Presented at
MEPTEC – IMAPS
Semiconductor Industry Speaker Series
November 11, 2020
www.meptec.org

CORNING

Ribbon Alumina Laminate

Tim Orsley
1 October 2020

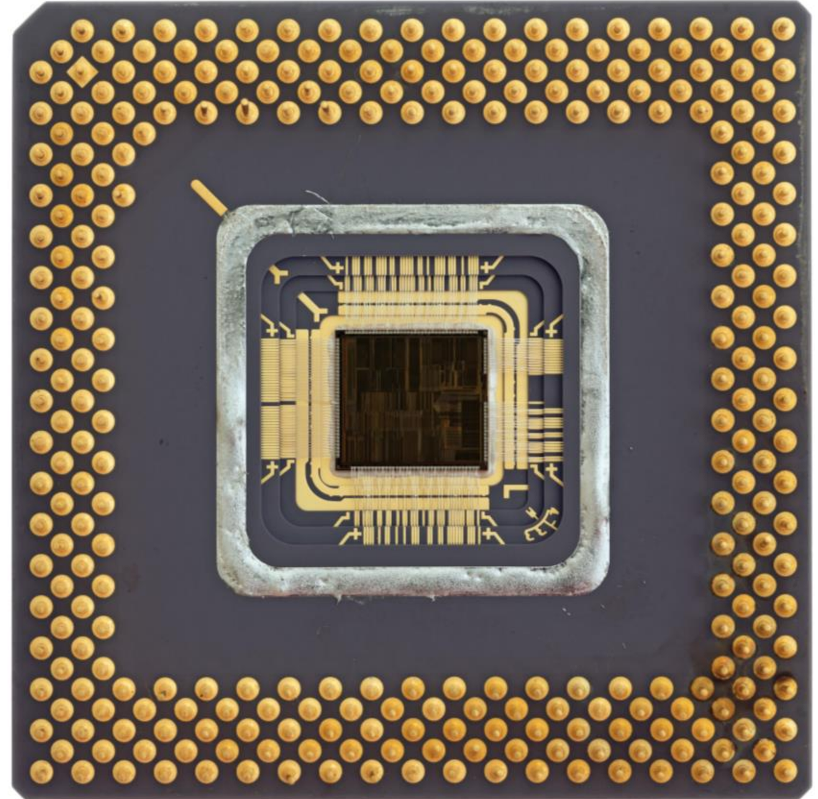
Overview

- Since ceramic materials inherently brittle once sintered, processing traditionally done in "green" state by ceramics vendor.
- In contrast PCB materials generic … customized by purchaser.
- Ribbon ceramics and its laminates thought to be first PCB-like ceramic – provided generic in sintered state with purchasers customizing.
- In addition to ease of processing, ribbon alumina laminate has number of attractive attributes including …
  - homogeneity to avoid differential skew
  - very low loss tangent and dielectric constant for high speed signaling (e.g., 5G)
  - lower CTE for better stress distribution as package substrate, and lower overall mismatch if used for both package and PCB

© 2020 Corning Incorporated. All Rights Reserved.

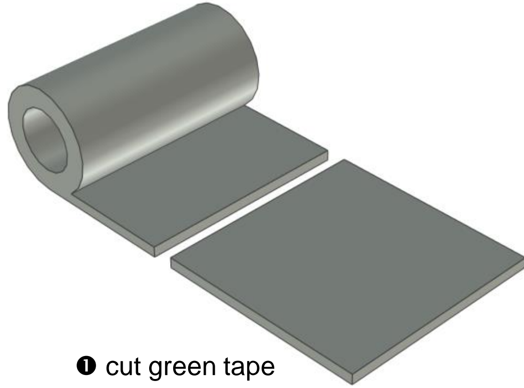
Traditional Pre-processed Ceramic Package Example

- Ceramic package can be delivered to IC vendor who can then bond IC to package and wire bond.
- Ceramic vendor would have punched green tape to size, punched vias and cavities, filled vias, screen printed conductors, stacked and laminated then co-fired.
  - Bulk of processing done in less brittle green state then sintering done at high temperature (~850°C).



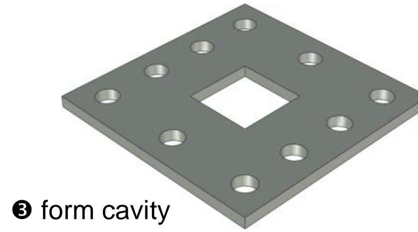
© 2020 Corning Incorporated. All Rights Reserved.

Low-temperature Co-fired Ceramic Typifies Pre-processing

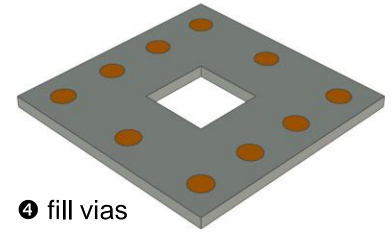


❶ cut green tape

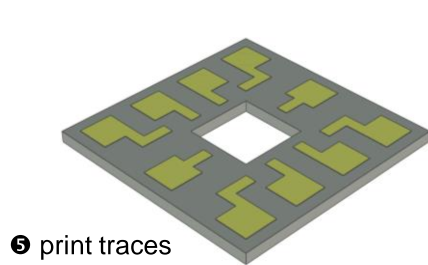
❷ form vias



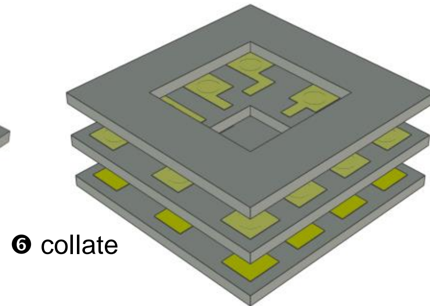
❸ form cavity



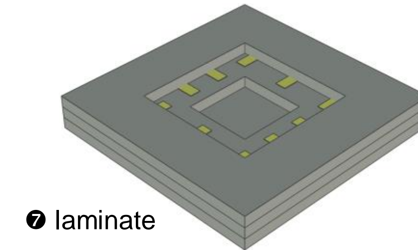
❹ fill vias



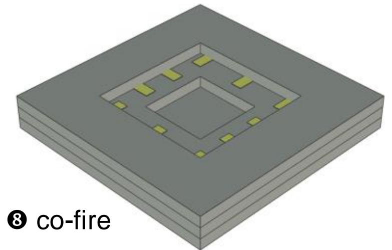
❺ print traces



❻ collate



❼ laminate

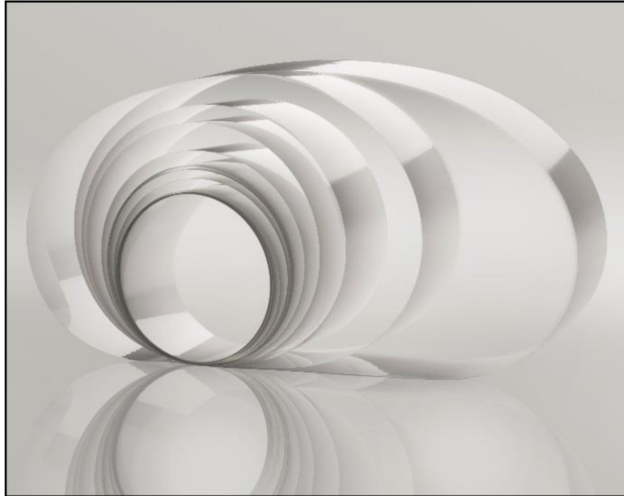


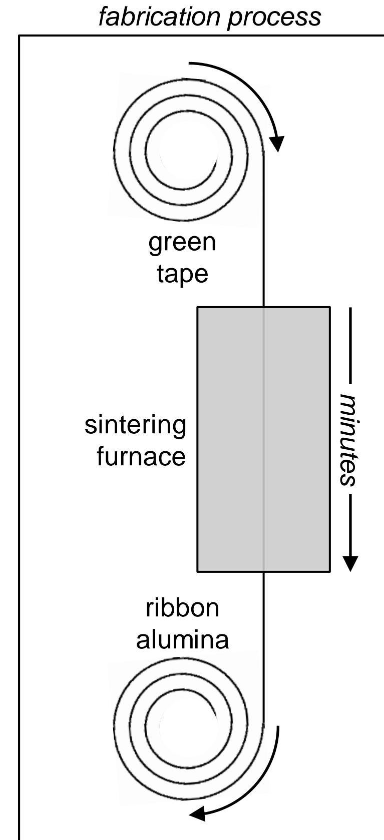
❽ co-fire

© 2020 Corning Incorporated. All Rights Reserved.

Ribbon Alumina

- Corning has developed new process for making ultra-pure >99.99% alumina.



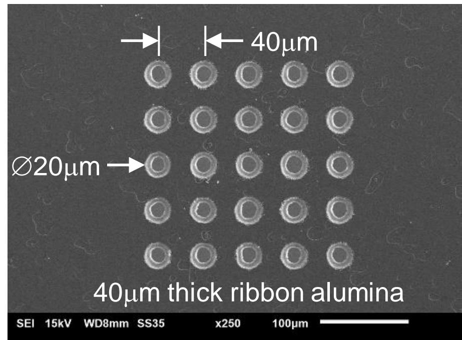


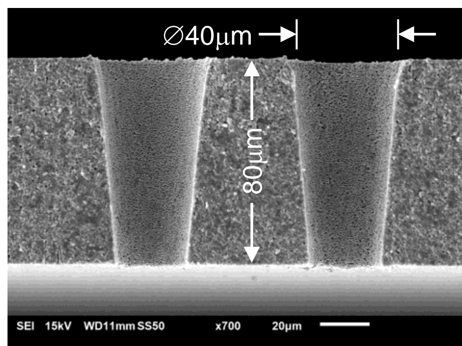
  – Ribbon has 40 or 80μm native thickness, 100mm width and spooled length of 100m.

© 2020 Corning Incorporated. All Rights Reserved.

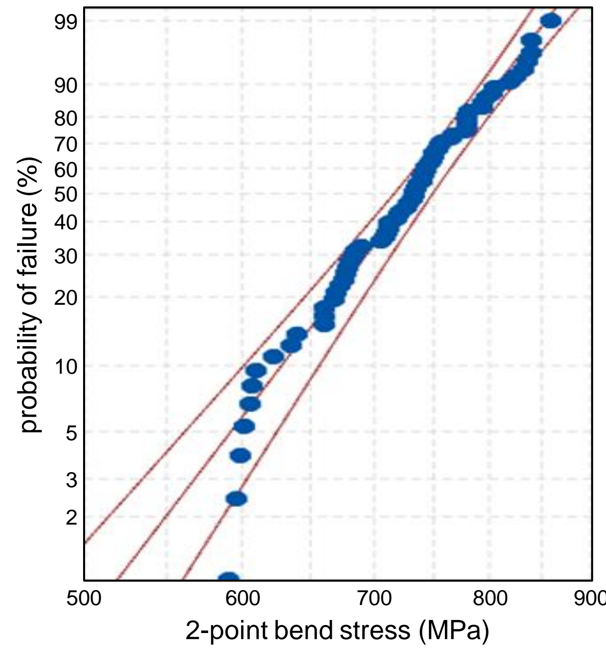
Ribbon Alumina Processing Examples

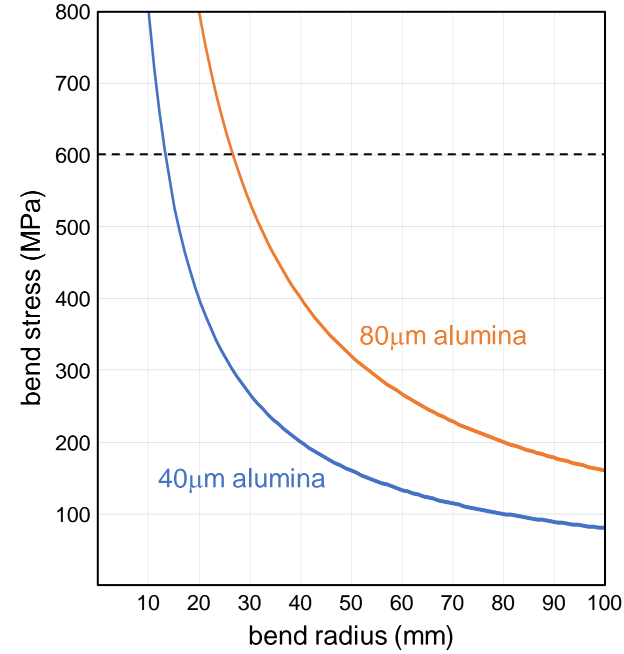
- Vias laser ablated.





- Good flexural strength maintained after laser cutting edge enabling good bend radius.





© 2020 Corning Incorporated. All Rights Reserved.

Ribbon Alumina Copper-clad Laminate

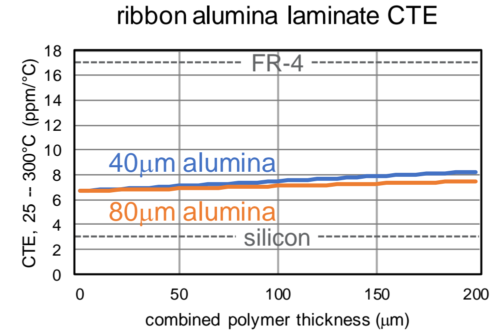
- Ribbon sandwiched between two polymer films (bonded with heat and pressure) to ease traditional processing challenges with alumina.*
  - For example, vias can be laser <u>or mechanically</u> drilled (∅40μm demonstrated) then conformally filled using standard PCB copper plating process.
- To maintain attractive electrical performance of ultra-high purity alumina, low loss polymer selected: Topas COC (cyclic olefin copolymer).
- Ultra-smooth copper foil can be laminated to the polymer.
  - 1.31N/mm peel strength demonstrated without Topas delamination from alumina.

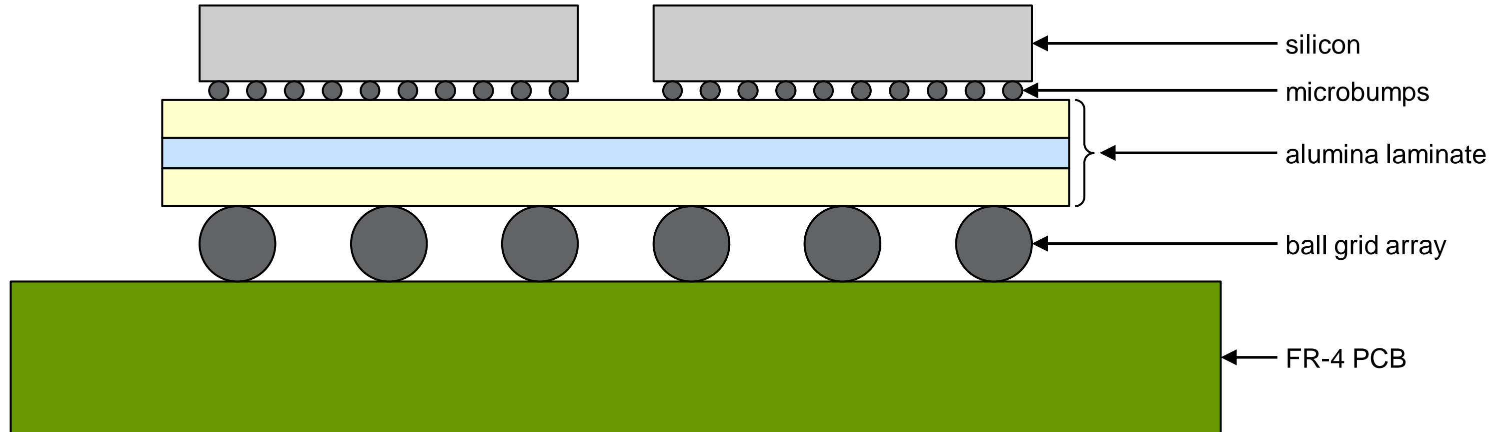
*Lamination also aids handling of very thin ribbon alumina.
**Topas also available in other thicknesses including 30 and 80μm.

© 2020 Corning Incorporated. All Rights Reserved.

Laminate Coefficient of Thermal Expansion

- Laminate CTE varies slightly with layer thickness but range lies between silicon and FR-4 which may be attractive for balancing overall stress.

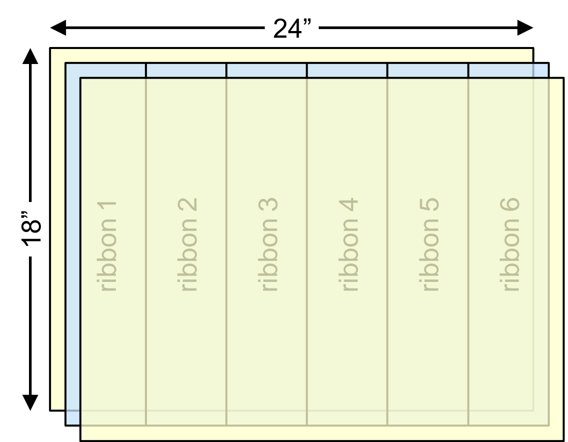


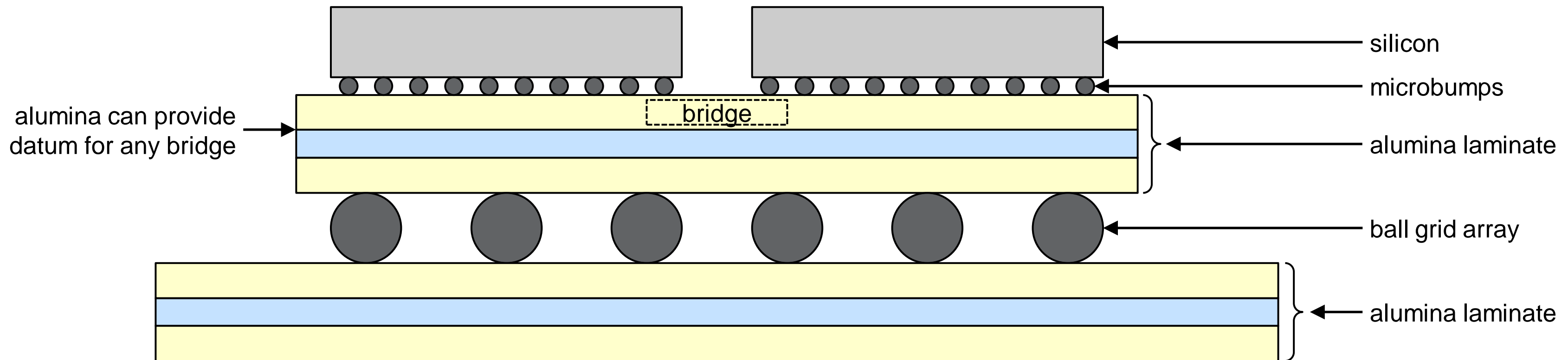


© 2020 Corning Incorporated. All Rights Reserved.

Reduced Thermal Expansion Mismatch

- If ribbon alumina laminate also used for PCB, overall thermal mismatch greatly reduced.
  - Since alumina width limited, polymer captures parallel ribbons to achieve standard panel size.



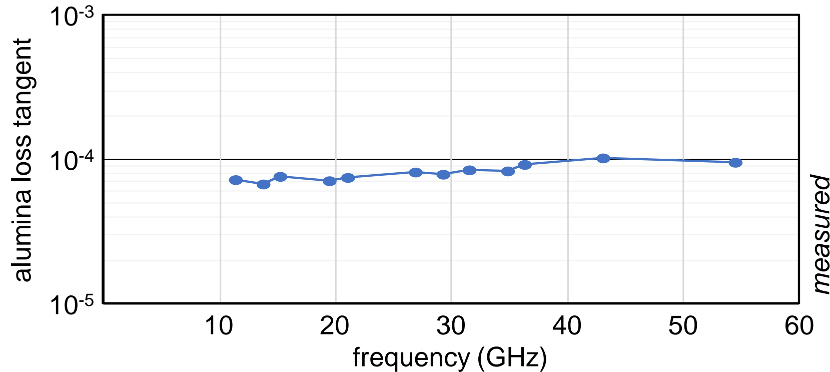


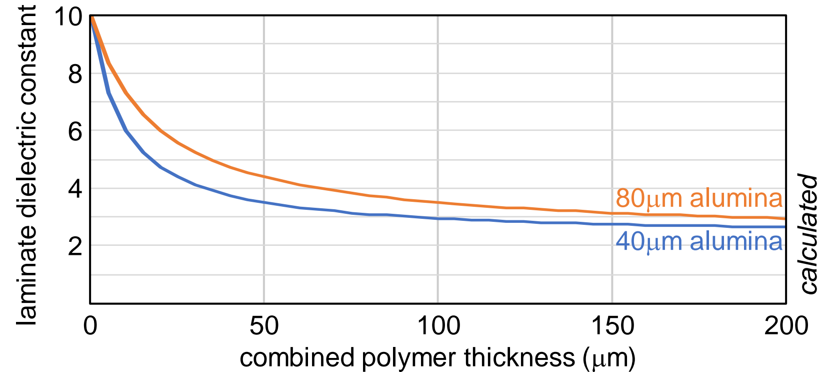
- Alumina laminate particularly attractive as PCB given consistent loss (no weave) thus avoiding differential skew.

© 2020 Corning Incorporated. All Rights Reserved.

Attractive Electrical Performance

- Ribbon alumina laminate electrical performance attractive for both package substrate (including 5G antenna-in-package) and PCB.
  - Laminate loss tangent thought similar to that of alumina alone, but dielectric constant influenced by relative layer thickness.



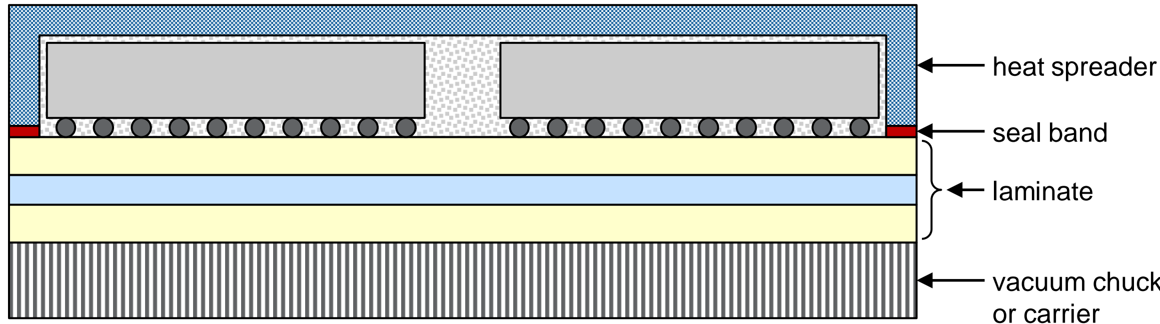


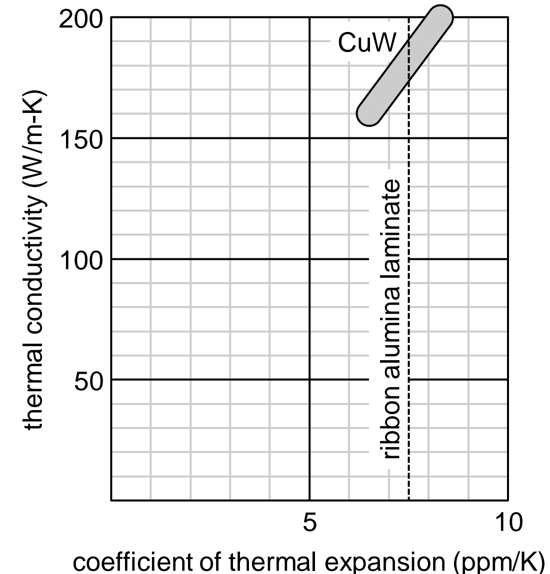
  - Degradation due to water absorption not expected from dense, closed network alumina with <0.1% porosity, and polymer with low absorption (0.01% ISO 62).

© 2020 Corning Incorporated. All Rights Reserved.

Flatness

- Because of its thinness and flexibility, flatness of ribbon alumina laminate can be improved with vacuum hold down or upon temporary carrier.*
  - Patterning of copper clad and build-up layers best done on either.
- To maintain flatness, CTE-matching heat spreader cavity can be bonded to laminate to form structurally rigid box prior to ball grid array deposition.



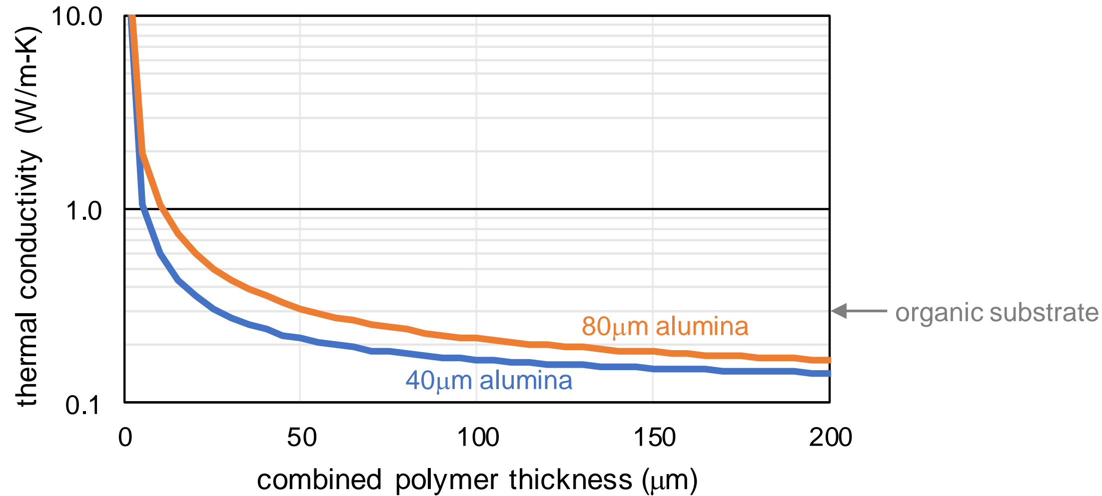


*Ribbon alumina laminate flatness anticipated to be similar to organic package substrates.

© 2020 Corning Incorporated. All Rights Reserved.

Thermal Performance

- Although thermal conductivity of ribbon alumina relatively high (36W/m-K), polymer strongly influences overall laminate performance.



- Relative thinness of laminate improves conductance proportionately.
- Thermal vias can further improve dissipation.

© 2020 Corning Incorporated. All Rights Reserved.

CORNING

Tim Orsley
Business Development
Corning Technology Center – Silicon Valley
680 West Maude Avenue
Sunnyvale, CA 94085
desk: 650-846-6013
mobile: 408-500-5518
OrsleyTJ@corning.com