STEWART ENGINEERS

Coating Technology Processes

Sputtered or **Pyrolytic CVD** Technology?

A variety of techniques are available to deposit thin films on flat glass, of these, the two most widely used for producing high quality functional coatings can be subdivided into two classes: Physical Vapor Deposition (PVD) and Chemical Vapor Deposition (CVD). PVD processes include a number of approaches of which sputtering is one, and is also the one most widely used for glass. Sputtered coatings are generally referred to as soft coated and are applied using PVD processes. Pyrolytic coatings are applied using CVD methods and are often referred to as hard coated. Both types of coating offer their own advantages and disadvantages. When considering which system is right for your operation, you should consider the performance and handling factors that best meet your product and manufacturing needs.

Sputtered Technology

Sputtered coatings are applied off-line independently of the float glass manufacturing process. Sputtered glass is produced by depositing 6-12 layers of thin metallic and oxide coatings onto the surface of pre-cut glass (either clear or tinted) in a vacuum chamber. The primary active layer is silver. Additional layers include barrier, color modification oxide layers, and sacrificial metals layers. The thin films are formed by accelerating high energy ions toward the target to be sputtered. These high energy ions mechanically dislodge atoms out of the target. The resultant ions condense on the glass (no bond is formed) forming a thin film often referred to as a soft coating. Sputtered coatings are applied at much lower temperatures compared to pyrolytic coatings.

There are several benefits in the off-line batch sputtering technique:

1. Sputtering is the traditional method used for depositing coatings on glass. Sputtering is a well-established process and fundamentally the range of target materials is wide compared to the cost effective CVD chemicals.
2. Processes necessary to apply and handle sputter coatings are well-established.
3. Sputtered glasses can, in some cases, offer superior optical property performance.

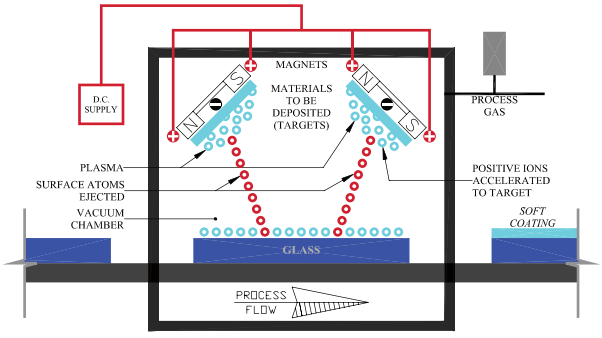

Figure 1. Typical sputtering process.

Beyond the performance of the glass, there are other key factors to consider when evaluating the sputtering process. These factors will impact the overall cost effectiveness of coated products. There are several disadvantages of applying coatings using the sputtering techniques:

1. Larger capital investment in the off-line sputtering equipment when compared to the on-line CVD process.
2. Higher manufacturing cost for Sputter coatings ~$4/m^2 vs. CVD coatings ~$1/m^2.
3. The off-line process adds additional processing time.
4. Since sputtered glass has a soft coating, it is susceptible to scratches during normal glass handling and fabrication. Thus special handling is required, resulting in longer lead times and increased capital cost.
5. Sputtered coatings tend to be more sensitive to moisture in the air, limiting sputtered coating's shelf life.
6. Not all sputtered glass can be tempered. The ones that can be tempered cannot be done under normal tempering conditions. Additionally, differences in appearance may occur in annealed and tempered glass used for the same application.
7. Many manufacturers of sputtered glass suggest that coatings on the edge of the glass be deleted to ensure adequate adhesion between the glass and sealants used in the manufacture of insulating glass units. Overall, edge deletion adds costs to the manufacturing facility for equipment and processing time.
8. There is noticeable color variability between batches.
9. Sputtered coatings cannot be used in monolithic applications.

The above factors deserve strong consideration relative to window manufacturers , market focus and customer base.

Pyrolytic CVD Technology

Pyrolytic coatings are produced by using the chemical vapor deposition (CVD) method, whereby metal oxides are deposited onto the surface of the glass during glass production and while the glass is still in a semi-molten state, typically at 600-700 °C. A chemical reaction occurs between the vapor and the glass surface, changing the chemical composition of the glass surface, resulting in a hard coating that strongly adheres to the glass. These coatings become part of the glass surface, rather than a layer on top of making the glass more durable than sputtered coatings. CVD coatings are handled and processed like standard float glass resulting in excellent lead times, improved customer service and overall cost effectiveness.

Pyrolytic coatings using CVD offer several benefits:

1. Lower capital investment in the on-line CVD process when compared to the off-line sputtering equipment.
2. Lower manufacturing cost for CVD coatings ~$1/m^2 vs. Sputter coatings ~$4/m^2.
3. CVD is an on-line process, resulting in excellent lead times.
4. Since the coating is closely integrated into the glass surface, CVD glass is far less susceptible to degradation and scratches than sputter-coated glass products and does not require special handling, care or equipment. These factors typically improve the final through put costs.
5. CVD coatings are not susceptible to moisture in the air, resulting in an unlimited shelf life.
6. CVD is done at atmospheric pressure avoiding the need for complex, high maintenance, and energy intensive vacuum equipment.
7. CVD glass can be tempered similarly to standard float glass products, resulting in improved throughput and cost effectiveness.
8. There is no visual differentiation between annealed or tempered CVD products. The result is a consistent appearance between an annealed and tempered product on the same project.

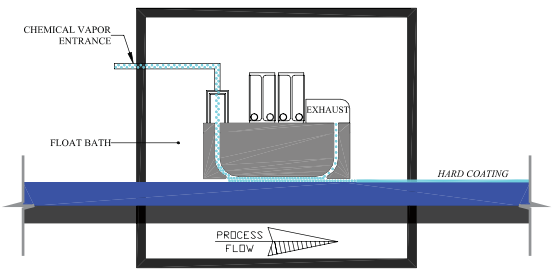

Figure 2. Typical CVD process.

While possessing several benefits from a production aspect, CVD is not as widely used as sputtering for the following reasons:

1. CVD system must be installed on a float glass manufacturing facility.
1. Performance properties of the finished product can exceed sputtered coatings in certain applications.
2. Since manufacturing line speeds are fast, deposition reactions must occur very quickly, which may limit layer thickness.
3. There are a limited amount of chemistries that can be used.
4. Until recently, CVD technology, for on-line use, was not readily available on attractive commercial terms.

Which is best?

Which type of coated glass is best depends on a number of factors, including where your customers are located, the size or type of your operation, operating costs, how quickly you move your glass inventory, desired durability, etc. While recent technological advances in sputter-coated glass and pyrolytic glass have narrowed the differences, the differences still exist.

Based on performance in respective markets, both sputter-coated glass and pyrolytic can be viewed as high-performance glass products. Advances in pyrolytic coating technology have generated coatings with superior performances resulting in new products with higher solar heat gain coefficient like Low E PRO for heating-dominated climates.

Glass Coatings

Pyrolytic CVD Technology

Hard Coatings

Material Properties

- Deposited at higher temperatures (650°C) using CVD methods
- Coating bonds to the glass

Production Benefits and Costs

+ On-line CVD processing
+ Excellent lead times
+ High durability
+ Unlimited shelf life
+ Process done at atmospheric pressure
+ Stable to tempering
+ Consistent appearance of annealed and tempered glass
+ Low manufacturing cost

– Performance properties may not be as good as sputtered coatings for certain applications
– Requires fast deposition rate, limiting layer thickness
– Limited amount of chemistries
– CVD technology, for on-line use is now available on attractive commercial terms
- Substrate must be hot

Consumer Benefits

+ Outperform sputtered coatings in heating dominated climates
+ Can be used in a single-pane, single glaze window
+ New CVD methods developed with lower Solar Heat Gain Coefficient allowing pyrolytic glass to be used in cooling-dominated climates
+ High visible light transmittance reduces load on lighting systems

Sputtered Technology

Soft Coatings

Material Properties

- Deposited at lower temperatures (ambient) using batch-sputtering techniques in vacuum chambers
- Adheres multiple layers of metal oxides to glass

Production Benefits and Costs

+ Traditional technique used to apply coatings
+ Wide variety of target materials available to form coatings
+ Well established process to apply and handle coatings
+ In some cases, superior optical property performance

– Off-line processing
– Increased lead times necessary
– Special handling required to avoid scratches
– Sensitive to moisture, limiting shelf life
– Tempering can cause visual differences with annealed glass
– Edge deletion is necessary
– Color variability between batches
- High manufacturing cost
- Higher capital cost per m^2 of output

Consumer Benefits

+ Better performance properties in cooling-dominated climates
+ Lower Solar Heat Gain Coefficient than pyrolytic
– Cannot be used in a single-pane or single-glaze windows
– Typically residential windows in cooling-dominated climates are single pane, single-glazed windows ---> sputtered coating not used in cooling climates