CORNING

High-Index Glass Waveguides for AR Roadmap to Consumer Market

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Outline

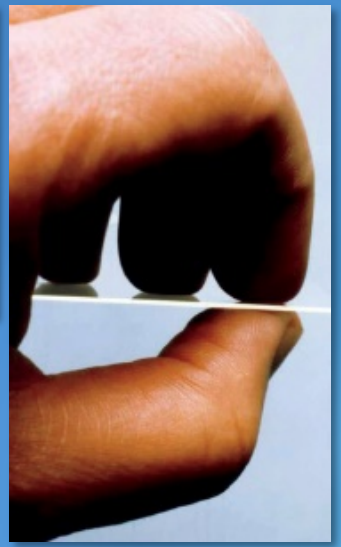
- Enabling the Display Industry Through Glass Innovations
- Our Solutions for Augmented Reality Applications
- The Challenges for Scalable and Cost-Effective Solutions

Corning's glass innovations have ***enabled displays for more than 80 years…***

1939

Cathode ray tubes for black and white televisions

1982



Liquid crystal display (LCD) glass for monitors, laptops

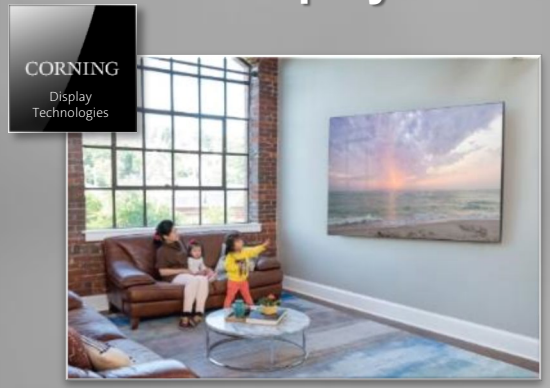
2019

25 Billion
Square Feet Sold

EAGLE XG® Glass is the LCD industry standard

Corning is a ***world-renowned innovator and supplier*** across the display industry

Display



Introduced glass panels for 1st active matrix LCD devices in 1980s

Have **sold 25 billion square feet** of flagship Corning® EAGLE XG®

Cover Glass for Display

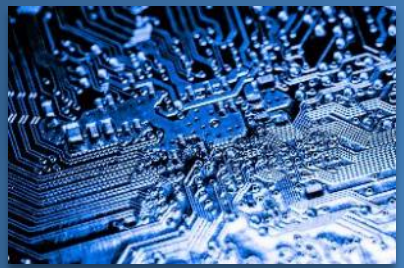
12 years of innovation in cover glass for smartphones, laptops, tablets & wearables

Corning® Gorilla® Glass is now on more than 7 billion devices worldwide

Glass For AR/MR Waveguides

Corning Precision Glass Solutions (PGS) was the first to market with ultra-flat, high-index wafers for top-tier consumer electronic companies pursuing **augmented reality and mixed reality waveguide displays**

PGS offers *best-in-class* ***glass substrates*** for semiconductor and consumer electronics applications

	Advanced packaging	Low-loss, low nonlinearity RF components	Wafer-level optics	Waveguide displays for augmented reality
Applications				
Corning Offers	**Glass Carriers** • CTEs: 3.4-12.6 ppm/°C • Select glasses available with high transmission & high stiffness properties	**Glass Substrates** • HPFS® has exceptionally low dielectric loss tangent: 10^{-4} @ 10GHz & is FEOL-compatible • Other compositions may be FEOL-compatible with coatings	**Optical Glasses** • HPFS® fused silica: FEOL-compatible & near-zero CTE • Other optical glass applications in CTEs from 3.4-10.0 ppm/°C	**High-Index AR Glass** • Refractive Indices ≥ 1.7 • TTV ≤1µm • Wedge < 0.02 arcmin • Wafer diameters: 150-300 mm

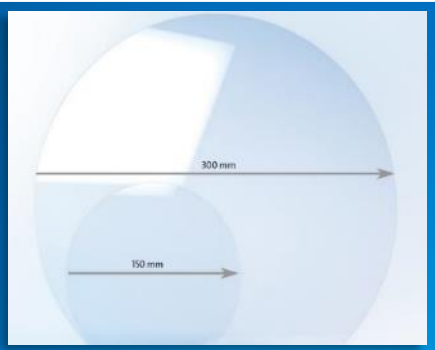
Corning enables the ***emerging AR/MR supply chain*** with high-quality materials and ancillary high-throughput equipment

Customer Challenges:

1. Wider field of view & lighter device	2. Higher equipment & material utilization	3. Demanding flatness requirements	4. Higher throughput

Corning Solutions:

High refractive-index glass & thinner form factors

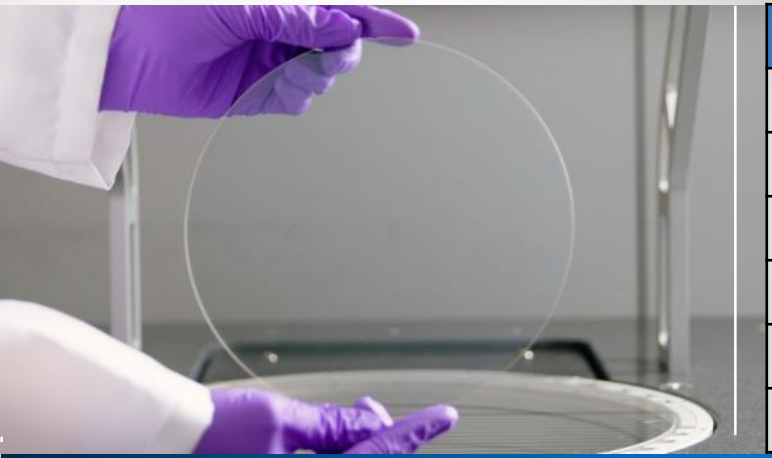


Larger-diameter wafers

Ultra-flat wafers measured with world-class metrology

Automated laser glass-cutting machines

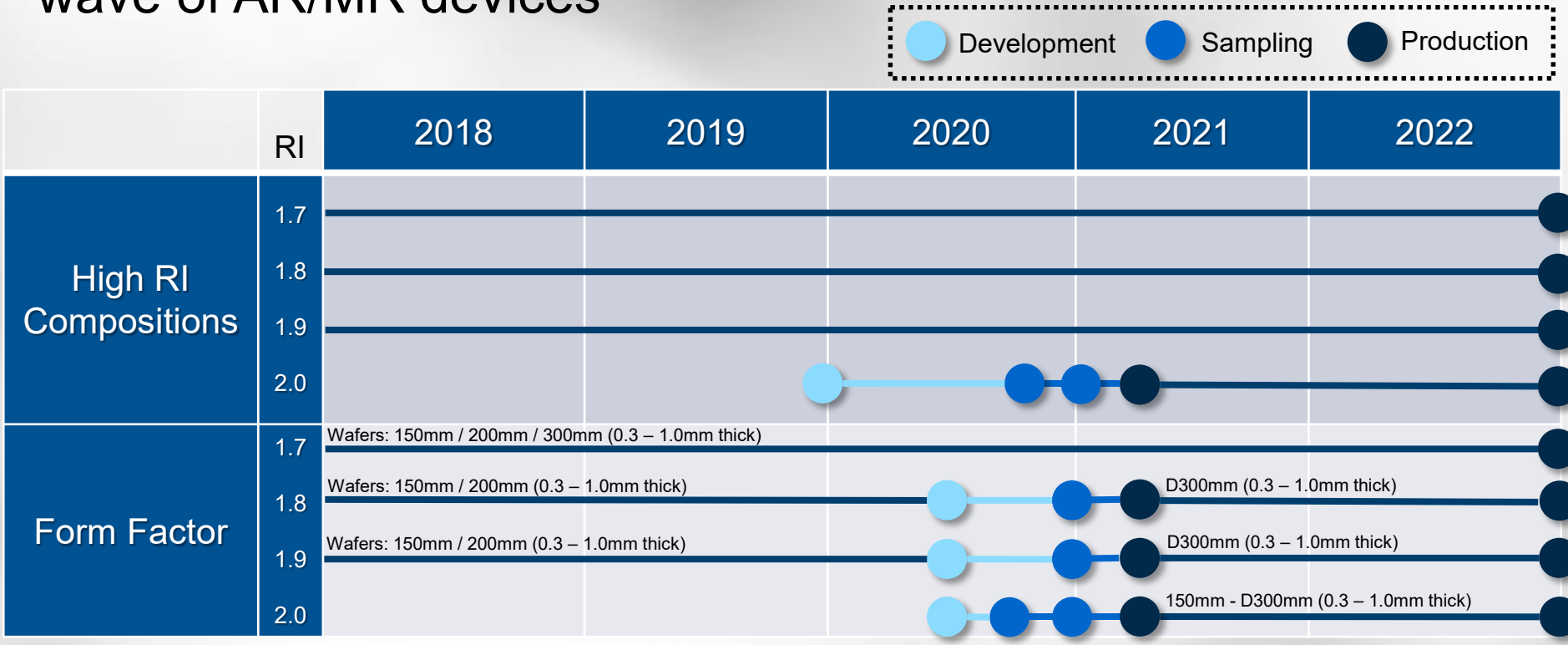
Corning's Augmented Reality Solutions deliver ***industry-leading substrates*** for superior image quality



Glass Attributes	Corning Offerings
Refractive Index	≥ 1.7
Diameter (mm)	150 – 300
Thickness (mm)	0.3 – 1.0
TTV (µm)	≤ 1
Wedge (arcmin)	< 0.02
Bow (µm)	≤ 20

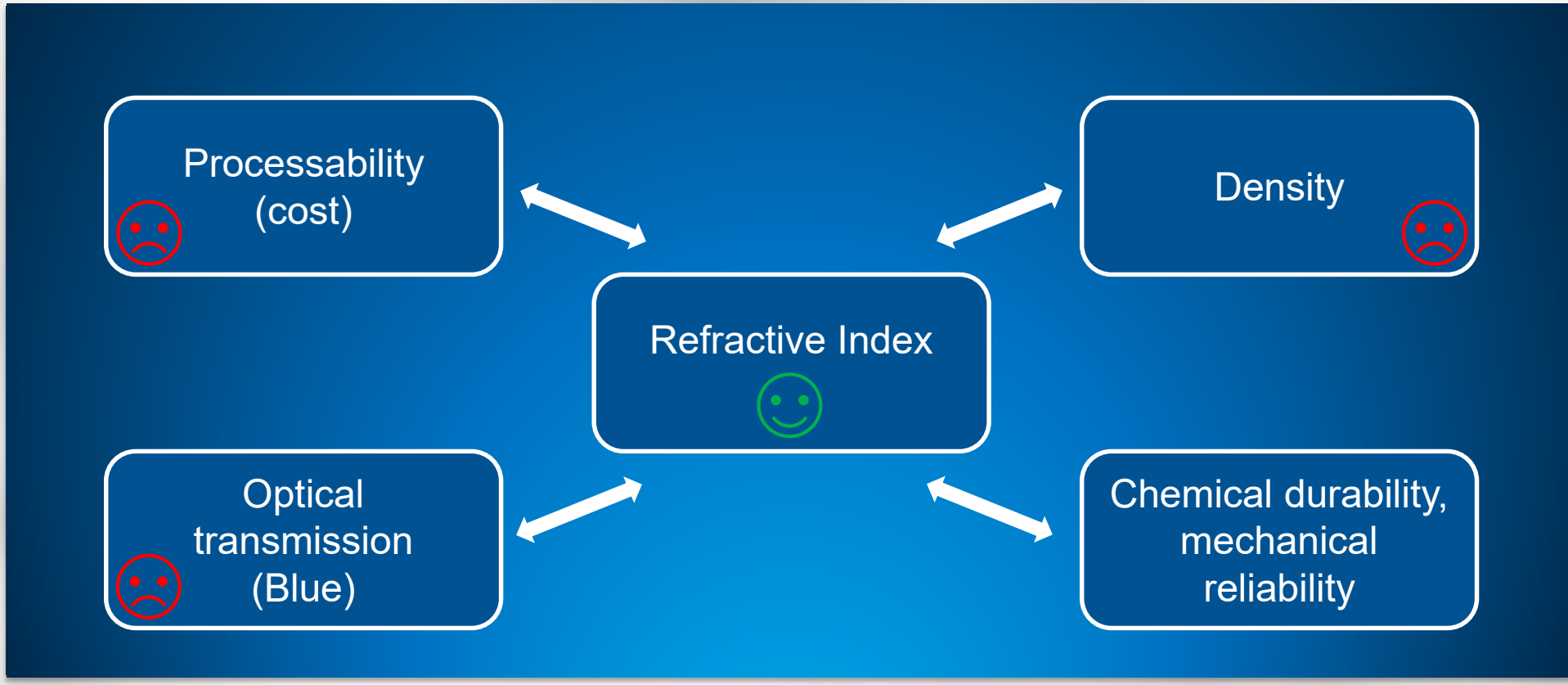
Corning has the longest experience providing ultra-flat, high-index glass to OEMs for waveguide-based AR/MR.
Demonstrated capacity >50K wafers/month

Corning is committed to developing solutions for the next wave of AR/MR devices



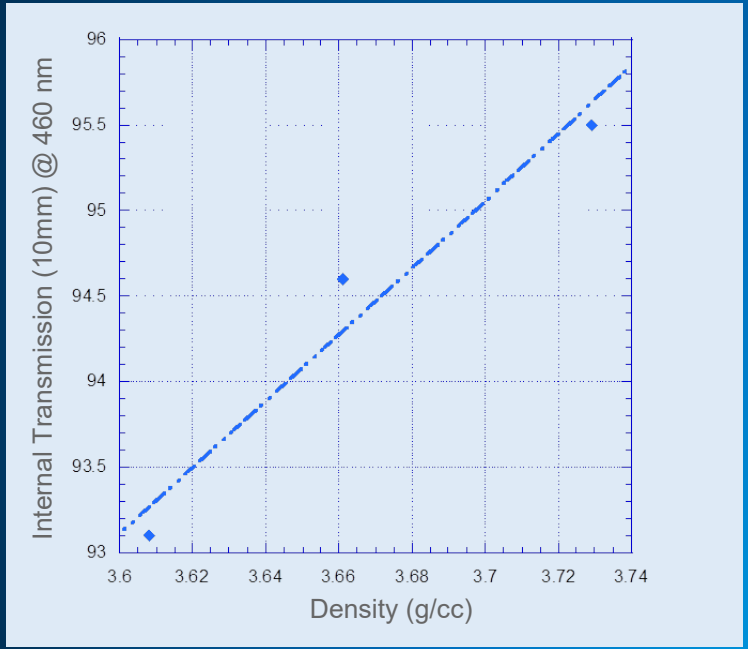
All high-index substrates delivered with leading geometric tolerances

Several ***trade-offs*** come with glass higher refractive index

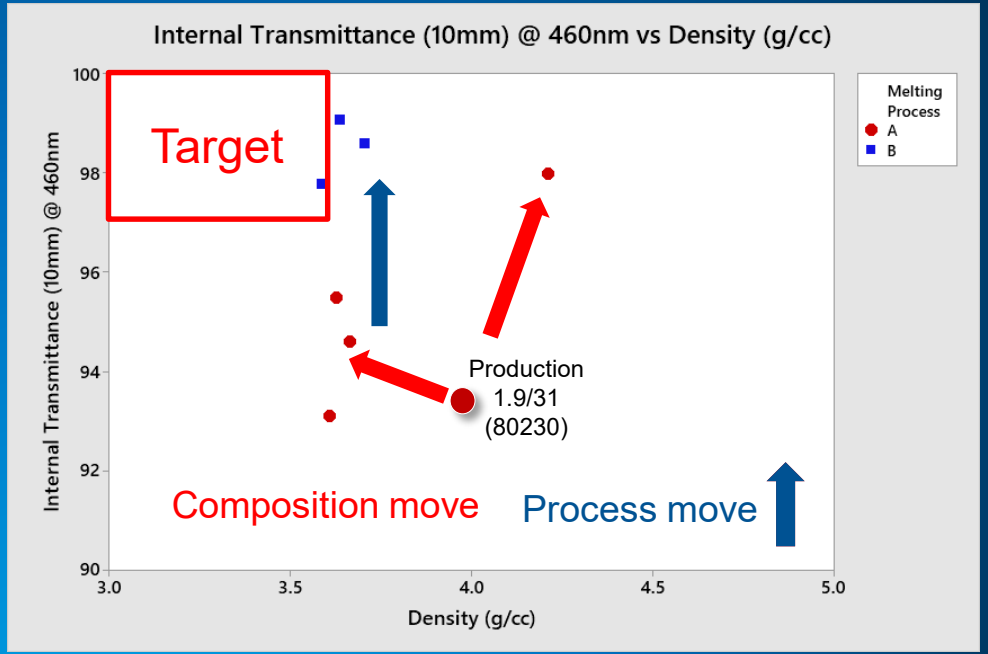


Process and composition levers are identified to ***improve density and transmittance*** of very high index glass (>1.9)

Trade-offs between density and optical transmission (Index >1.9)



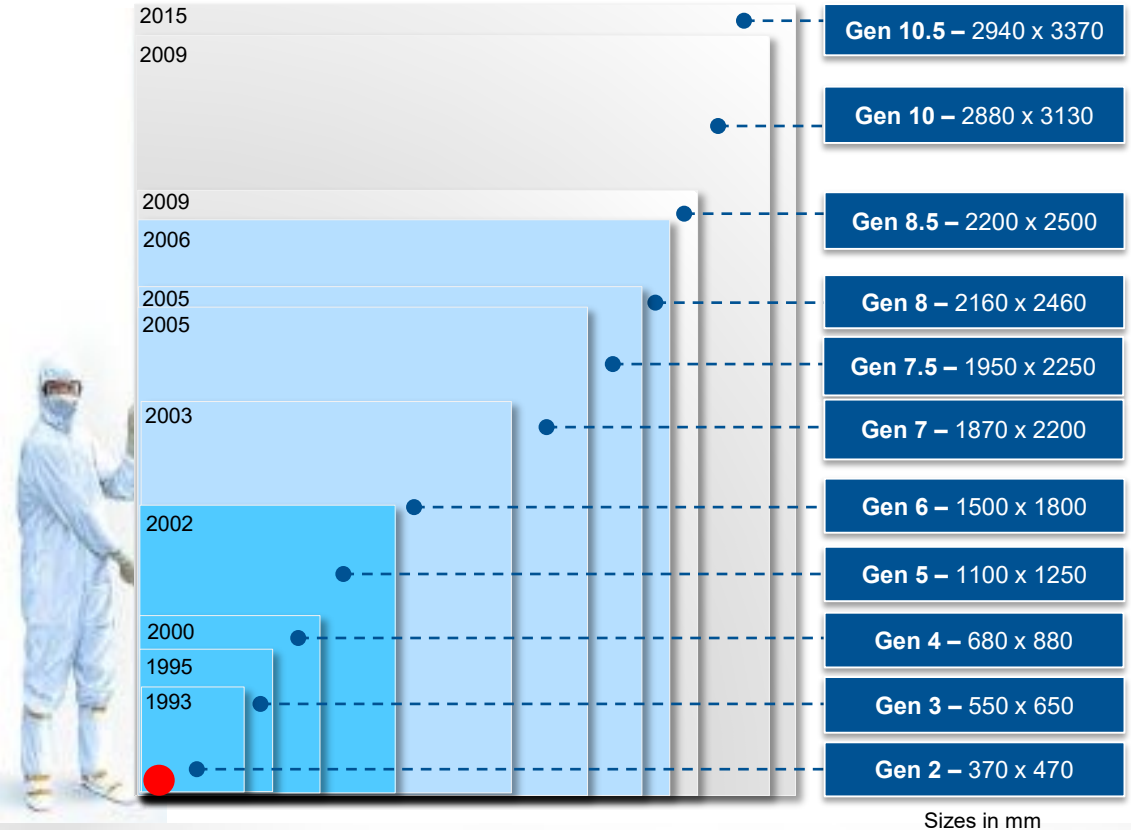
1.9 glasses in R&D improved (vs production ●)



So… Are we there yet?

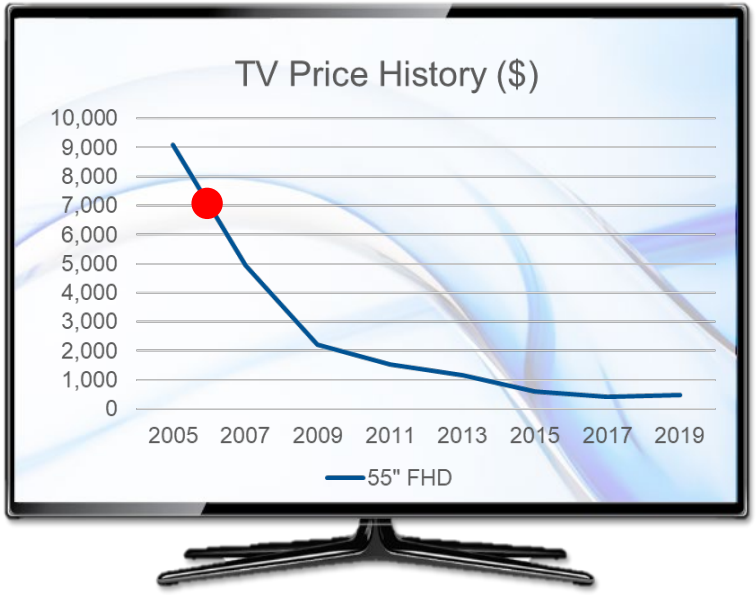
- ☑ Refractive Index
- ☑ Flatness
- ☑ Wafer / Substrate Size
- ☑ Optical Transparency
- ☑ Density
- ☒ Cost

Compared to flat panel display, AR/MR glass waveguide *manufacturing is in its infancy*



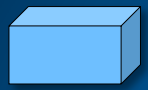
Sizes in mm

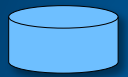
AR/MR: You are here

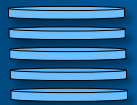


A new glass forming technology is required to reduce finishing and enable a large consumer market

Process of Record *Vs.* **Continuous Sheet Process**


Glass block


Core drilling


Wire Saw

$$


Lapping

Polishing

Technical Challenges

- Devitrification
- Low viscosity
- Warp
- Thickness control (TTV, wedge)

Corning is writing a new chapter in its display glass history

CORNING
Precision Glass Solutions

Glass For AR/MR Waveguide

We are addressing key challenges…

- ✓ Product Performances
  - Very High Index
  - Optical Transmission (Blue)
  - Outstanding flatness
- ✓ Cost-effective glass forming process

To learn more, scan the QR code below to visit our website:

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