungate™**

- Reduce the temperature inside the cabin by 11°C when car is at 100 °C
- Reduce by 40% the time to cool down the cabin to a comfortable temperature.
- Films include metals, semiconductors and sacrificial films.
- Color can be tailored according to client specs.
- Blocks UV radiation
- Block IR radiation, allowing only 3% of passing radiation
- Increase a vehicle's fuel efficiency by up to 4 %.

Soft coating in a laminated product
NANOTECHNOLOGY APPLICATIONS: Deicing

Deicing of windshields by heating soft coatings provide:

- Reduced time to remove ice
- Reduce the possibilities of windshield damage during cleaning.
NANOTECHNOLOGY APPLICATIONS: Deicing

Weathermaster™
- Raise the temperature of the windshield by pass electric current through coating.
- Helps to deice the windshield.
- Controls fog.
- Designed to defrost the ice stock at the bottom of the windshield.
NANOTECHNOLOGY APPLICATIONS: Antenna

Hidden slot antennas on solar control coating of a windshield:

- Allows multiple communication system.
- Improved performance in UHF.
- Excellent aesthetics.
- Avoid a source of vandalism (the snapping of the antenna).
- Retain solar benefit.

Comfort

Soft coating in a laminated product

UHF:

- Cellular phone
- Wi-Fi
- Bluetooth
- TV
- Tyre Pressure Monitoring system
- GPS
- Remote key Entry
NANOTECHNOLOGY APPLICATIONS: Hard coatings

Hard coatings are important for application in tempered and laminated products. The wear of coatings used for outdoor applications can:

- Affect driver visibility.
- Reduce the lifetime of the product (durability).
The use of hydrophobic coatings on rainy-driving conditions:

- Improve visual acuity by 34% [1].
- Decrease response time to recognize a target by 25% [1].

Hydrophobic coatings can also be applied on the sidelite to easy removal of ice.
NANOTECHNOLOGY APPLICATIONS: Hydrophobic

Aquapel™
- Outdoor applications
- High durability, contact angle 118°.
- Resistant to UV radiation
- Resistant to thermal cycles

R: perfluoroalkyl radical as hydrophobic group.

Perfluoroalkyl silane film
Silica film
Glass
PVB
Glass

Safety
NANOTECHNOLOGY APPLICATIONS: Durability of TiO$_2$ based films

To ensure that driver visibility is not affected by the film damage that occur during the wear of glass is necessary to evaluate the film performance by using:

- Taber abrasion test (accelerated wear test)
- Define the haze value
  - This value determines the visibility that a driver experiences, it should be lower than 2.

Representation of the Taber abrasion test.

Taber test simulate 10 years of wiping of a windshield.
NANOTECHNOLOGY APPLICATIONS: Durability of TiO\textsubscript{2} based films

- The use of active TiO\textsubscript{2} films on glass requires the use of an alkalis barrier to avoid TiO2 poisoning.
- SiO\textsubscript{2} film acts as a alkalis barrier.
- Lack of adhesion between SiO\textsubscript{2} and TiO\textsubscript{2} films results coating of extremely low durability.
- Top films of SiO\textsubscript{2} and TiO\textsubscript{2} mixed compositions were tested to improve adhesion.

Wear samples after 1000 Taber abrasion cycles:

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<tr>
<th>S/T-a</th>
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<tr>
<td>SiO\textsubscript{2} ~ 30 nm</td>
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NANOTECHNOLOGY APPLICATIONS: Durability of TiO$_2$ based films
Wear samples after 1000 Taber abrasión cycles:
This results were associated with the smaller friction coefficient of the top surface and smaller roughness value.
NANOTECHNOLOGY APPLICATIONS: Durability of TiO$_2$ based films

Influence of SiO$_2$-TiO$_2$ film thickness on the driver visibility:

Samples wear by 1,000 Taber abrasion cycles

Haze value after Taber test

Thicker samples leads to higher haze values, then the top thickness is limited by this value.
Thank you!