

# Edge Deletion of Sputtered Low-E Coatings

## BACKGROUND

Low Emissivity (low-E) coatings were developed to fill the need for insulating glass (IG) products to have better thermal performance. These coatings have been successfully used in residential and commercial applications since 1983. Significant improvements in optical characteristics, thermal performance and coating durability have been made since the introduction of Sputtered Low-E coatings. The silver metallic layer(s) in the low-E coating stack provide the beneficial summer daytime and winter nighttime performance. Sputtered low-E coatings remain the best coating type available due to their performance, aesthetics, price and customer acceptance.

When low-E coatings were developed for use in IG constructions, all experience and testing indicated that these coatings would need to be completely removed from the periphery of the glass (edge deletion) to eliminate silver corrosion at the glass edge. To date, there has been no evidence that this has changed. While significant improvements have been made to the low-E coatings (providing more durability during shipping, storage, handling, and washing), the edge of the coating remains the most vulnerable section, as the silver is still exposed to the environment.

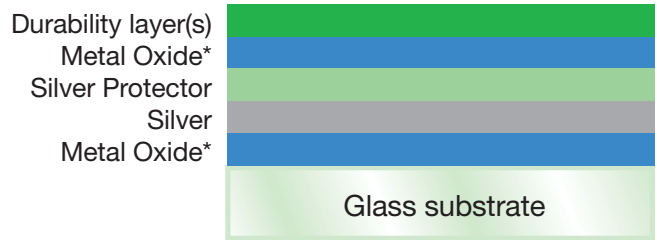
## Low-E COATINGS

Low-E coatings produced by a vacuum deposition process called Reactive Magnetron Sputtering (RMS) are made with multiple coating layers. The first RMS low-E coatings were produced with one silver layer, while advanced generations of RMS low-E coatings have two silver layers (see Figs. CG01-1 and CG01-2). The double silver layer coating has gained wide acceptance by window manufacturers because of its improved (i.e. lower) U-factor and Solar Heat Gain Coefficient as compared with the original single silver layer coating.

On both the single and double silver coatings, durability layers are placed at the top of the coating stack. These layers protect the silver during shipping, handling, washing and fabrication of IG units.

However, these protective layers are on the face of the coating—not on the coating edge. When the glass is made into cut sizes or stock sheets (eventually to be cut

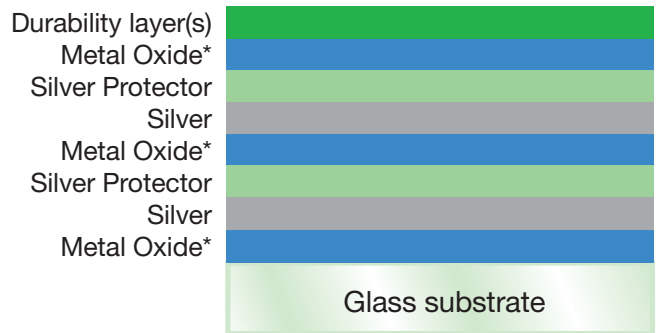
down into smaller sizes), the silver at the glass edge is directly exposed to the environment. If coating corrosion due to exposure to moisture or adverse chemicals is to occur, it will most likely begin at the edge, where the silver in the coating stack is exposed.



Approximately 1/200,000 inch thick

\*or Metal Nitride

Fig. CG01-1: Typical Low-E Coating – Single Silver Layer



Approximately 1/200,000 inch thick

\*or Metal Nitride

Fig. CG01-2: Typical Low-E Coating – Double Silver Layer

## TESTING AND PAST EXPERIENCE

Low-E coatings are similar to mirrors, in that they both use silver and have silver exposed at the edge, so experience with the weatherability of mirrors can be used to determine the potential failure mechanism and weatherability of low-E coatings.

Failures of mirrors normally occur at the edge and are caused by corrosion of the silver. In the industry, this is called the “black edge effect”. When mirrors are exposed to relatively high humidity levels or to common cleaning solutions that contain acids (even diluted ones), silver corrosion can occur. It is important to note that the degradation begins at the edge and propagates from this point. Black edge mirror failures have been reported to occur anytime from 3 months to 6 years, depending on the environment to which the mirror is exposed.

Tests conducted by Cardinal IG Company on edge deleted and non-edge deleted IG units indicate that silver corrosion similar to the black edge effect seen in mirrors can occur on the non-edge deleted low-E coating.

Competitive double silver low-E coatings were tested without edge deletion. These samples were fabricated using a dual seal construction with PIB (polyisobutylene) as the primary seal and silicone as the secondary seal. The samples were exposed to accelerated weathering of 1,400°F, 100% relative humidity and UV light, a test known in the industry as the P-1 test. This test was chosen because Cardinal IG and some other IG and sealant manufacturers have used it to determine the durability and weatherability of IG unit constructions.

Significant corrosion of the silver in the low-E coating was visible after 4 weeks of this test (as can be seen in Fig. CG01-3). The failure mechanism involved corrosion beginning at the edge and then progressing into the silicone secondary seal, through the primary PIB seal and into the viewing area of the IG unit. The corrosion and failure mechanism are important because butyl materials are considered to be the best IG sealant materials when it comes to resisting moisture permeation. Since the PIB primary seal did not stop the corrosion of the low-E coating, corrosion of low-E coatings will most likely occur with any other sealant material when exposed to the same test conditions.

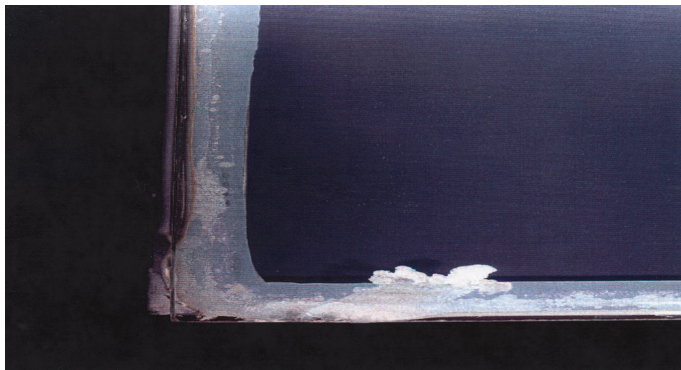


Fig. CG01-3: Coating Corrosion at Edge

Corrosion of the silver, as these tests showed, can create the following anomalies:

- Obstruction of vision into the daylight opening of the IG unit
- Premature seal failure of the IG unit (caused by a splitting of the coating layers causing moisture to enter the airspace of the IG unit)

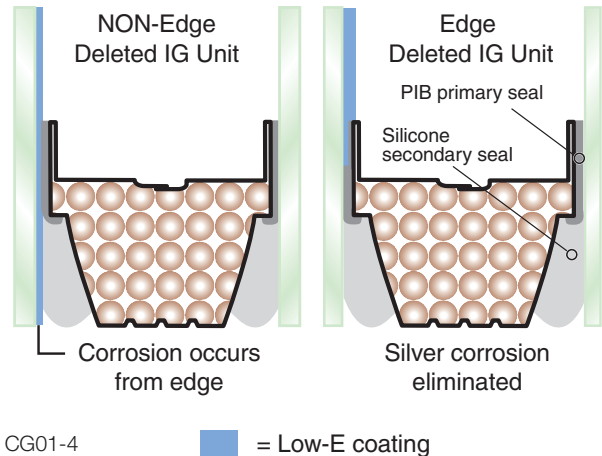


Fig. CG01-4

 = Low-E coating

As shown in Fig. CG01-4, corrosion occurs from the edge of the glass because the silver in the coating stack is completely exposed. Testing has indicated this will occur in single or double silver coating stacks; however, since there is less silver in the single silver layer stack, corrosion will most likely take longer to occur.

The same tests conducted for 1 year on low-E coatings (single silver and double silver layers) that had undergone edge deletion showed no degradation of the coating, with the seal of the IG unit intact.

Obviously, the IG or window manufacturer cannot control the exposure of the glass edge to moisture or acidic conditions (e.g., acid rain or household cleaning solutions). Therefore, it is difficult to design a system that will not expose the edge seal of an IG unit to these conditions.

**PROCEDURES AND COSTS**

It is recommended that the low-E coating be completely deleted around the periphery of the glass, as shown in Fig. CG01-4. Since the low-E coating contains multiple coating layers, all layers should be removed to ensure adequate and consistent adhesion of the sealants. The coating should be deleted using an edge grinding technique that removes all of the coating down to the glass surface. The deletion should reach to a height that does not contact the sealant(s) or, in a dual-seal system, to a minimum of half the primary sealant height.

Contrary to some beliefs, Cardinal's edge deletion process has not been found to cause damage to the glass, which would reduce glass strength. Independent testing on non-edge deleted and edge deleted glass samples has shown that there is not a concern for glass strength reduction with edge deletion. In addition, with Cardinal's edge deletion process, filters are used near the edge deletion

wheel to help remove any microscopic coating fragments that could possibly get into the atmosphere.

To varying degrees, all glazing systems permit the edge seal of an IG unit to be exposed to moisture, cleaning solutions, and depending on climatic conditions, acid rain. The presence of these substances in the glazing reglet (pocket channel) will cause the silver in low-E coating to corrode, although weep holes in the window frame will help reduce the potential exposure of the low-E coating. However, many window manufacturers do not use weep holes; if they are used, there is no guarantee that they will be functional.

Cardinal estimates that the cost of edge deletion is between \$0.01 and \$0.02 per square foot of IG, with an in-line operation. Some companies (such as Cardinal) will supply edge deletion equipment free of charge to companies purchasing a reasonable amount of their low-E coated glass products.

### **ADVANTAGES AND DISADVANTAGES**

The advantages of edge deletion are as follows:

- The sealants bond to the glass rather than the coating
- Corrosion of the coating from moisture, acid rain, and cleaning solutions is eliminated
- Delamination of the low-E coating stack is eliminated
- Seal integrity of the IG unit is not compromised

The main disadvantage of edge deletion is its cost, which ranges from \$0.01 to \$0.02 per square foot, as mentioned earlier.

### **FABRICATION AND SEALANTS**

It is believed that the best unit construction with low-E coatings is a dual-seal unit with polyisobutylene primary sealant and a compatible secondary sealant. Other sealant systems have been successfully used with low-E products and it is recommended that the low-E and sealant suppliers be contacted to obtain their recommendations on sealant types.

Sealants with low moisture vapor transmission will slow down the corrosion of the low-E coatings if the edge is not deleted. However, as shown by accelerated testing, corrosion of the silver can eventually take place with any sealant if edge deletion is not performed.

### **FAILURES OF LOW-E IG UNITS**

Since Cardinal introduced low-E coatings in 1983, over 250 million IG units have been fabricated with Cardinal's single and double silver low-E coating stacks.

All of these IG units have had the low-E coating edge deleted. To date, there has not been a single reported IG unit failure caused by corrosion of the coating in the sealant area. This case history proves that edge deletion eliminates silver corrosion at the glass edge and the potential for premature seal failure of the IG units.

### **WARRANTY ISSUES**

The IG unit manufacturer and/or window manufacturer usually warrants the IG unit against visual obstruction of the airspace surfaces, which can occur when moisture enters the air space through a splitting of the low-E stack when the coatings are not edge deleted. Warranties and liabilities should be carefully reviewed with the low-E supplier if it is recommended that the low-E coating not be edge deleted. Who has the liability for failed IG units caused by corrosion of the coating, if the low-E glass supplier recommends that the coating need not be edge deleted?

Replacement of IG units under warranty has been reported to cost from \$150.00 to \$200.00 or more per unit. This includes the service call, new IG unit and replacement. Since the cost of edge deletion is between \$0.01 to \$0.02 per square foot, it does not make good business sense to risk field failure replacement at \$150.00 to \$200.00 for the cost of edge deletion.

### **THE ARGUMENT OF EDGE DELETION**

Low-E coatings have been used in IG units in North America since 1983 to improve the thermal performance of the insulating glass unit. Silver is used as the main coating material, and experience with mirrors (as well as accelerated testing of low-E products) indicates that the coating is most vulnerable at the edge of the glass. Therefore, the coating should be edge deleted around the glass periphery.

If the low-E coating is not edge deleted, corrosion and delamination of the coating can take place and the IG unit seal integrity compromised. In the long run, the cost of replacing an IG unit far outweighs the cost of edge deletion.

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