Not long ago....
Guardian Industries

- Global Presence
- Approx. 19,000 Employees Worldwide
- 66 Facilities Throughout the World
- Second Largest Float Glass Manufacturer
- Largest Sputter Coated Manufacturer
- Largest Mirror Manufacturer
Market Approach

Make Glass  Coat  Fabricate  Install

G GUARDIAN
G GUARDIAN Select Fabricator SunGuard
PPG
AGC

CFP

Glazier

VIRA CON

"The Leader In Glass Fabrication™"
Energy Saving Glass Solutions
Energy Saving Glass Solutions

• High Performance Coated Glass
  • Low-E Coatings
  • Solar Control Coatings
  • Spectrally Selective Coatings

• Advanced Energy Saving Systems
  • Triple Glaze Insulated Glass
  • Vacuum Insulated Glass
  • Switchable Glass
Window System Evolution

Pyrolitic Low-E

PVD Double & Triple Silver Low-E

Clear Glass

PVD Single Silver Low-E

Triple Glaze Insulated Glass

Vacuum Insulated Glass

Advanced IG
Low Emissivity Coatings

- Low-E coatings are highly transparent with high reflectance (low-emittance) to long-wavelength infrared radiation
- Reduces heat transfer by a factor of 5 to 10
- Passive solar heat gain is desired for heating dominated climates
- R-values with Argon gas = R2-3
- Pyrolitic CVD coatings were the market choice until PVD technology became mainstream
- Primary markets are Europe, Canada, and Northern US
Solar Control Coatings

- Solar control coatings reduce transmitted solar energy and heat gain by reflecting incident solar energy (visible and infrared).

- Low-E coatings with solar control properties are used for insulation and to keep the heat outside.

- Coatings applied to Surface #2
  - PVD coatings on clear glass
  - Pyrolitic on tinted glass

- R-values with Argon gas = R2-3

- Goal is to reduce the solar heat gain coefficient for the IG unit.

- Used in cooling dominated climates.
Spectrally Selective Coatings (SSC)

- Spectrally Selective Coatings combine the performance attributes of Low-E and solar control coatings into one product

- Keep heat out in the summer and heat inside in the winter

- Coatings applied to Surface #2

- R-values with Argon gas = R4

- Goal is to reduce the solar heat gain coefficient and u-Value for the IG unit

- North American market uses SSC for residential and commercial
Coating Technology Evolution

- Low-E coating technology increases in complexity with increases in performance
- The performance gain from each step diminishes in magnitude due to limitations in emissivity

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Coating Performance Evolution

Comparison of Coating Transmission

Wavelength (nm)

Transmission (%)
Reaching the Technical Limits….

• Low-E coatings are now approaching the physical limits in terms of insulation performance
  • Single Silver Low-E R-Value = R3.0
  • Double Silver Low-E R-Value = R3.5
  • Triple Silver Low-E R-Value = R4.0

• Light to Solar Gain improves with each additional silver layer but the insulation values only improve slightly
  • Single Silver Low-E LSG = 1.5
  • Double Silver Low-E LSG = 1.9
  • Triple Silver Low-E LSG = 2.3

• Higher performance levels must come from alternative IG unit technologies
Canadian Energy Star Climate Zones

Zone D  > 8000 HDDs
Zone C  > 5500 to <= 8000 HDDs
Zone C  > 3500 to <= 5500 HDDs
Zone A  <= 3500 HDDs
Emerging Energy Saving Technologies
Triple Glaze (TG) windows are a short term technology improvement.

- TG unit construction
  - Three pieces of glass
  - Two Low-E coated lites
  - Argon or Krypton gas

- Sizable insulation increase
  - R6 with Argon gas
  - R8 with Krypton gas

- Utilizes existing glass, coating, and IG technology

- Coating value is increasing solar gain and transmission
Guardian Vacuum Insulated Glass

- **Reduced Glass Profile**
  - Basic VIG configuration < 12-mm total IG unit thickness
- **High quality aesthetics**
  - Acceptable pillar color, size, reflectance, etc.
  - Low profile pump-out tube acceptably located
- **Automated Manufacturing**
  - Limit manpower requirements
  - Consistent and repeatable process
  - Support traditional IG fabrication size parameters
- **Production Cost Goals – High Volume System (All In Costs)**
  - < $4 ft.2
- **20-Year Product Warranty**
  - Maintain hermetic seal
  - Comply with rigorous product testing
  - Resistant to stress and impact
Vacuum Insulating Glass (VIG) with ClimaGuard Low-E

- **Vacuum Insulating Glass Benefits**
  - Significantly improves the comfort and energy efficiency of a window
  - Functions like a thermos – minimal heat transfer

- **Center of Glass Performance**
  - COG U-value < 0.55 (EU Regulations)
  - COG R-value >10.0
  - Inside Glass Temp. + 10°F vs. standard low-E
  - Sound Transmission Coefficient ≥ 34
    - Comparable to 0.76 mm PVB laminate
  - Optical performance equal to standard IG unit
VIG Triple-Glaze Unit
Clear Third Lite

- Accommodates between-glass accessories
- Center of Glass Performance
  - U-Value = 0.083
  - R-Value = 12
    - Inside Glass Temp. = 65°F
    - Summer Inside Glass Temp. = 89°F
  - SHGC = 0.345
  - Tvis = 64%
  - Tuv = 19%
  - Thickness / Profile = 13/16”
  - Weight = 5.5 lb/ft²
- Ashrae winter, thermal stress summer
  1mph wind speed w/curtains, LE #2, 0.25mm pillar height. 1mm pillar diameter, 48mm separation, 3/8” gap air-filled
VIG European Test Installations
Switchable Glazing Technology – Polymer Azobenzene Liquid Crystal (PALC)

- PALCs operated on the principle of electrically controlled light scattering.
- Rapid change between transparent and opaque states
  - Provides desired day lighting level in the transparent state.
  - Provides desired privacy / security in the opaque state.
- Intensity of image can be varied and controlled.
- Familiar laminated glass manufacturing process
  - Scalable, Bendable, Meets impact standards
  - Provides sound attenuation
- Uses standard household electricity
  - Simplified connector assembly
- Equivalent ≥ 15 year field life expectancy
Guardian’s Switchable Glass Products

- **Product Overview**
  - Color in Off State: Frosted White
  - Color in On State: Clear
  - Transmission - Off State: 61%
  - Transmission - On State: 74%
  - Haze - Off State: 100
  - Haze - On State: 4 to 6
  - Operating Voltage: 120 VAC / 60 HZ
  - Power Consumption: 50 mW/m²
  - Operating Temperature: -29°C to 75°C

- **Glazing benefits**
  - Reduces Solar Heat Gain Coefficient when not “ON”
  - Reduces visible light transmission
Switchable glazing provides day lighting in transparent state and privacy and/or energy performance in the translucent state.

Three primary technologies for switchable glass:

- Electrochromic (EC)
- Suspended Particle Device (SPD)
- Liquid Crystal Display (LCD)

Current market prices range from $100-$300 ft.²

Guardian goal is < $30 ft² for phase I

Initial launch market

- Automotive Sunroofs for premium vehicles
Performance Glazing Evolution

U Value

LSG

Pyrolitic  SS Low-E  DS Low-E  TS Low-E  TG  VIG

Guardian Proprietary
Conclusions

• Energy efficient glass solutions are becoming more critical as energy prices continue to rise

• Low-E coatings significantly improve energy costs in both heating and cooling dominated climates

• Low-E coating technology is reaching its pinnacle – R4 with a standard two pane insulated glass unit

• “Wall Like” energy performance will come from the combination of coated glass and advanced IG technologies
  • Triple Glaze, Vacuum Glazing and Switching.