Engineering the Intelligent Future

Through Glass Via (TGV) Etching on Glass Core Substrates for High Density 3D Advanced Packaging Applications

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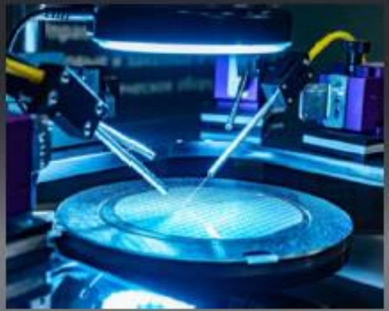
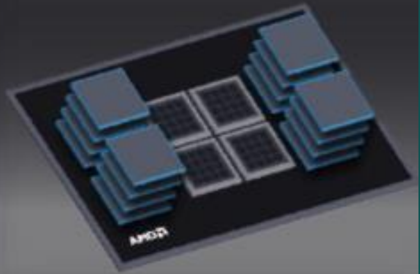
IMAPS DPC, Phoenix, AZ, March 4, 2025

Outline

- Introduction
- TGV Etching: Laser modified post-chemical treatment
- Etch Results: Etch Rate based on Glass Types
- TGV Performance and Analysis
- TGV Process Control
- Summary

Key Challenges for AI Hardware


Silicon	Memory	High Speed Signaling	Power Delivery	Thermals
Increased density High Perf/watt	High Capacity/BW Low latency	Signal Delivery Integrity	High power Requirements	Effective Heat Removal
Scaling/Yield Challenges	Near ASIC Integration	Signal Integrity Issues	High Current Delivery Related Issues	Thermal Management

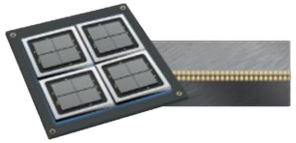
Manish Dubey, AMD, Keynote Talk, Advanced Packaging for AI – WLPS, Feb, 2024

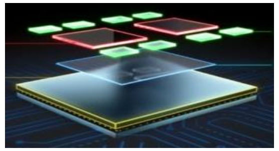
- Silicon, Memory and High Speed Signaling continue to challenge hardware
- Advanced packaging innovations can help address these challenges
- Package size growth is driving towards glass core substrates

Megatrends Driving YES Innovation

High-Performance Compute for AI, Cloud and Edge

Wafer Scale Packaging 2.5/3D
xPU Power, BPD & L4 Cache

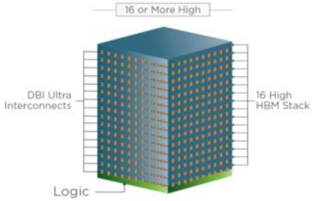




High-Bandwidth Memory (HBM)

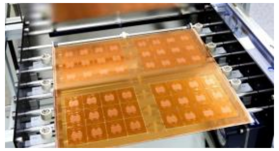
HBM3/3E/4 uBump reflow

HBM4+ Hybrid Bonding



Advanced Substrates

Large Substrate CCL: Fine Pitch BU
Glass: Core & FO

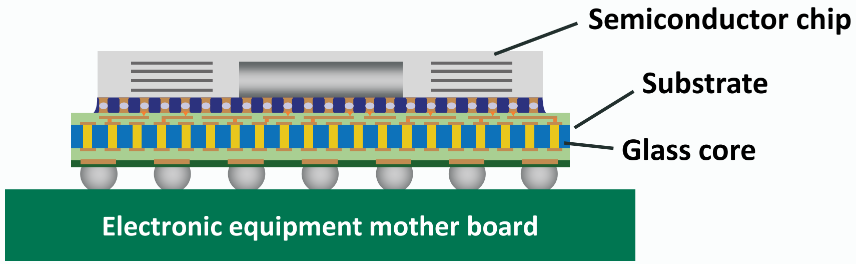


Power, RF and Thermal

Power Conversion GaN/SiC

Thermal Solutions Heat Sink Attach

Glass Core Substrates - Future of Technology



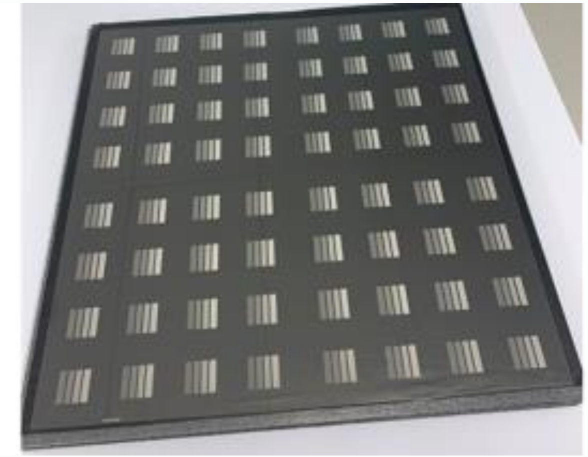
- The Emerging AI and 6G Technologies are leading to increasing chiplet count and large package size

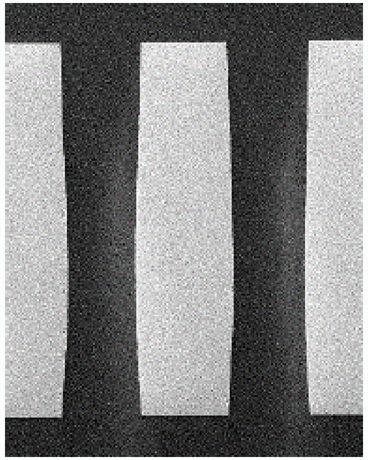
- Advanced Semiconductor Packaging demands:
  - Better structural integrity, higher performance with low power
  - Good temperature handling of devices (CTE)
  - Chemical inertness
  - Mechanical strength to hold packed chips

- Glass core substrate technology meets the requirements making it ideal for next generation microelectronics demands for extending Moore's law to 2030 and beyond

Thru' Glass Via Etch: TGV Systems' Requirements

- Demonstrated features for panel applications
  - CCL, glass and wafer panels (200µm to higher thickness)
  - Unique load/unload to handle panels
  - Bath control/dosing automation
  - All side overflow baths to minimize surface contamination
  - Wide range of Dryer 0ptions: including surface tension gradient (STG)
- Proven applications with TGV BKM chemistries
  - Glass etching for TGV and cavity trench
  - Custom chemistries for different types of Glass



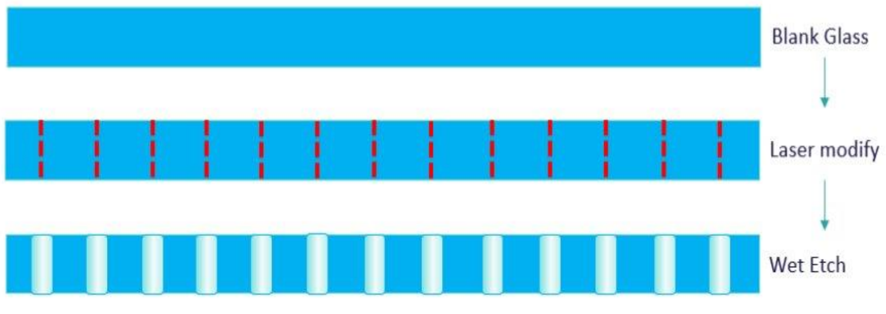


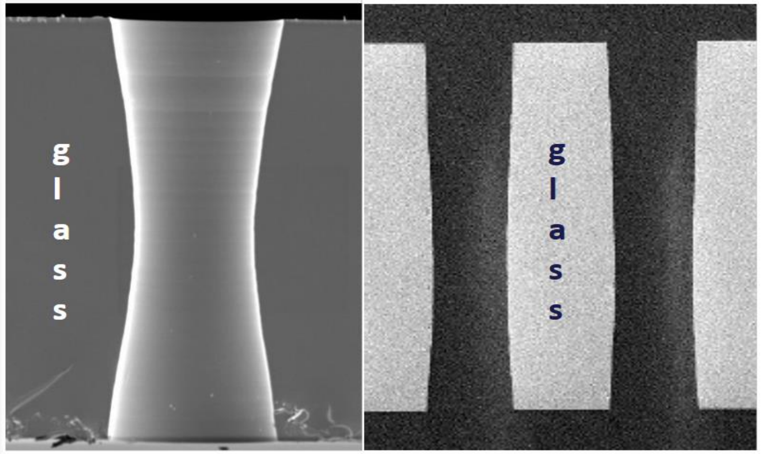
50µm via hole on 250µm glass with 4:1 AR

Thru Glass Via (TGV) Based on
Laser modified post chemical treatment (LMCT)

- Historically various methods have been developed to make TGV, including Lithography.
- Laser modified post-chemical treatment (LMCT) technology is discussed to form through glass vias (TGV)
  - First, glass is locally modified by laser pulses in a desired pattern
  - Then, laser patterned areas are advantageously etched with a wet etching process, exposing all the TGVs at the same time
  - Laser modified areas etch at least 5x FASTER
- TGVs are subsequently metallized

TGV Etch by LMCT

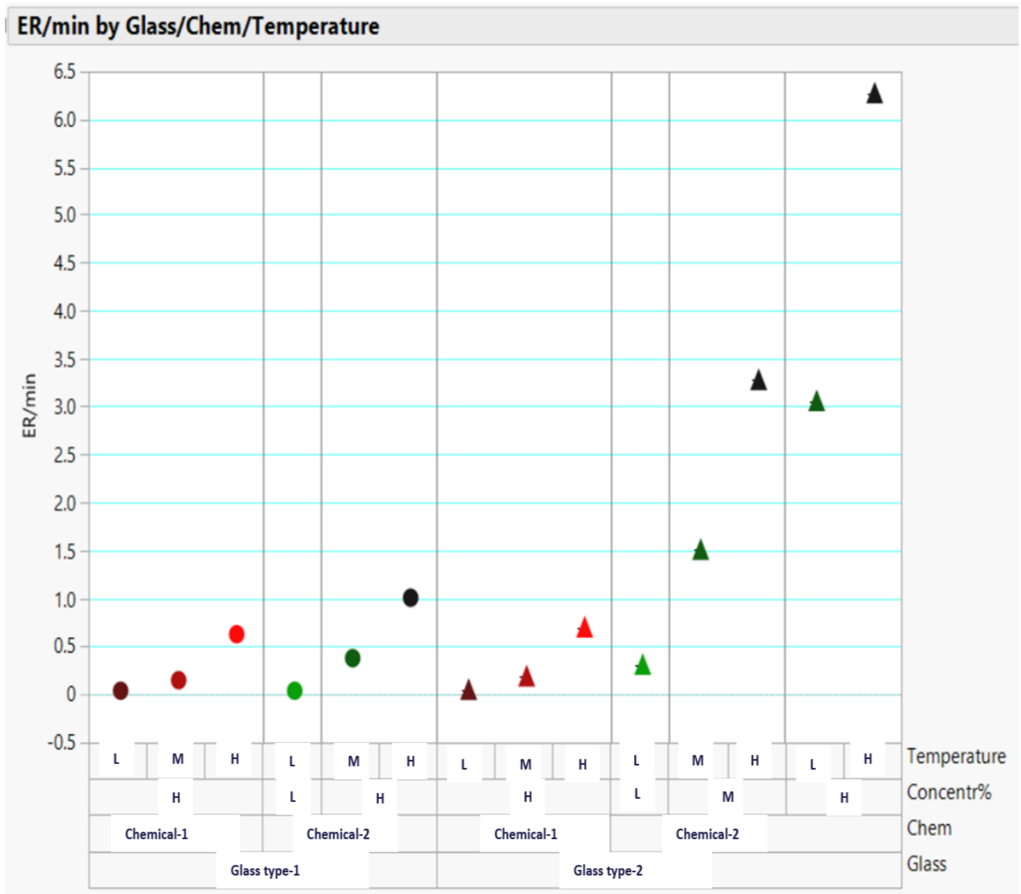




XSEM from typical 50um "hour glass" Via

Glass Etch Rates: Dependent on Glass Types

- Two key glass types have been used to develop TGV process for wide market applications
- The etch rates and uniformity have been optimized to get a good selectivity and cycle times for high volume manufacturing .
- Various other glass types also tested to cater for the customer specific needs



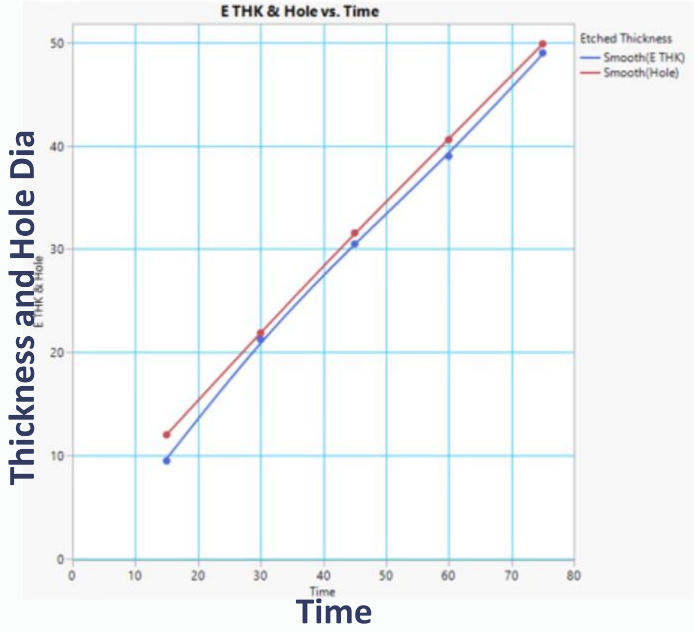
Glass Selection and Etch Rate

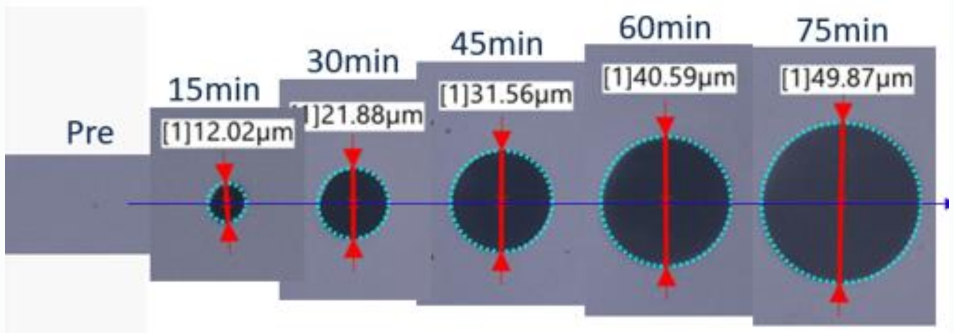
- Unlike silicon wafers, the selecting the correct glass type is an integral challenge to glass core substrates
  - CTE
  - Young's Modulus
  - And more
- Within the TGV wet etch process, the differing glass types can have impact on:
  - Bulk glass etch rates
  - Etch process chemistry and temperature selection
  - Via taper angles
  - And more
- Different glass types with different vendors and customers
  - Table to the right shows some of the etch rates observed

Type	Etch Rate (um/min)
A	0.60
B	0.62
C	0.86
D	0.97
E	1.60
F	0.75
G	0.81
H	0.65
I	0.41
J	0.45
K	0.33

How TGV Evolves Over Process Time

- TGV Process Development was carried out on a 3-panel development at the YES Arizona Technology Center (YATC) in Chandler, AZ
  - Capable of etching:
    - 50mm x 50mm
    - 100mm to 135mm square coupons
    - 200mm wafers
    - 510mm x 515mm glass panels
  - Opportunity to develop other adaptors
- Using 250um laser-modified glass coupons were process through etch then cleaner tanks to evaluate the evolution of a LCMT via over time
- The selectivity of laser modified & non modified area is the key for via formation. The aspect ratio plays a greater role to determine the Via tapper angle.

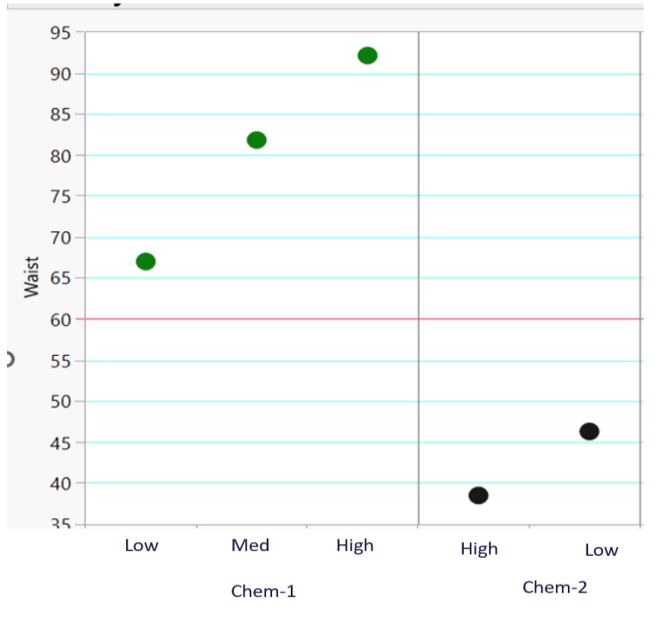


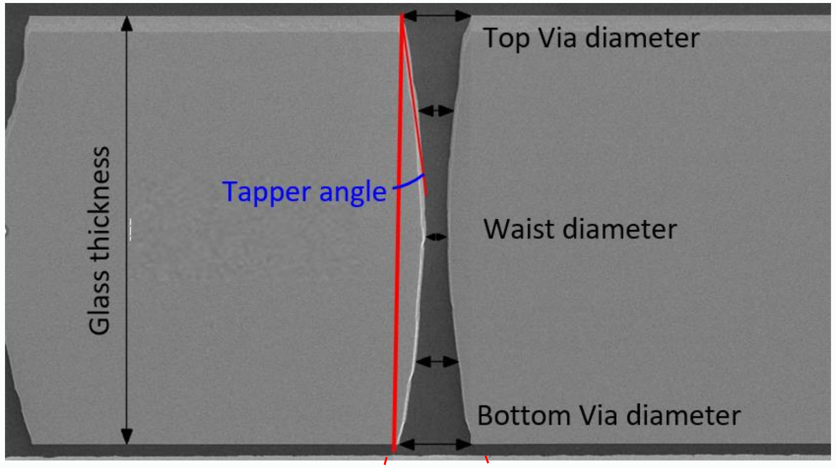


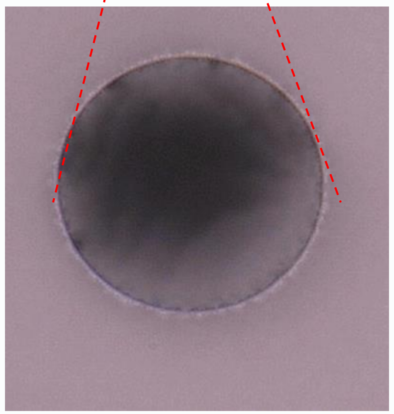
Via CD evolution

TGV Performance Analysis

Waist % by Chemical & temperature



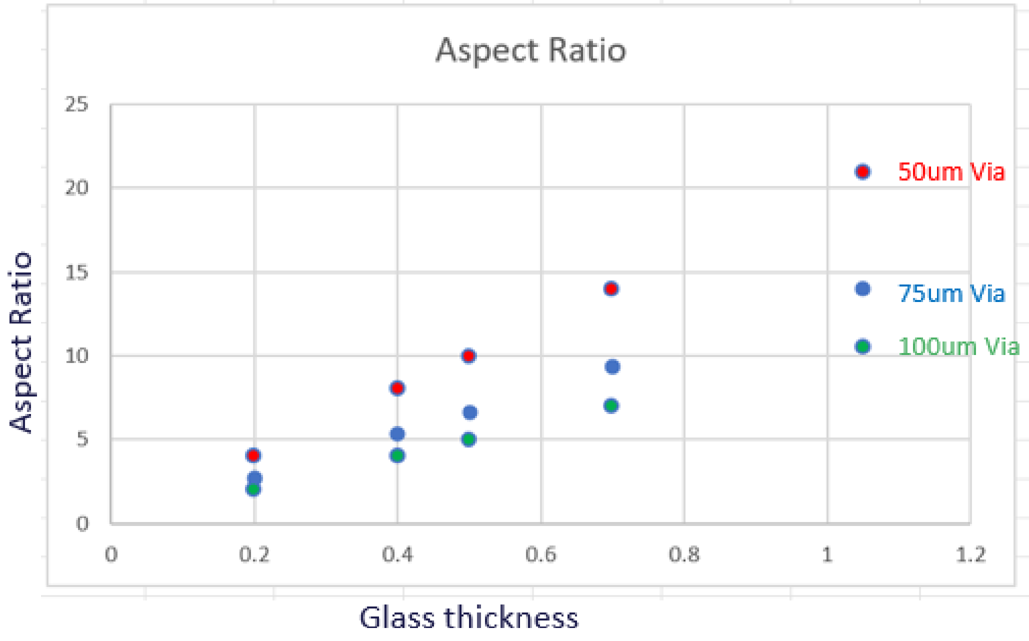




- Uniform Via formation across panel
- Final glass thickness and uniformity (Total Thickness Variation TTV)
- Aspect ratio (Glass thickness/via hole diameter)
  - Key to metallization technology selection
- Taper Angle & Waist diameter

TGV Aspect Ratio Performance

- The glass thickness and the via hole diameter determines the aspect ratio
- YES has experimented and developed the etching processes by varying temperature, chemistry, and process time for the AR ranging from 1:4 to 1:20
- For Vias ranging from 10-100 um
- Different applications require different aspect ratios which can be tuned as combination of the laser-modification and wet etch process



Panel Level Thickness Uniformity

- TTV and post thickness uniformity is important for downstream processes
- With glass being the core of the substrate any thickness non-uniformity is transferred throughout the package
- Blanket panels were used to measure the TTV and uniformity within the panel
- A post thickness uniformity <1% achieved and TTV of 5 µm for a 75 µm etch on a 500 µm blanket panel
- Within the HVM Tool, YES is developing a post-process integrated TTV metrology tool for APC

Pre

702	702	702	702	702	702	702
701	701	701	701	701	701	701
700	700	700	700	699	699	700
701	701	701	701	701	701	700
701	701	701	701	701	701	701
699	700	699	699	700	700	700
699	699	699	699	699	699	699

Post

671	671	671	671	671	671	671
671	671	672	671	672	672	672
670	670	670	671	670	670	670
671	671	672	672	672	671	671
672	671	672	672	672	671	671
670	670	671	671	671	670	671
666	669	671	670	670	669	667

Etched

31	31	31	31	31	31	31
30	30	29	30	29	29	29
30	30	30	29	29	29	30
30	30	29	29	29	30	29
29	30	29	29	29	30	30
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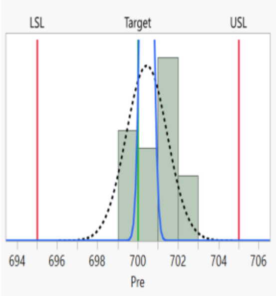
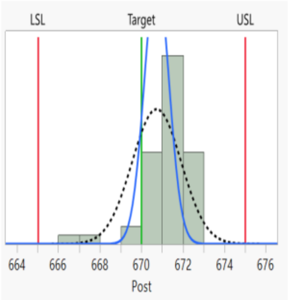
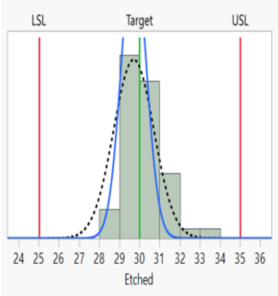
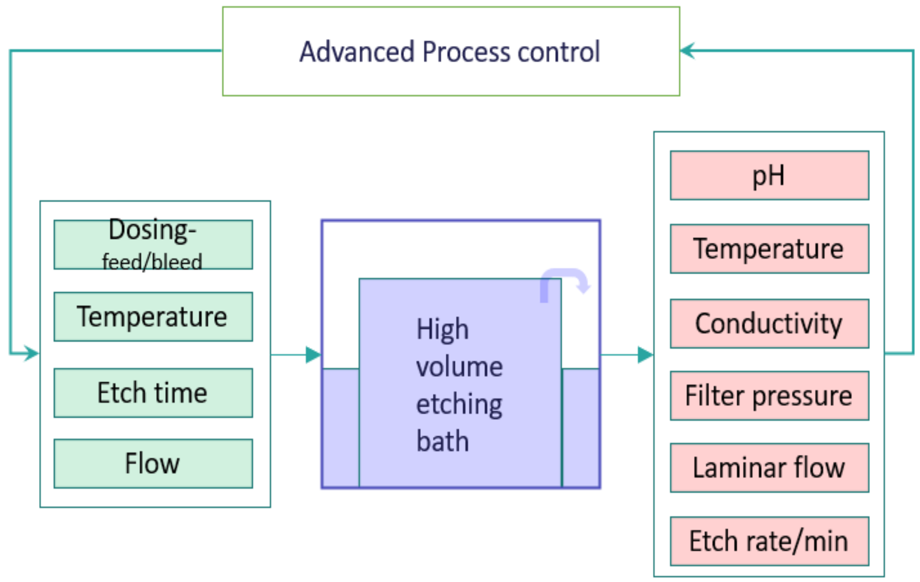




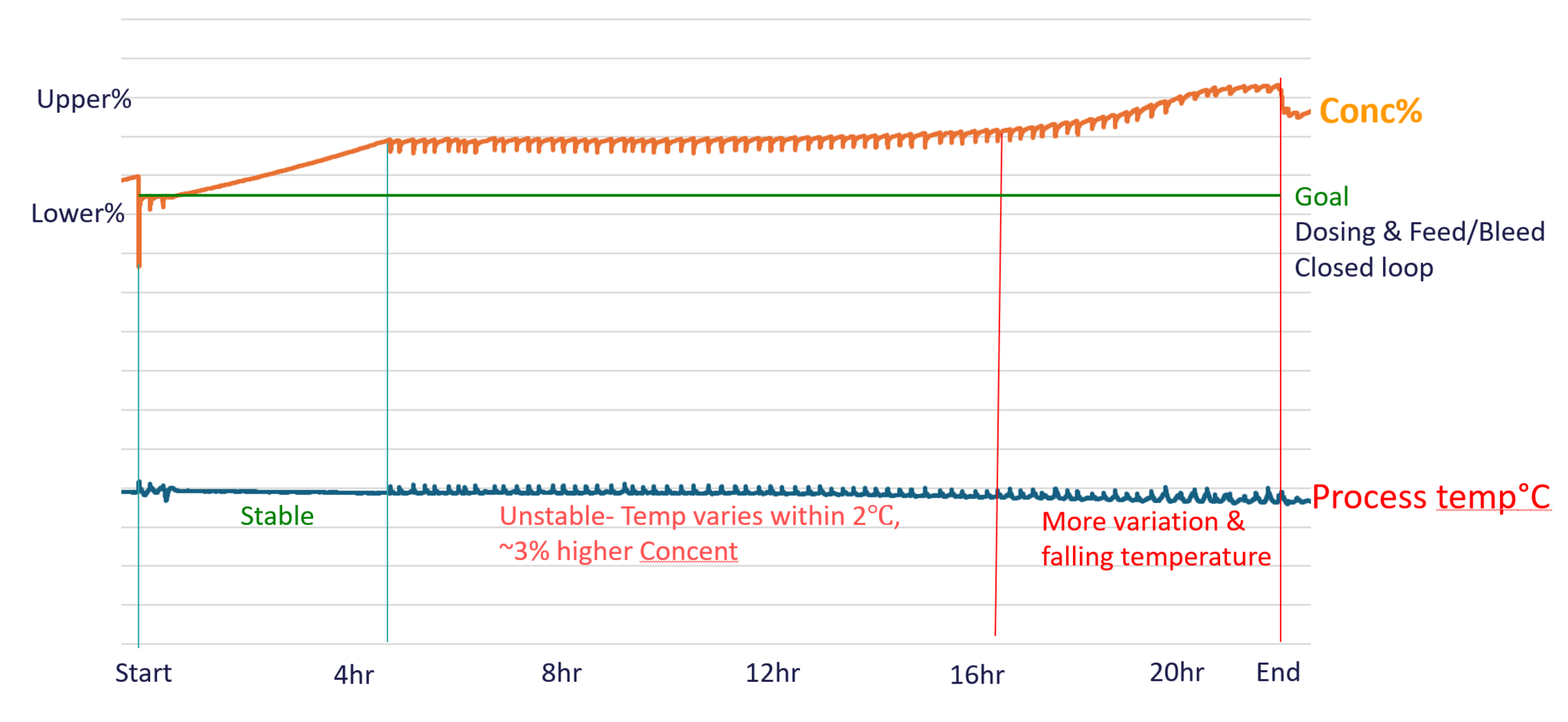


Advanced Process Control for HVM

- The high volume HVM process tank needs to be kept at a constant etch regime for proper and repeatable performance
- This is achieved with an automatic process control system with the inputs from the bath itself
- When the etch rate of the bath decrease over time fresh chemistry is dosed to the system at the same time bleeding an equal amount of the used chemistry
- The conductivity and pH of the bath is continuously fed back to the APC to determine the dosing, temperature, and flow



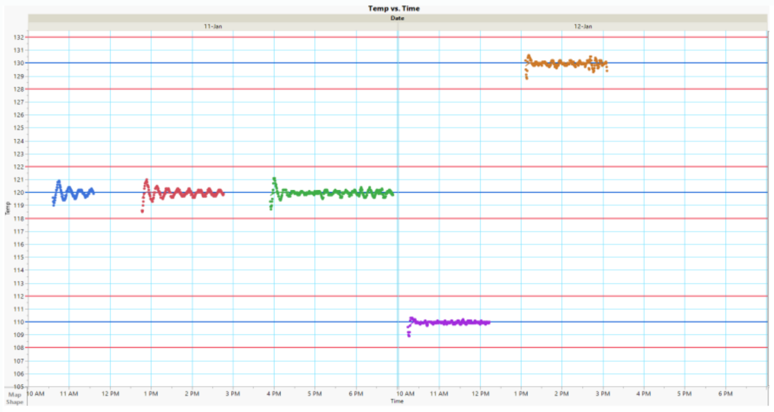
Bath life enhancement using APC



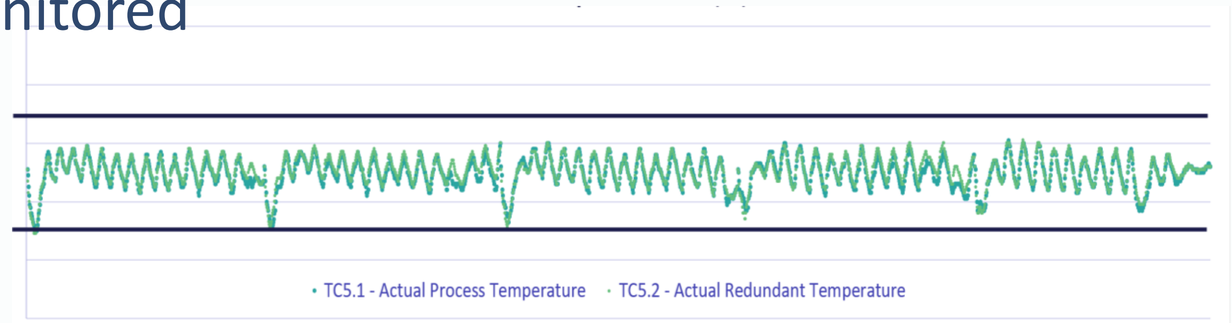
- In open loop control, the concentration keeps on going up as the water evaporates constantly.
- As the concentration trends high, the etch rate trends lower.
- A closed loop control with dosing and feed/bleed will keep the concentration constant.

Bath Temperature Control With APC

- The YES TGV Development tool maintains a ±1 °C temperature control throughout the tank during process with a lot introduction drop of less than 2 °C
- The YES HVM Tool incorporates redundant Thermal Couples in the process tanks to monitor multiple regions within the process tank and maintains a ±1 °C temperature control
- Introducing a processing lot in the HVM Tool produces a temperature drop less than 2 °C
- To further enhance reliability, the temperature throughout the recirculation loop is also monitored



Temperature Uniformity



Summary

- A viable glass etching process by applying LMCT technology established with fully automated equipment enabling advanced process control options
- Various glass types tested with a combination of chemistries and process parameters to optimize the TGV process
- Various aspect ratios from 1:4 to 1:20 developed with process parameters and chemistries
- The post etching data demonstrated a panel etch uniformity of <1%
- TTV measurement integration and temperature and concentration monitoring for advance process control in HVM
- A fully automated tool equipped with 12 panel carrier is introduced in high-volume manufacturing for Glass Core and Glass Interposer process

Acknowledgement

- Thanks to our customers and key glass manufacturers for supplying glass panels and post-process characterization
- YES Wet Process Group for system and engineering support during this work
- The YES Wet Process Application Lab team for contributing their expertise in wet etching
- YES-YATC Facilities team for providing excellent Clean Room environment

Q&A

- QA

- Thanks.

YES™

Is The Answer