Advancements in Glass for Packaging Technology

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Corning has two complimentary semiconductor glass product lines

Product line	Application	Description
Carrier	Si Thinning	700um Silicon Wafer, Glass Wafer → Flip & Bond → Thin & Process → De-bond, re-use (50um)
	Fan-out (FOWLP)	Laminate → Place → Molding Compound → Remove Carrier → Bump/RDL/etc.
TGV	Radio Frequency Front End (RF)	Filters, antennas, switches in mobile phones, telecom infrastructure, medical equipment
	Interposer	Re-routes connection between layers inside a semiconductor package (ie: chip) using through vias (ie: holes)

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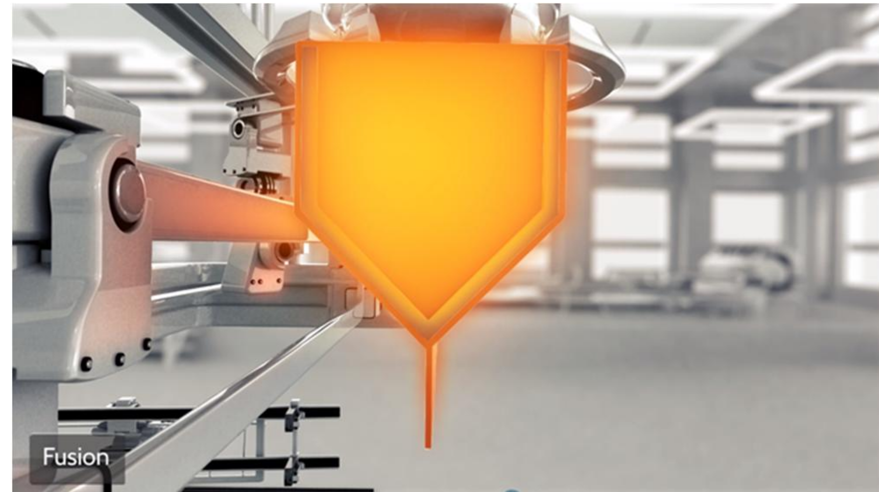
Our precision glass offers many attributes that are attractive for semiconductor applications…

Precision Glass

Corning's advanced **fusion** forming and **innovative glass compositions** provide:

- Adjustable **CTE** offerings to meet various process requirements
- Profoundly **flat**
- **Scalable** with an ability to provide a wide variety of sizes and offerings: 100 mm to 450 mm
- **As-formed** surface
- Optical and transparency properties enabling visible **inspection** and other **light-based processing techniques**
- Excellent **chemical durability**
- Reusable



Corning's proprietary fusion manufacturing process is at the core of its innovation, providing precision glass that is smooth, flat, and dimensionally stable from millimeters thick to microns thin.

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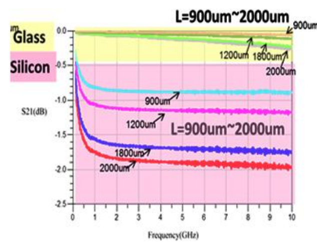
…and translate into meaningful value for our customers

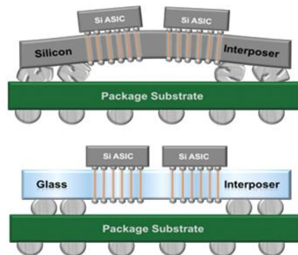
Electrical Properties



Low Electrical Loss

- Improved signal isolation
- Lower insertion loss = less power or longer battery life

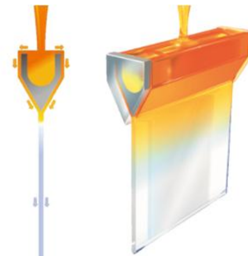
CTE Adjustability



Capability to deliver multiple CTEs

- Improves reliability
- Offer range of CTEs from 2.7-12.4

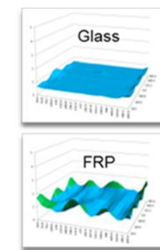
Surface Quality



Enables fine line spacing

- Smaller package size
- Fewer metal layers, resulting in cost savings

Stiffness



Glass is stiffer compared to organics

- Better flatness enables fine line spacing

Form Factor

Forming at thickness + panels

- Better yield/cost
- Better quality and efficiency in panels

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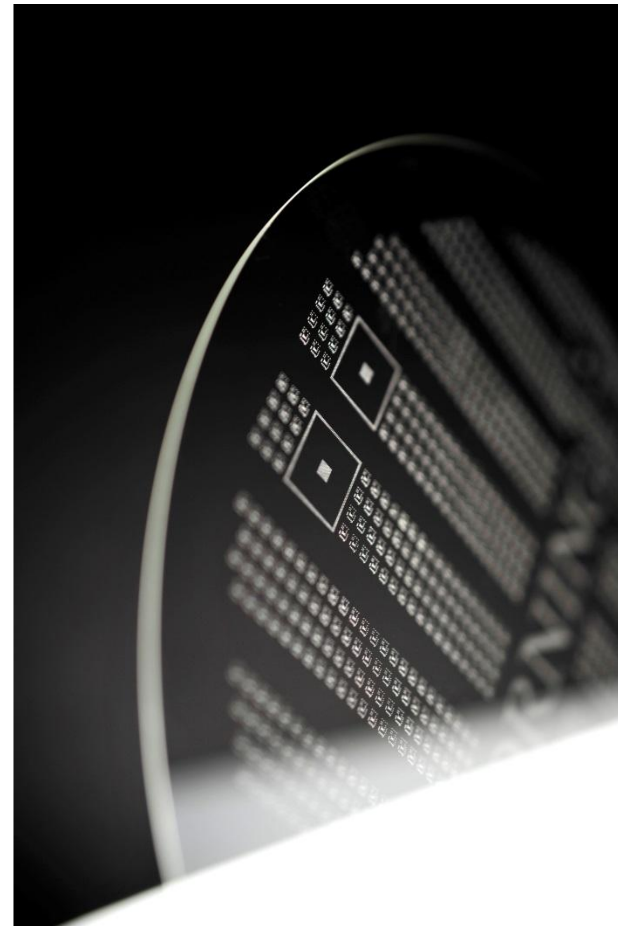
Corning offers TGV with precision holes; product attributes are a good fit for both RF and interposer applications

Precision Holes

Glass Size:

Wafers:	100mm → 300mm
Panels:	> 500x500 mm
Thickness:	~100µm → 700µm
Type of Holes:	Blind-Holes, Thru-Holes
Pattern:	Customer X,Y Location
Aspect Ratio:	~3-10:1 (in part dictated by metal)
Pitch:	Minimum 2x Hole Diameter
Hole Diameter:	100µm → 20µm → 10µm



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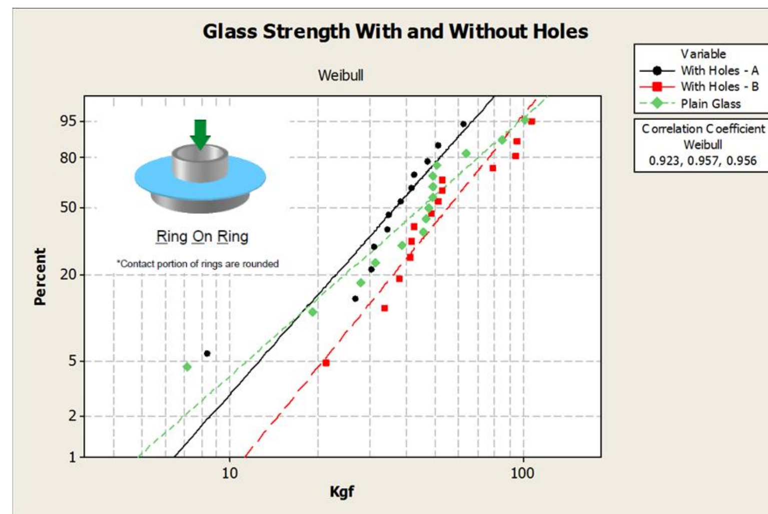
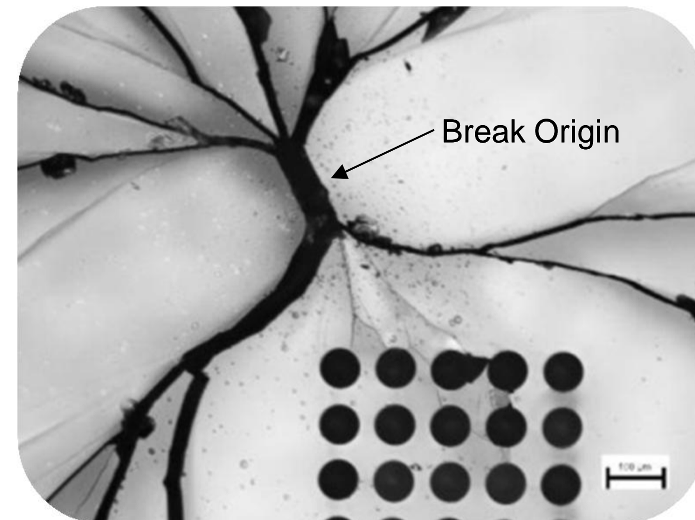
Our glass maintains strength throughout TGV process

Corning's advanced hole fabrication process retains the inherent strength of the glass substrate



Ring on ring results for glass samples with and without holes. The strength of glass with holes brackets the strength of glass without holes.



Picture of ROR broken glass sample with 5x5 via array. Note that breakage did not originate at via array.

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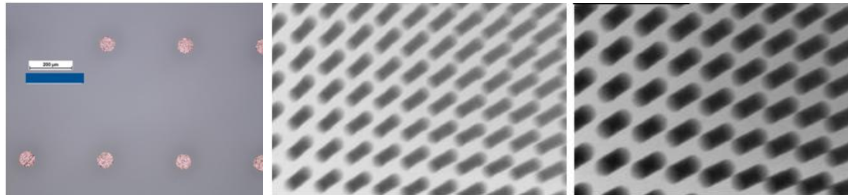
Demonstrated successful metallization of glass vias with several industry partners and are working on real projects

Paste Filling



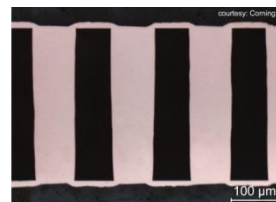
Paste filled TGV 30µm via 100µm thick

60µm via void free 300µm thick glass

80µm via void free 300µm thick glass

Panel Processing

<3um L/S 370x470mm (130µm thick) with ~100,000 holes



Atotech's double side plating process can fill through holes in panel format with low overburden

Sample Projects

- TGV for RF Applications
- Low Cost Glass Interposer
- General Purpose Glass Modules

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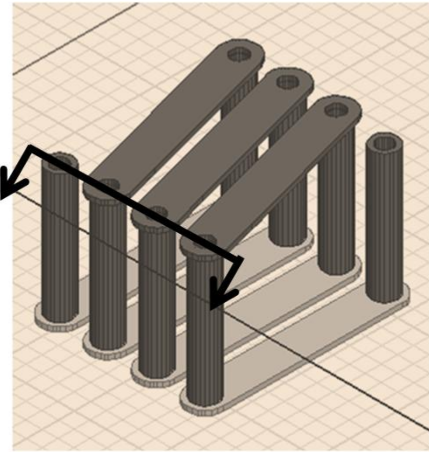
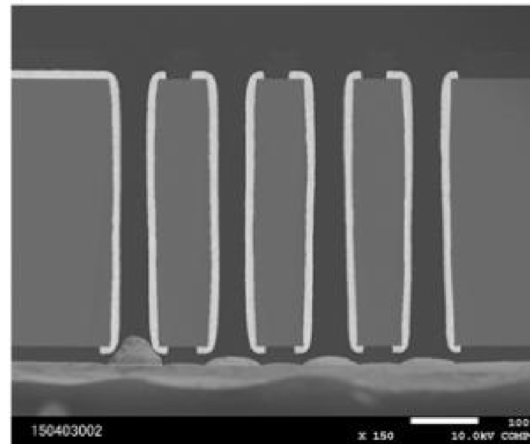
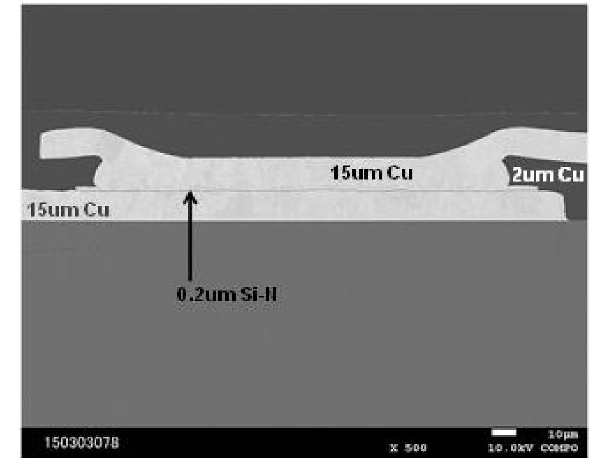
High Q inductor/capacitor prototypes demonstrated in conjunction with QCOM and DNP



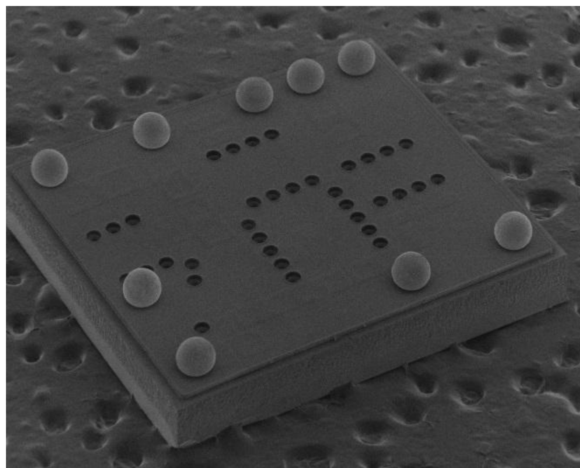
3D rendering of inductor structure, top-down view



Cross-sectional SEM of a fabricated 3D inductor



Cross-Sectional SEM of Cu-Silicon Nitride-Cu MIM structure



- Completed LC Network
- High Q inductance from 3D Solenoid inductor
- Capacitance achieved through MIM structure

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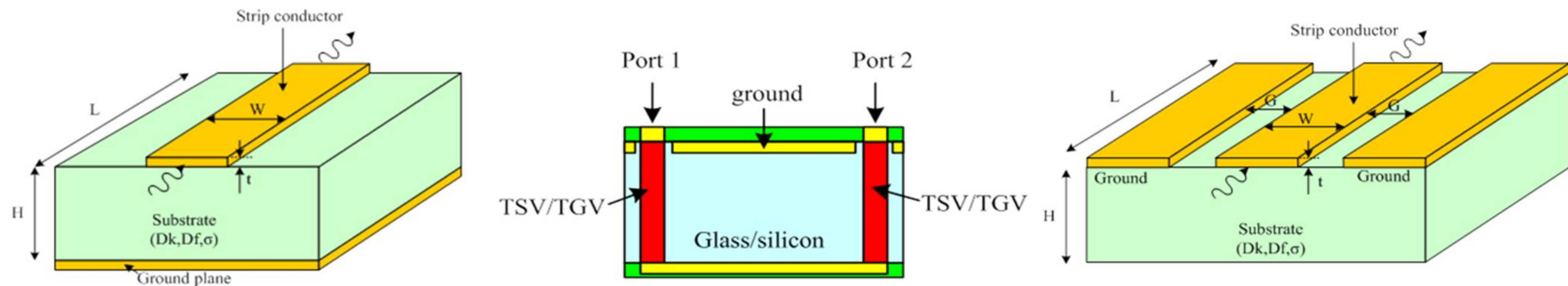
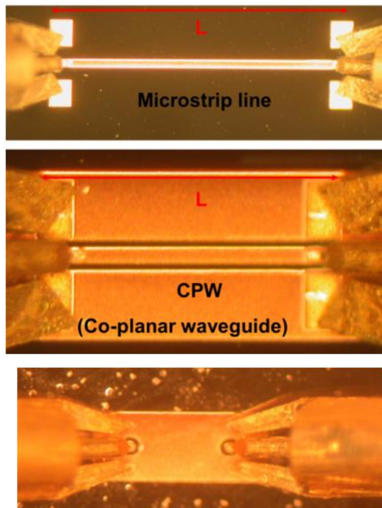
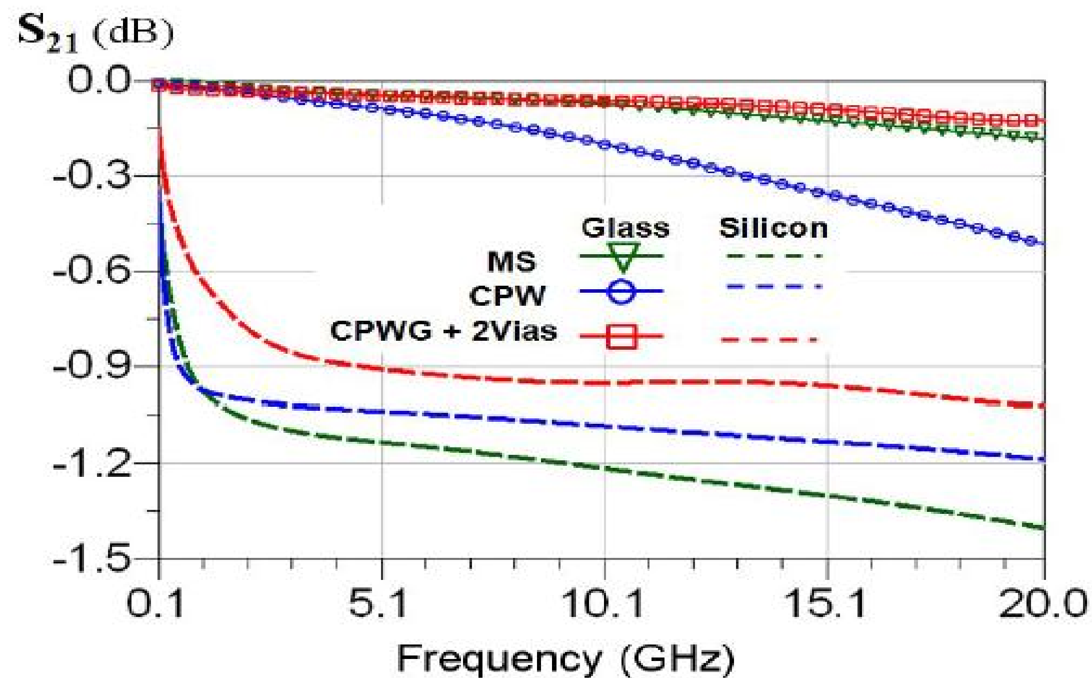
Electrical testing at ITRI shows that glass has better insertion loss vs standard Si, especially at high frequencies







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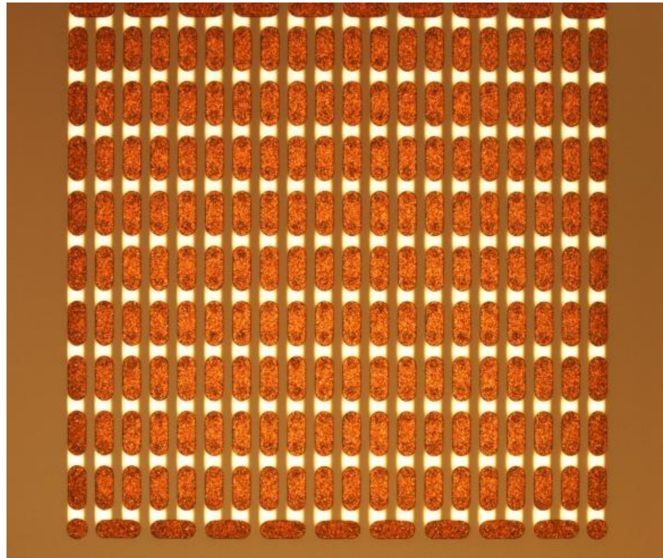
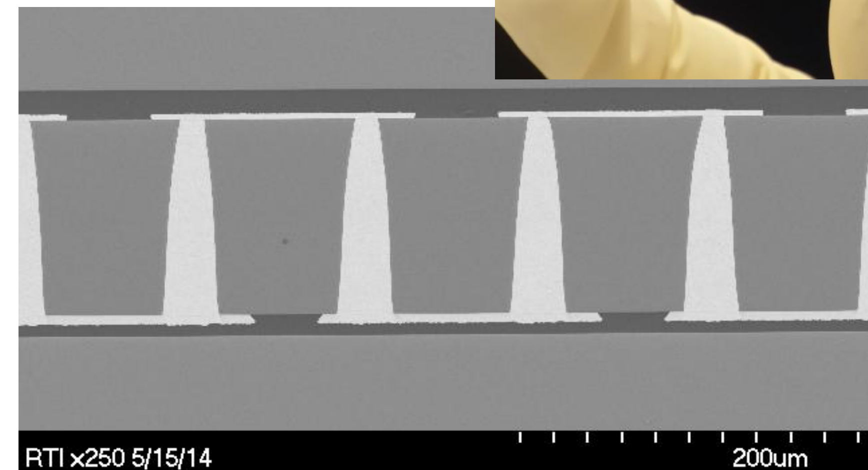
Joint work with RTI demonstrated reliability of glass after 1000 thermal cycles



Daisy chain of Cu TGVs



Profile of filled TGV

Electrical testing of TGV daisy chains: thermal cycling (-40 C to 125 C)

Wafer	CTE (ppm/°C)	No. of 20x20 arrays tested	No. of TGVs per chain	Pre-Thermal Cycling Yield of TGVs (%)	500 Thermal Cycles Yield of TGVs (%)	1000 Thermal Cycles Yield of TGVs (%)
SWG 3	3	8	400	100.00	100.00	100.00
SWG 8	8.5	8	400	100.00	100.00	100.00

RTI INTERNATIONAL

www.rti.org

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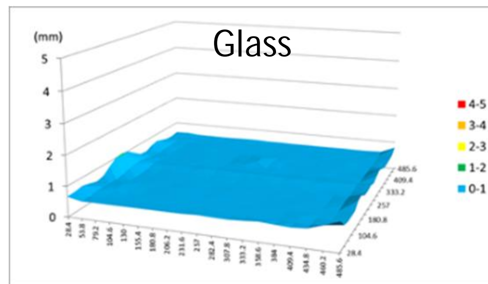
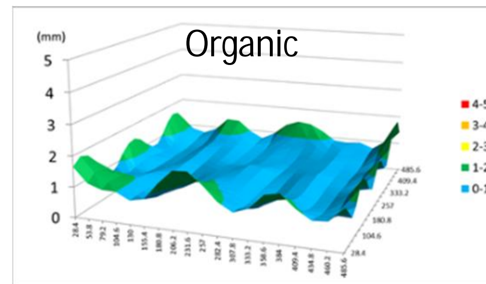
Glass helps enable panel-level packaging, which potentially enables significant process savings for our customers

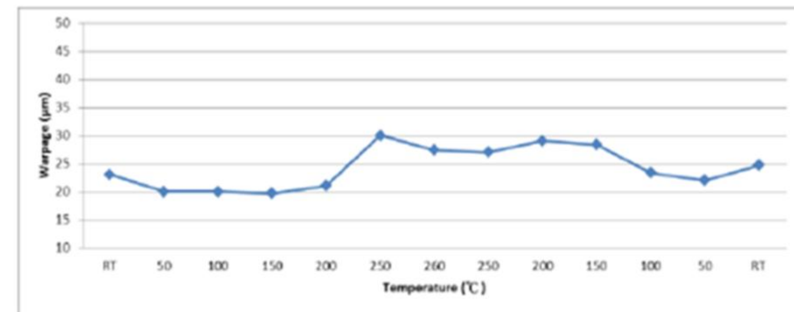


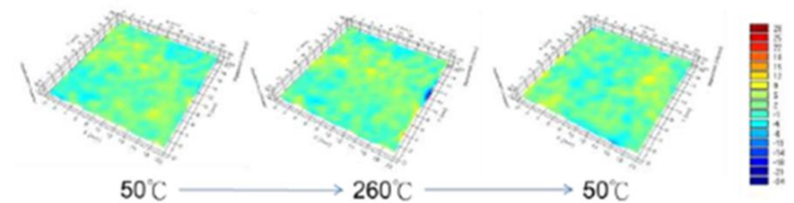


Left: Warpage measurement of glass substrate (2 build-up layers)

Right: Warpage measurement of organic substrate (2 build-up layers)

508 x 508mm glass panel





Targeted CTE of glass improves reliability of package (20x20mm)

Source: YH Chen et al., Unimicron Technology Corp., Qualcomm Technologies, Inc., Corning Incorporated, "Low Cost Glass Interposer Development", 47th International Symposium on Microelectronics, San Diego 2014.

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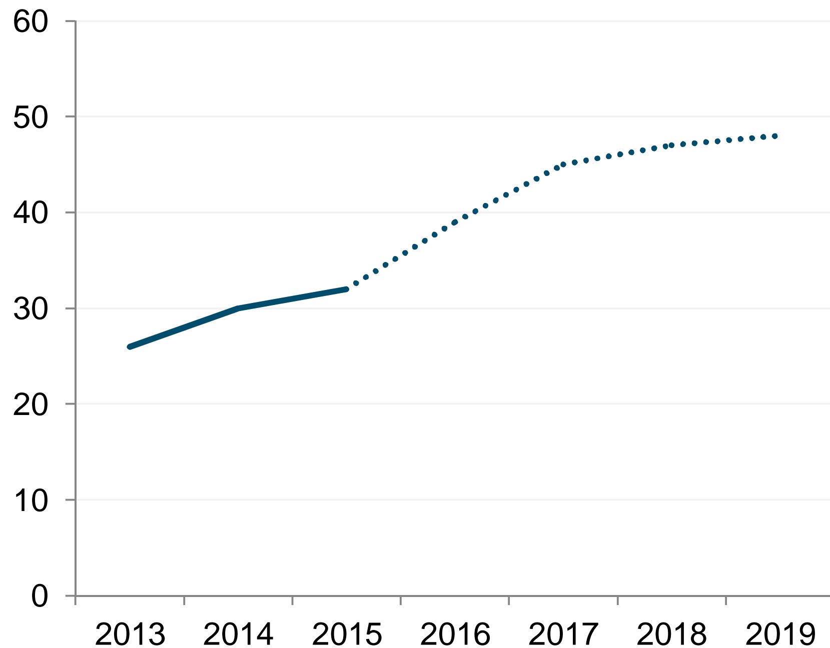
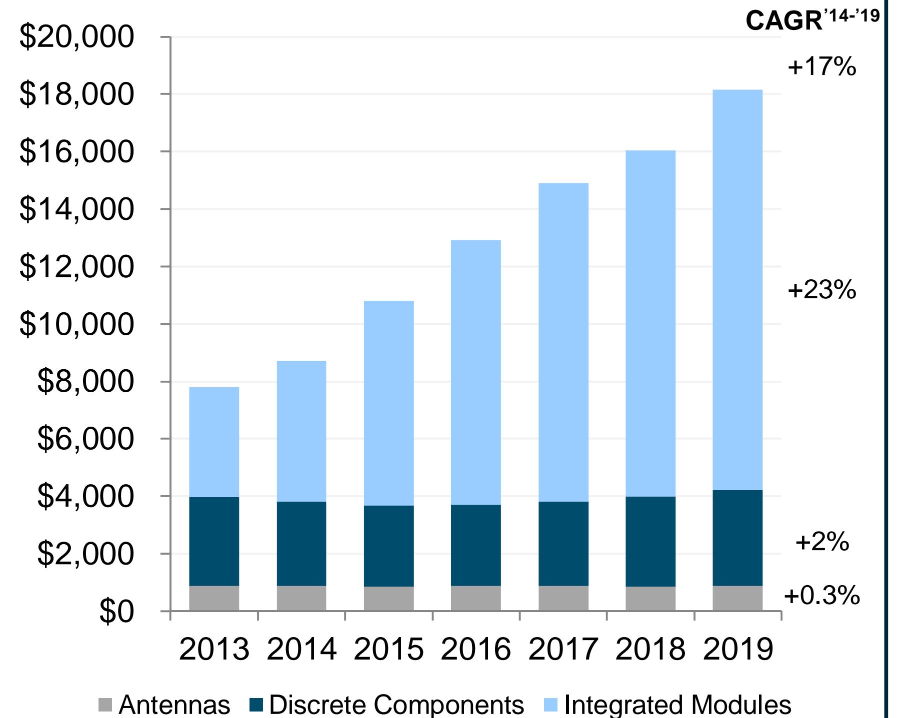
Glass is a good fit for the growing RF market

WW Frequency Bands



RF Front-End (RFFE) Market Size ($M)



CARRIER	3G			4G LTE	
	NETWORK	BANDS	FREQUENCIES (MHz)	BANDS	FREQUENCIES (MHz)
VERIZON	CDMA	0, 1	850, 1900	2, 4, 13	1900, 1700 f, 700 c
AT&T	GSM/UMTS/HSPA+	2, 5	1900, 850	2, 4, 17	1900, 1700 abcde, 700 bc
T-MOBILE	GSM/UMTS/HSPA+	2, 4	1900, 1700/2100	2, 4, 12	1900, 1700 def, 700 a
SPRINT	CDMA	10, 1	800, 1900	25, 26, 41	1900 g, 850, 2500
US CELLULAR	CDMA	0, 1	850, 1900	5, 12	850, 700 ab

- RFFE market approaching $20B in next few years
- Market growth driven by # bands
- Outlook flat for discrete devices, significant growth in integrated modules

Source: Mobile Experts, Corning Analysis

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Key Takeaways

- Corning offers precision glass and precision holes for carrier and TGV applications; our unique offering translates into meaningful value for our customers
- We have demonstrated successful metallization of glass vias with several industry partners and are now working on real projects
- Electrical testing shows that glass has better insertion loss vs standard Si, especially at high frequencies; making it ideal for RF applications
- TGV is a reliable solution and can be offered in panel form factor, which potentially enables significant process savings for our customers

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