

# Translating Durability Into Performance: *Solarphire*® AR Glass by PPG



Solar module manufacturers measure the performance of glass products according to two primary factors: solar transmittance and durability. While anti-reflective (AR) glasses often are used on solar modules to maximize solar transmittance, they traditionally have been handicapped by coatings that cannot withstand the rigors associated with processing and long-term field performance.

*Solarphire* AR glass by PPG is a new generation of anti-reflective glass that, due to a proprietary,

permanent, protective overcoat developed by PPG, combines high solar transmittance with exceptional durability.

The following document examines common types of AR glass and explains why the durability of *Solarphire* AR glass enables it to outperform and deliver better long-term value than other AR glasses for many solar applications.

## COMPARING AR GLASS COATINGS

*“Solarphire AR glass by PPG is a new generation of anti-reflective glass that, due to a proprietary, permanent, protective overcoat developed by PPG, combines high solar transmittance with exceptional durability.”*

Anti-reflective glass coatings are manufactured by applying a single or multiple layers of material onto a highly transmissive, ultra-clear glass. Coatings are engineered to reduce reflection at the air/glass interface so that more electricity-producing photons can enter the solar cell.

By enhancing solar transmittance, these coatings enable devices equipped with AR glass to convert solar energy into electricity more efficiently. Anti-reflective coatings increase module power output and lower the cost-per-watt, which is the key value measure for any solar power generating system.

### *Sol-Gel and Other AR Coatings*

Most commercial AR coated glasses for the solar industry feature a layer of uniform or graded low-density material that is applied to a glass substrate by various deposition processes, including wet techniques – such as *sol-gel*, spray, dip, and flow – or dry processes, such as vacuum deposition.

*Sol-gel*-based coatings are one of the most popular types for AR glass because they are highly transmissive across a broad range of the solar spectrum. That makes them especially effective for solar-thermal applications where the collection of heat energy has equal or greater primacy than the collection of energy in the visible range of the solar spectrum.

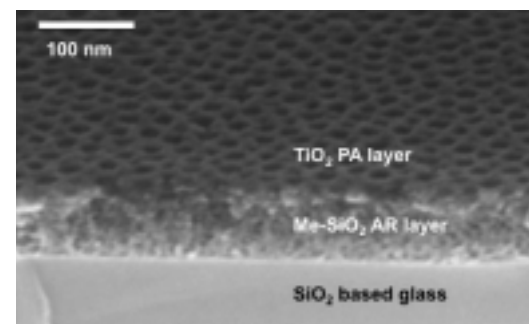
One major drawback with low-density AR coatings, including those made with the *sol-gel* process, is that they are relatively soft, which can lead to processing and handling difficulties. Soft

coatings placed “side-down” during assembly can adhere to conveyor rolls and other processing equipment. This not only deposits damaged coating residue on the rolls themselves, but also leaves roll marks on the finished glass, which can diminish the effectiveness of the coating. They also scratch easily during shipping and handling.

Another shortcoming associated with low-density AR coatings is a porous structure that, when deposited on a glass substrate, tends to densify during heat-treating. Later, during field use, the coatings have propensity to collect environmental contaminants due, again, to their porosity. Both phenomena make the coating less transmissive, which ultimately results in lower performance for the AR-glass equipped solar module.

For these reasons, many AR coatings cannot pass all of the environmental testing protocols established in IEC 61215, the standard for predicting field durability of solar glasses

### *Sol-Gel AR Glass*



*Wet-applied AR coatings are porous as deposited. When heated, they tend to become less so, which increases reflectivity and lowers glass performance.*

### Solarphire AR Glass

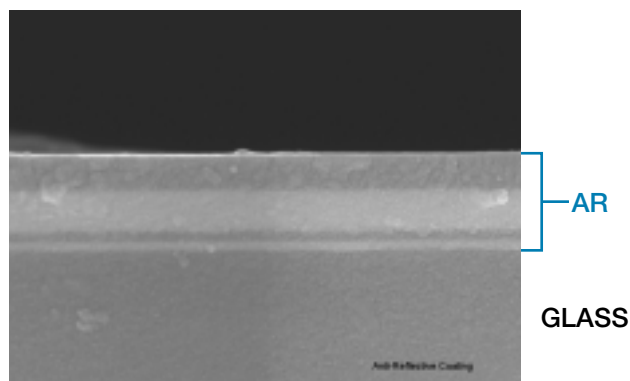
Solarphire AR glass is a new solar glass by PPG that provides both exceptional solar transmittance and revolutionary breakthroughs in durability and long-term performance.

With its unique formulation and coating characteristics, Solarphire AR glass provides the following processing and performance advantages over sol-gel and other wet-applied AR glass products:

- The proprietary design of the Solarphire AR coating optimizes module performance in two ways: first, by increasing transmittance of the glass in the spectral range where common photovoltaic (PV) conversion materials, such as silicon and cadmium telluride, need it; and second, by reflecting infrared (IR) rays not converted by these materials into electrical energy. This reduces heat build-up in solar modules and makes them more energy-efficient.
- Solarphire AR glass can run “coated side down” on processing conveyors. That means customers require no special handling equipment to switch from an uncoated product to Solarphire AR glass.
- Because of its unsurpassed durability, manufacturers can apply the Solarphire AR coating on the first surface of a PV module and have high confidence that it will perform well throughout its service life. As the test results on page 3 demonstrate, Solarphire AR coatings survive exposure tests well in excess of those prescribed in IEC 61215 testing.

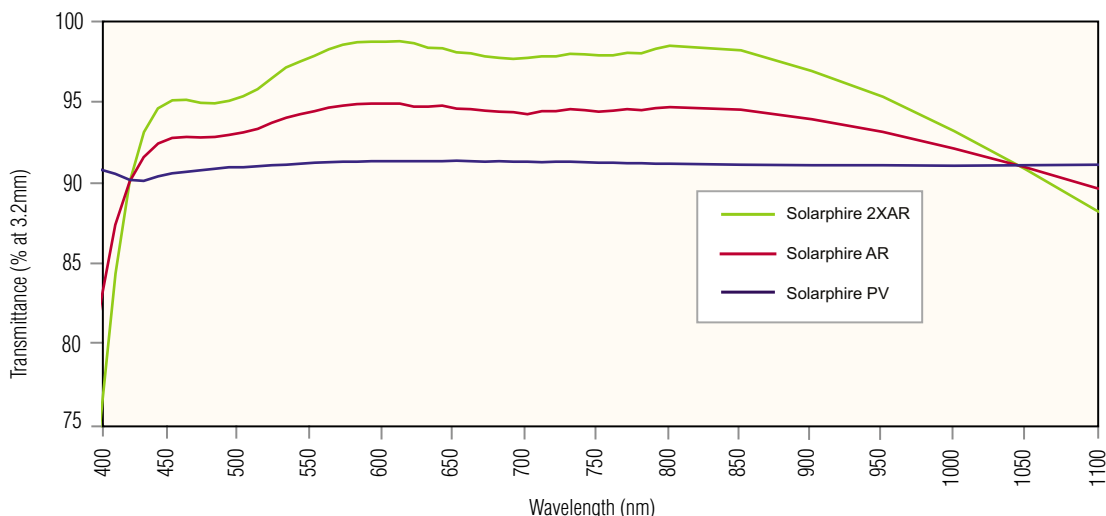
- Solarphire AR glass requires heating to achieve the best optical performance and durability test results. At 1185°F, there is a chemical reaction in the Solarphire AR coating that makes it less energy-absorbing. Consequently, in applications that require heat-treating or bending, Solarphire AR glass actually outperforms those that do not have heat-treated glass.
- Solarphire AR glass is available with the AR coating on both sides of the glass substrate (Solarphire 2XAR glass). In applications where both surfaces of Solarphire 2XAR glass are exposed, such as cover plates for concentrated photovoltaic (CPV) modules or receivers, the resulting 4 to 5 percent increase in transmittance can substantially improve the overall efficiency of the module.

### Solarphire AR Glass



Solarphire AR coating is multi-layer, smooth and durable. Transmittance of this glass improves with tempering and other heat treatments by about 1/2 percentage point.

### Spectral Curve Chart



**PERFORMANCE TESTING**

To measure the durability and long-term transmissivity of *Solarphire* AR glass, PPG subjected product samples to standard IEC 61215 and Taber Abrasion tests.

**Taber Abrasion Test**

Although the Taber Abrasion Test is not commonly done on solar glass products, it is recognized as an especially rigorous method for measuring the wear resistance and durability of specific products and/or materials.

To complete the test, two abrasive wheels were rotated over the surface of *Solarphire* AR glass with varying levels of pressure to simulate the physical effects of abrasion.

The purpose was two-fold: first, to gauge the susceptibility of the glass surface to scratching during handling and fabrication and, second, to assess its ability to maintain transmittance after repeated exposure to a wear mechanism that was significantly more abrasive than any it would encounter in processing or actual field service.

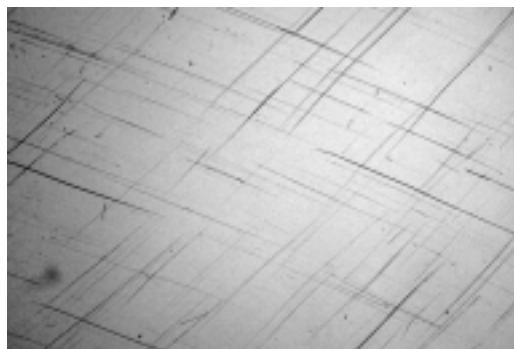
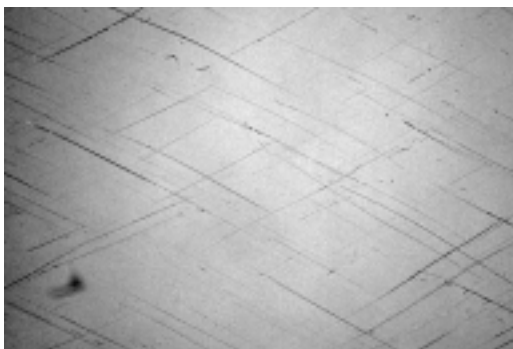
Final results showed that, even after stringent abrasion testing, *Solarphire* AR glass maintained virtually undiminished solar transmittance.

**IEC 61215 Industry Standard Testing**

The IEC 61215 protocol specifies 1,000 hours of damp heat exposure (85°C/85% relative humidity) and 10 cycles of humidity-freeze testing. PPG testing far exceeded these standards by exposing *Solarphire* AR glass samples to one full year of damp heat exposure, 60 cycles of humidity-freeze testing and 17 weeks of salt-fog testing as prescribed by the American Society of Testing and Materials (ASTM) B-117 procedures.

When measured after each of these individual tests, *Solarphire* AR glass showed decreases in transmittance of less than 0.5 percent in the PV range of the solar spectrum (400 to 1100 nm).

*Solarphire* AR glass also passed sulfuric and abrasion testing for EN 1096-2, the European standard for glass coating performance.



Taber scratch density of Solarphire AR glass (left) compares favorably with that of the uncoated Solarphire PV glass (right).

**Exposure and Durability Testing**

Test	Result
1 Year 85C, 85% RH (IEC 61215)	Pass*
Humidity Freeze 60 cycles	Pass
EN1096-2 Sulfuric Acid	Pass (same response as uncoated)
EN1096-2 Abrasion Test	Pass (same response as uncoated)

\*Pass criterion: <0.5% degradation in ISO9050 (400-1100nm) transmittance

## SUMMARY

- Taber abrasion and other industry-standard testing shows that, due to its proprietary, permanent, protective overcoat, *Solarphire* AR glass maintains original transmittance when subjected to conditions far beyond what would be typically expected during processing and in the field.
- Because of its proprietary formulation and coating technology, heat-treated *Solarphire* AR glass increases solar transmittance 2 to 2.5 percent in the PV range of the solar spectrum. When the AR coating is applied to both sides of the *Solarphire* glass substrate (*Solarphire* 2XAR glass) in heated-treated applications, solar transmittance levels increase by 4 to 5 percent in the PV range.
- *Solarphire* AR glass can be run “coated side-down” on processing conveyors without causing a build-up of coating materials on the contact surfaces or damage to the coating itself.
- Solar manufacturers require no special equipment to process *Solarphire* AR glass.
- Unlike some AR glass products that lose performance when heat-treated, *Solarphire* AR performance actually increases in such applications.
- *Solarphire* AR glass increases the reflection of heat produced in the IR range of the solar spectrum that is not useful to the creation of electric energy. This reduces the heat load on the solar module, resulting in an increase to its peak performance thresholds and long-term output.

To learn more about *Solarphire* AR glass and the entire line of PPG solar glass solutions, call **1-888-PPG-SUN1 (774-7861)** or visit **[www.PPGSolarphire.com](http://www.PPGSolarphire.com)**



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