SIXTEENTH ANNUAL

BiTS

Burn-in & Test Strategies Workshop™

March 15 - 18, 2015

Hilton Phoenix / Mesa Hotel
Mesa, Arizona

Archive – Session 4

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Session 4

Rafiq Hussain
Session Chair

BiTS Workshop 2015 Schedule

Performance Day

Tuesday March 17 8:00 am

Material Magic

"Reliability and Failure over Time"

Mike Gedeon - Materion

"Using Cold Heading Technology and Deutsch Coat to Produce Test Probes & Spring Contacts "

Jimmy L. Johnson - Tyco Electronics

"APEX Glass for Burn-In and Test Sockets"

Jeb H. Flemming & Tim Foster - 3D Glass Solutions, Inc.

"C3 Coating : Solution for IC Testing"

Bert Brost & Valts Treibergs - Xcerra Corporation

Nakaya Katsura - Kobelco Research Institute, Inc.

BiTS Burn-in & Test Strategies Workshop 2015

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BiTS 2015 Burn-in & Test Strategies Workshop™

APEX® Glass for Burn-In and Test Sockets

Jeb H. Flemming & Tim Foster
3D Glass Solutions, Inc.

2015 BiTS Workshop
March 15 - 18, 2015

3D Glass Solutions Company Overview

- 3DGS was founded in 2007 to provide our customers with an integrative solution in IC packaging that allows them to integrate more components onto a single platform while decreasing overall manufacturing costs.
- Core APEX Glass IP for applications and fabrication filed in 2008 and 2009
- Providing glass enabled systems integration foundry services since 2010
- Engaged with over 60 different companies in 2014
    - Major Handset Suppliers
    - Major Defense suppliers
    - Tier 1 Electronics MEMS suppliers
- Fully established production supply chain for HVM in 2014

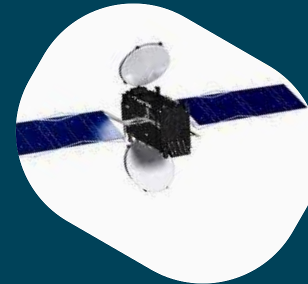
Typical Markets Served

WLP/MCM/SiP

- Inductors
- RF Switches
- Power Amplifiers
- CMOS Image Sensors

- Wireless Charging
- Fingerprint Sensors
- Timing Devices
- MEMS / Sensors

Optimized High-Q Designs



- Next Generation PCB material
- Satellite / SATCOM
- Automotive Radar
- DC to 100GHz

Typical Markets Served (Cont'd)

Integrated Optoelectronics

- Electronic Connectors
- Fiber Optic Connectors
- Optoelectronic and Opto-RF
- Mechanical aligners, spacers, and mirrors

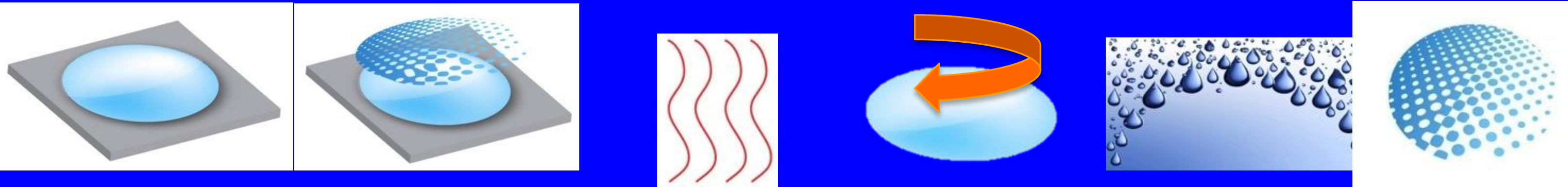
Glass Interposers/Substrates

- WiFi and Bluetooth Antenna
- WiGi Transceivers
- Fiber Optic / Opto-RF Electronics

The APEX Glass Advantage

- Enables batch/HVM of micro-components in glass
- Multi-step processing enables greater integration of active components
- Smooth surfaces and ultra-small, high density though holes = smaller routing densities
- Broad spectrum transparency optimizes Optoelectronics and Opto-RF packaging
- Better material constants compared to laminates and silicon
  - ➢ Enables up to 66% chip size reduction
- Micro-fracture free production of through holes ensures lower loss and better reliability

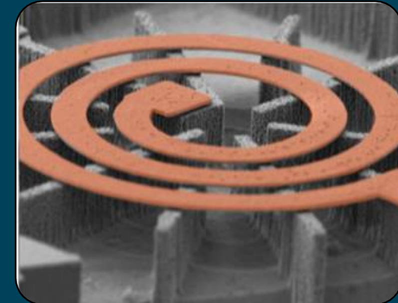
A Simple Microfabrication Approach



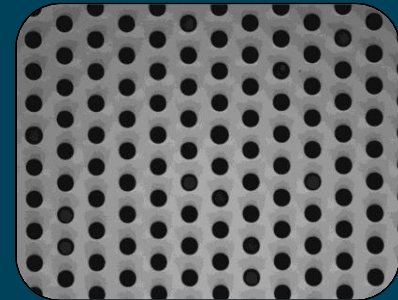
APEX Glass Wafer | Mask & Expose to UV Light | Bake to Form Ceramic | Polish Wafer | Etch Away Ceramic | Final Part

Enabling Next Generation Test Packages

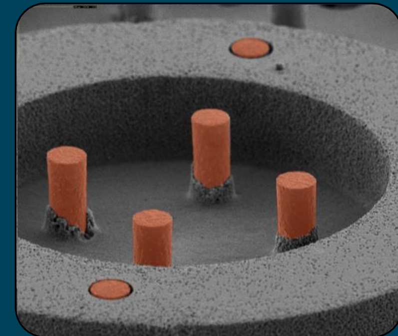
- Batch manufacturing = low-cost production
- Creation of through glass vias (TGVs) >10 microns
- Micro-fracture free production of high density TGVs
- Wafer level integration:
  - TGVs
  - Cavities
  - Trenches
  - Copper filled TGVs
  - Surface metals



50um copper line resting on 17um glass rails



60um diameter TGVs



60um diam. copper pillars in cavity

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APEX Glass for Burn-In and Test Sockets

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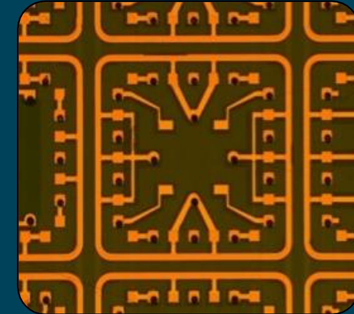
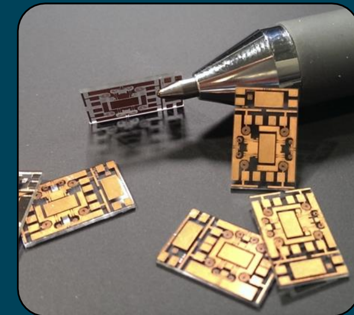
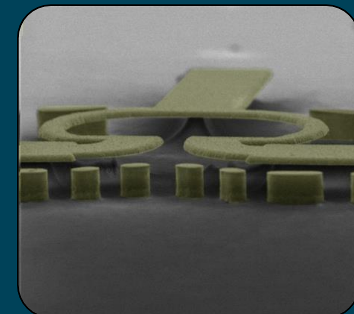
3D Glass Solutions' Role

- 3DGS provides complete glass-enabled systems integration services for our customers: These include metallization and dielectric processes
- We offer cradle-to-grave fabrication services for customers looking to produce next generation products out of glass
- Importantly, 3DGS has expended tremendous resources to develop standard operating procedures to integrate these highly functionalized IC packages with standard HVM process flows
- Prototyping, low to mid volume production, and bridge manufacturing is done in Albuquerque, NM
- Ultra high volume manufacturing is transitioned into a network of foreign and domestic supply chain partners to ensure low cost production for price-sensitive applications
- We have a robust IP portfolio to protect our customers' designs and applications.

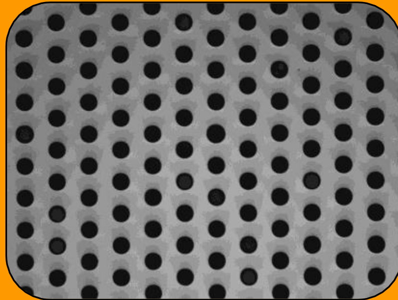




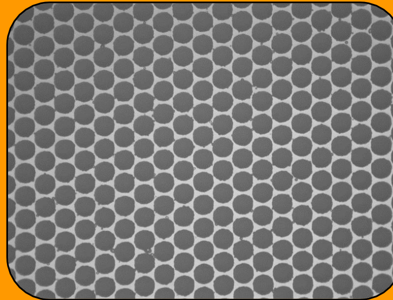


Micro-Features in Glass

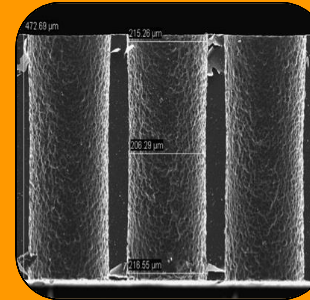
TGVs, Cavities, Trenches, Pillars, Air Gaps



Through Glass Vias

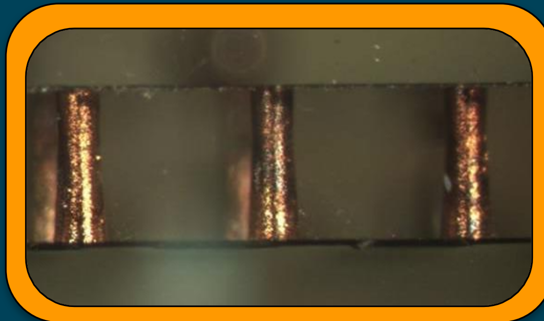


At High Densities



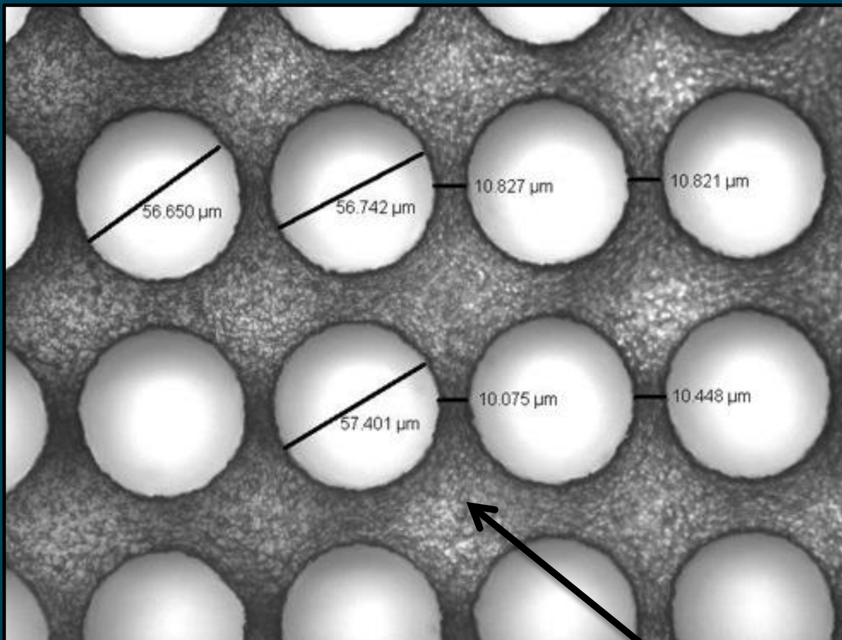
Anisotropic Etch

Through Hole Filling with Copper Metal



Surface metallization & Final Product

Through Glass Vias

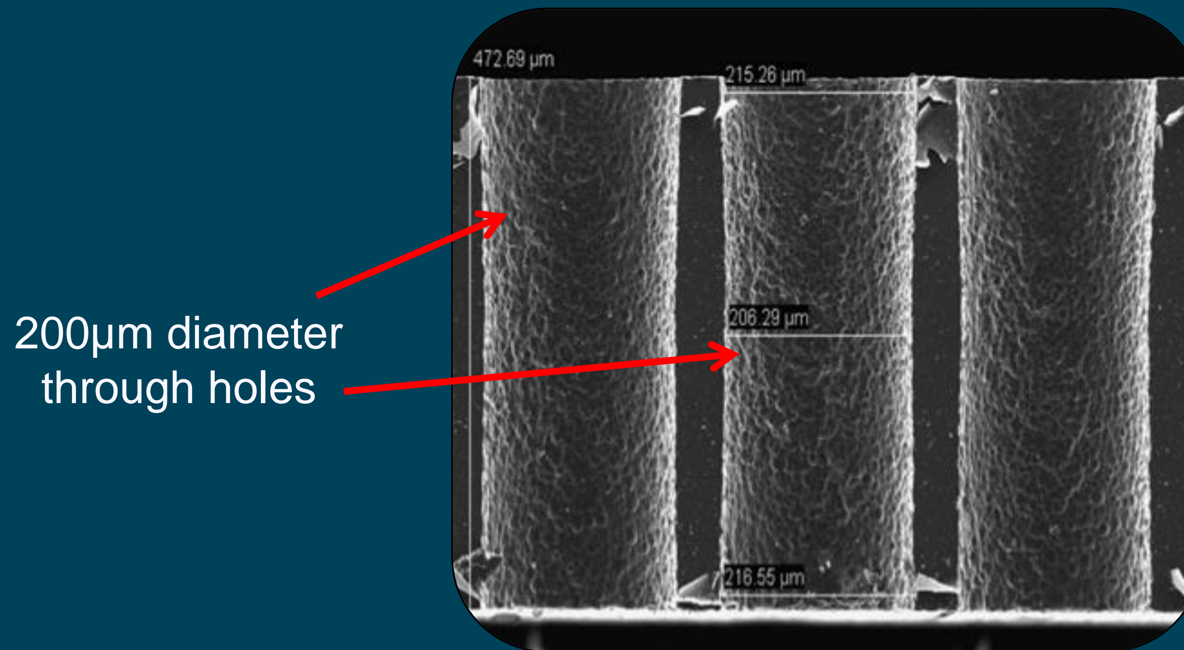


Material Thickness: 250µm
Center-to-Center Pitch: 65µm
TGV Aspect Ratio: 4.5:1
Vias per cm^2: 23,661

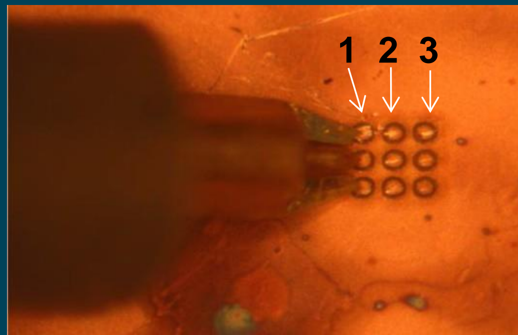
Diameter	Edge Gap
56.65µm	10.83µm
56.74µm	10.82µm
57.40µm	10.08µm
56.36µm	10.45µm

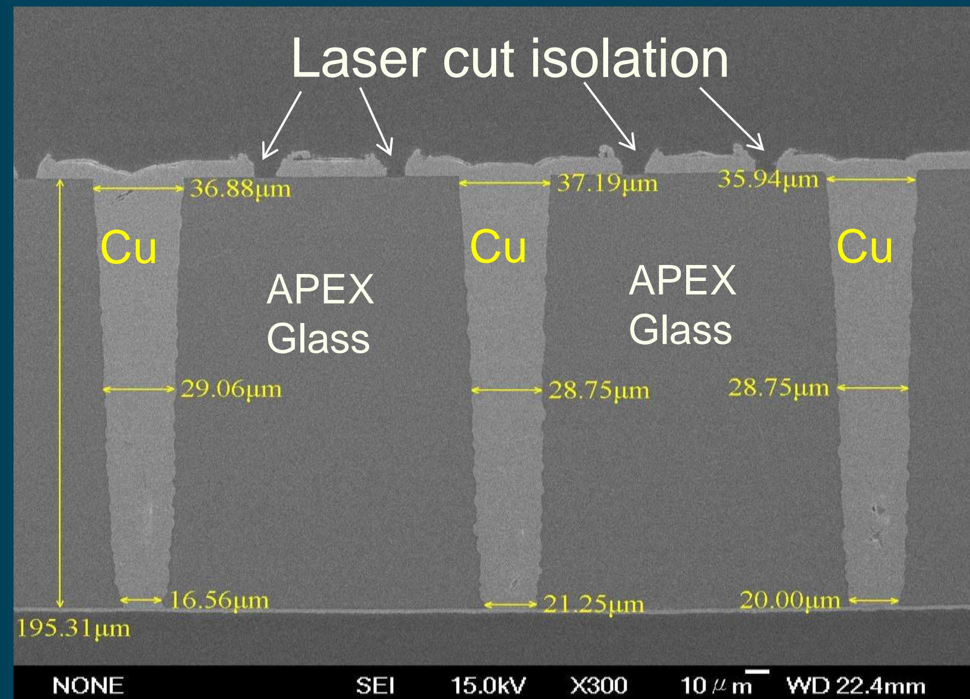
Increased surface roughness due to mechanical lapping

Through Hole Cross-Section



TGV Samples

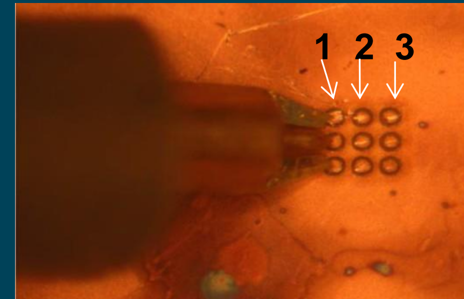


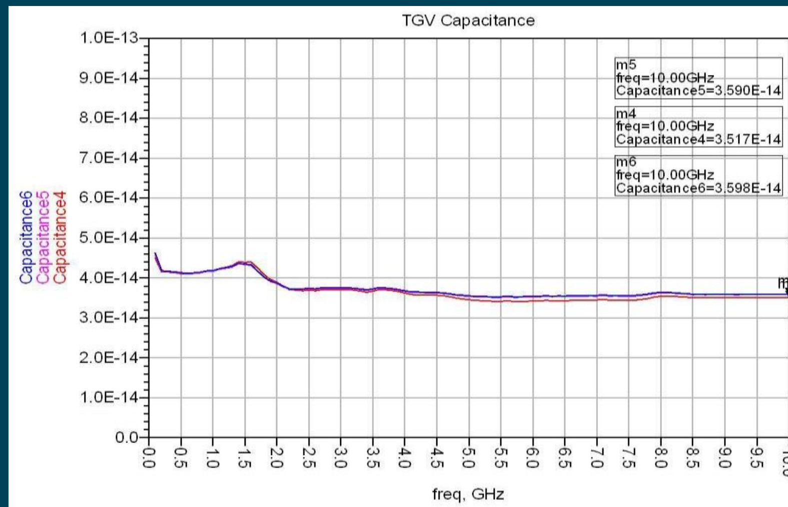


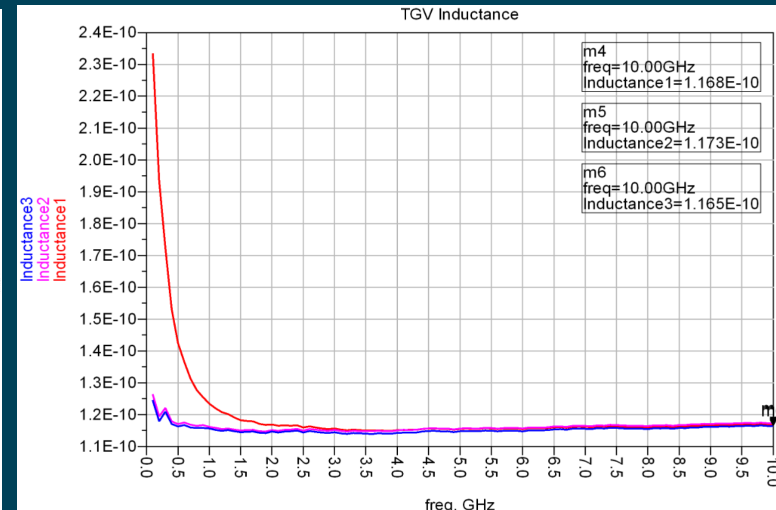
- TGV Spec: Avg. diameter between top & bottom=28µm, Length=195µm, Pitch=150µm
- Simulated Capacitance by Q2D=22.7 fF; by Q3D=33.1 fF; and by measurement=36fF
- Simulated Inductance by Q2D=129.6 pH; Measurement=116.8 pH

TGV Samples Measured Results

TGV Description	Specification
Average Diameter	28µm
Length	195µm
Pitch	150µm







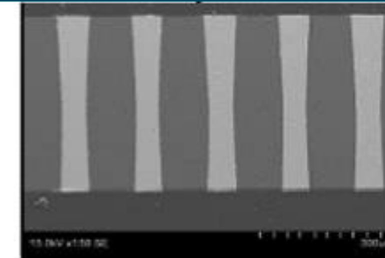
Sample 2 avg. capacitance at 10GHz=36 fF

Sample 2 avg. inductance at 10GHz=116.8 pH

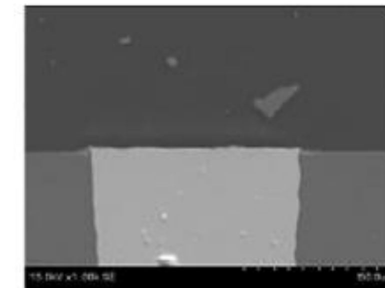
TGV Copper Plug Plating

Description	Specification
Diameter	75µm
Pitch	115µm
Wafer Thickness	500µm

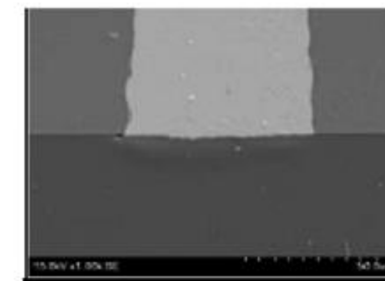
Wafer Cross-Section



Top of Plated TGV Close Up



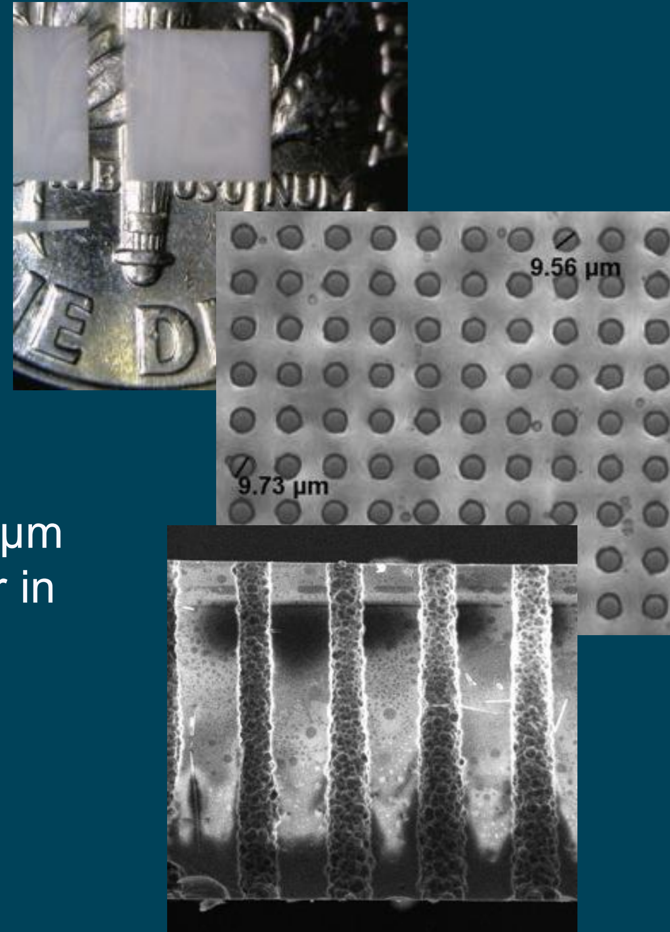
Bottom of Plated TGV Close Up



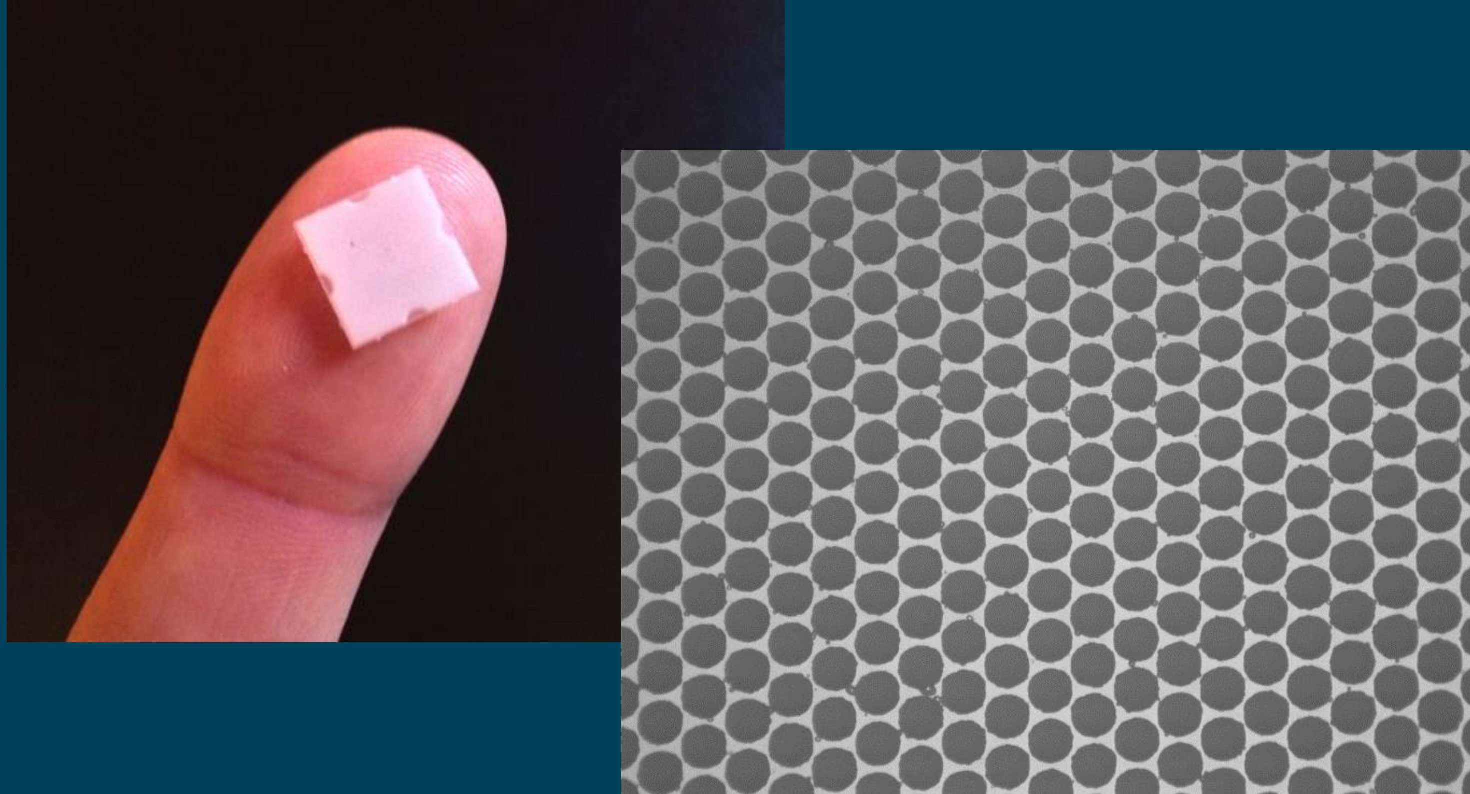
Create 10 Micron TGVs

Processing Parameters:

- 10µm patterns on 20µm pitch
- Array pattern: 40,000 TGVs per array
  - Wafer had 100 arrays
  - Total TGVs 4,000,000
- Exposure: 22 Joule/cm^2 at 310nm
- Etch time: 4 minutes
- Results: TGV diameter 9.61µm +/- 0.15µm
- Produce over 100M TGVs in an 8” wafer in under 30 minutes of processing time

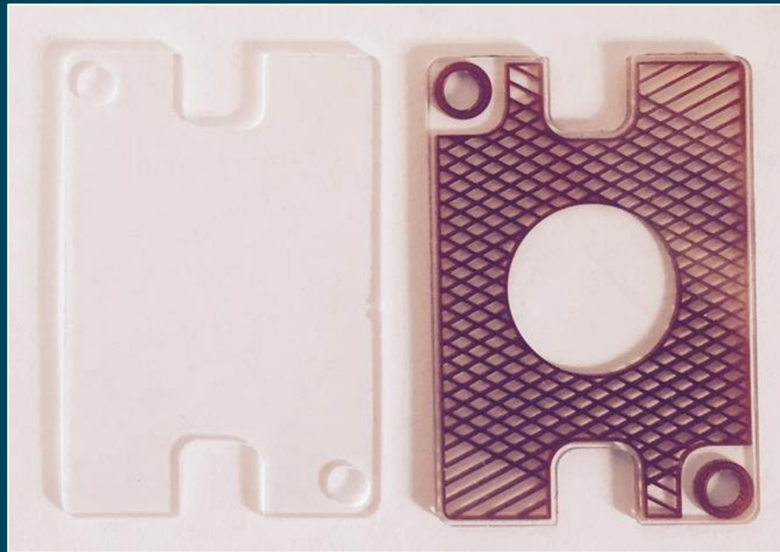


Tight Pitches



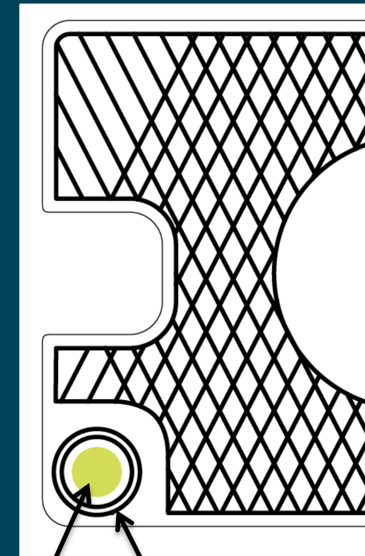
25,000 TGVs in 1 cm^2 -- 65µm Diameter on 72µm Pitch

Ceramic Reinforcement



Fully glass part

Glass part with ceramic structures for mechanical reinforcement.

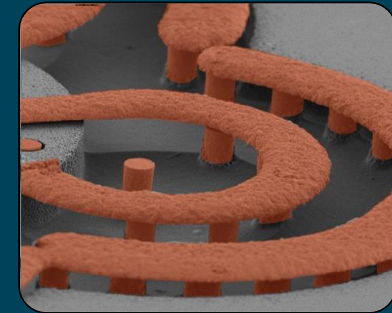


(Orange) Open Through Hole

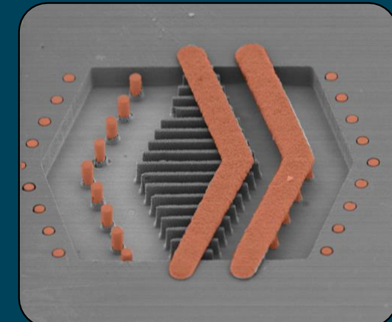
3 ea 150µm wide ceramic circles enclose the screw hole.

Systems Integration of Micro-Cavities

- Glass based micro-cavities offer several advantages:
  - Precise structural formation for controlled volumes
  - Integration with copper-filled TGVs
  - Chemical compatibility
- Providing solutions for multiple applications:
  - Cell phone sensors
  - Bluetooth timers
  - Optoelectronics
  - MEMS technologies
  - Batteries
  - Electronic connectors
- Create cavities for wafer level packaging lids for both active and passive components
- Create angled sidewalls into cavities for metallization on the bottom of the wells



60um diam. copper pillars in cavity with metal overhang



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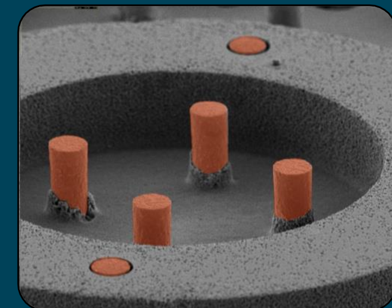

60um diam. copper pillars in cavity

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Technical Specifications

APEX Glass Physical Properties	
Coefficient of Thermal Expansion (Glass)	10 ppm / K
Coefficient of Thermal Expansion (Ceramic)	9 ppm / K
Softening Point (Ts)	472 C
Glass Transition Temperature (Tg)	452 C
Density	2.35 g / cm^3
Young's Modulus	80 GPa
Thermal Conductivity (Glass)	1.5 W / mK
Thermal Conductivity (Ceramic)	2.8 W / mK

Technical Specifications (Con't)

APEX Glass Index of Refraction			
	Glass	Ceramic	Precipitate
532nm	1.5283	1.5293	1.5260
633nm	1.5238	1.5249	1.5216
986nm	--	1.5166	1.5137

Standard Design Rules

Process Description	Capability
Final Glass Thickness	200-1,500µm
TGV Diameter	>30µm
TGV Aspect Ratio	10:1
TGV Pitch	As low as 1.2 x TGV diameter
Sidewall Angle	>88°
TGV Diameter Tolerance	+/-7%
Cavity/Trench Depths	25µm - 800µm +/- as low as 0.5µm

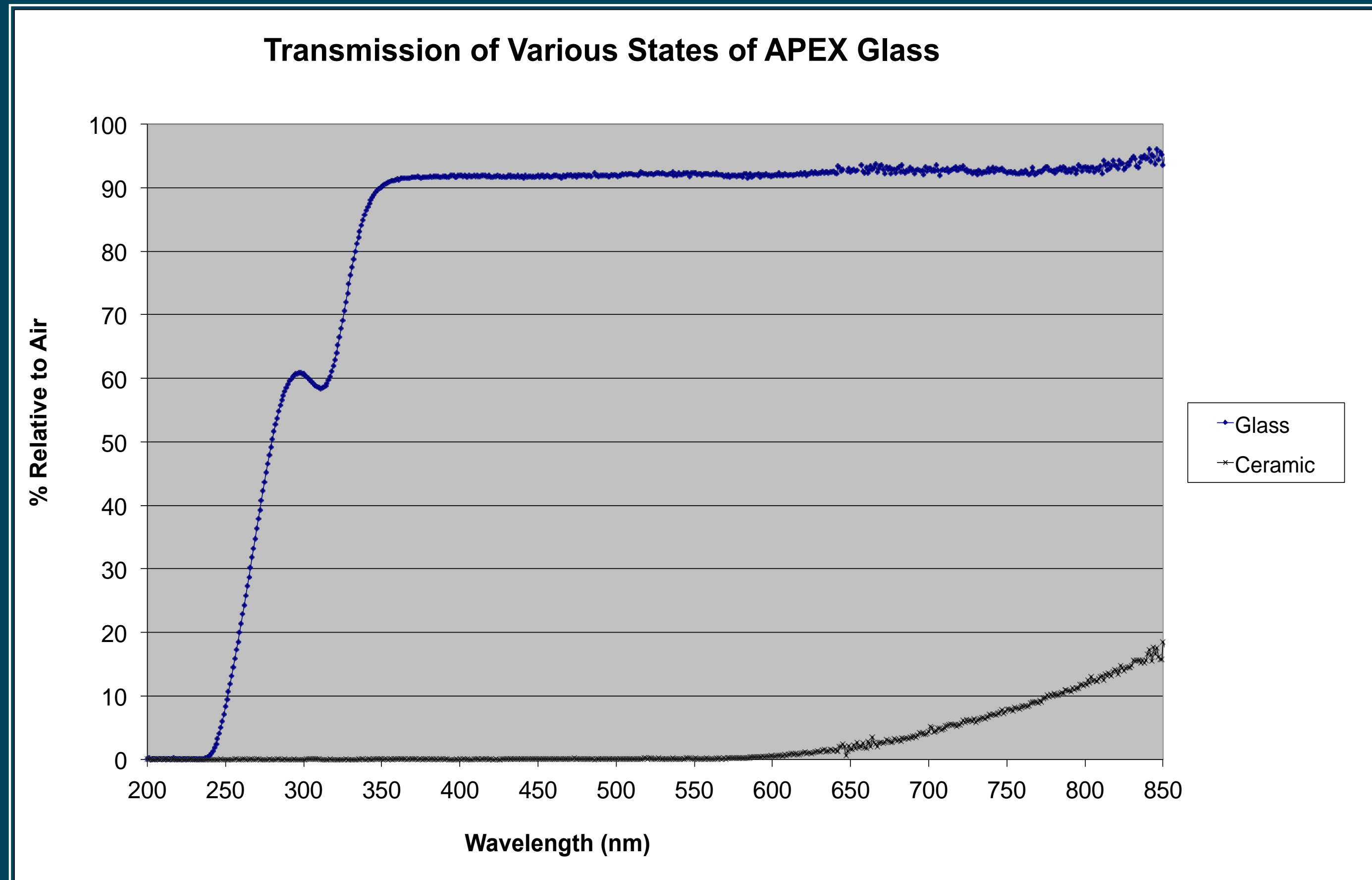
Standard Design Rules (Con't)

Process Description	Capability
Feature-to-Feature Tolerances	<10µm
Surface Metal Type	Sputter: Cr, NiCr, Ti, TiW, Cu, Ni, and Al Evaporation: Cr, Ti, Cu, Au, and Pt
Electroplated Copper Thickness	<10µm
Surface RDLs	2 Redistribution Layers

APEX Glass Formats and Volumes

Glass Description	Capability
Wafer Sizes	Current: 100mm, 150mm, 200mm 2015 Q4: 300mm 2016: 508mm x 508mm
Wafer Thickness	200µm – 1500µm
Thickness Uniformity	+/- 6µm
Surface Finish	10nm Ra
Prototype & Bridge Production	200-400 wafers / month
HVM Capacity	20,000 wafers / month in H2 2015 40,000 wafers / month in H1 2016 100,000 wafers / month in H1 2017 (Based upon 8” wafer equivalents)

APEX Glass Transmission Curves



1mm Thick

Conclusion

- 3DGS presents APEX Glass as a unique material for the burn-in and test community
- It is used in many IC industries
- Presents unique manufacturing flexibility
- Batch manufacturing = cost effective production
- Create TGVs, cavities, etc.
- Copper-filled TGVs represent unique product solutions