

DuPont™ GreenTape™

low temperature co-fired ceramic system

Design and Layout Guidelines



Introduction

The DuPont™ GreenTape™ low temperature co-fired ceramic (LTCC) system line provides designers with a technology option that bridges the gap between high temperature co-fired ceramic (HTCC) and standard thick film technologies. It combines the benefits of each to provide a high density, high reliability, high performance low-cost interconnect package.

With GreenTape™ LTCC, the System Integrator/OEM customer will see benefits versus not-in-kind organic laminate technologies, such as Liquid Crystal Polymer (LCP), Duroid®, Teflon®, and variants, in the form of higher circuit routing density, an approximate 20% reduction in footprint, embedded resistor capability, better hermeticity and approximately 80% better TCE match with Gallium Arsenide and Silicon die.

DuPont provides two key GreenTape™ LTCC material options, DuPont™ GreenTape™ 951 and DuPont™ GreenTape™ 9K7—each has its own set of compatible gold and silver conductor systems. The GreenTape™ 951 material system is designed for general applications up to 35 gigahertz (GHz). GreenTape™ 9K7 was developed for high frequency applications—up to 100GHz and beyond—where low loss characteristics are desired.

This guide outlines the current capabilities of both the GreenTape™ 951 and GreenTape™ 9K7 systems, and can be used as a reference during the circuit design phase. Although up-to-date, the data in this manual should not be interpreted as design limits of GreenTape™ systems. The systems are evolving technologies and testing is continuous. Customers are encouraged to contact a DuPont Microcircuit Materials Technical Representatives to explore the latest advancements in the GreenTape™ system offerings.

To assist new customers with the implementation and adoption of GreenTape™ technology in a timely and cost effective manner, DuPont offers on-site technical service and startup assistance in addition to custom tailored seminars for training.

LTCC Terminology

The following figures are intended to familiarize the reader with some of the relevant terminology being used in this documentation.

Figures 1 and 2 are cross-sectional views describing some of the general multilayer inter-connect features and terms that will be discussed in this documentation.

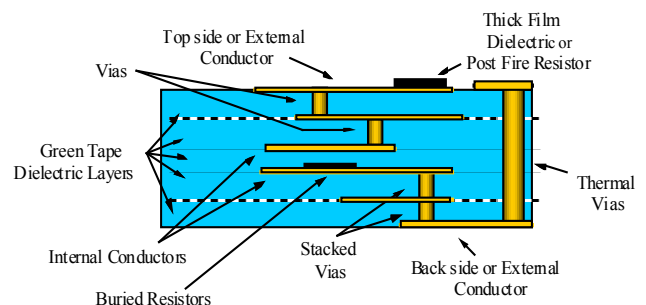


Figure 1: Interconnect Terminology

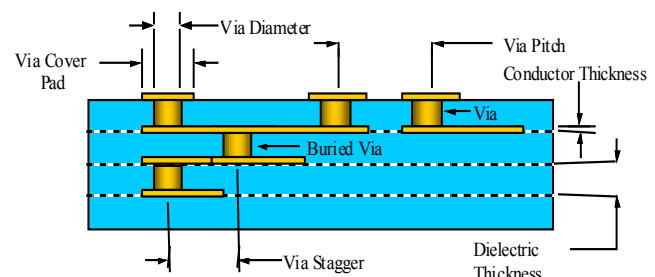


Figure 2: Feature Terminology—Cross Section

Figure 3 represents a top view of a typical DuPont™ GreenTape™ low temperature co-fired ceramic (LTCC) substrate identifying a small sampling of the features that should be taken into consideration during the design phase of a project.

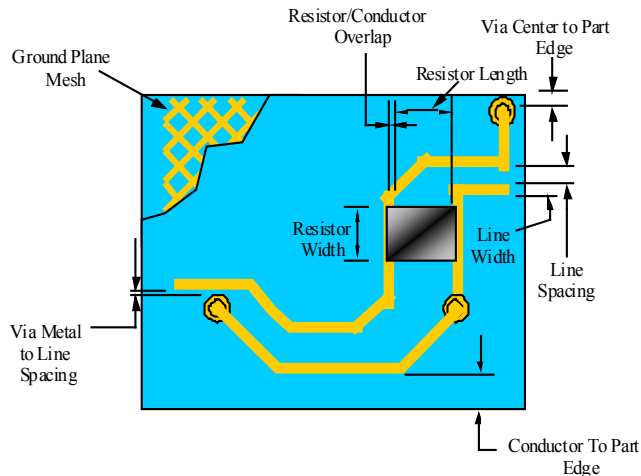


Figure 3: Feature Terminology – Top View

LTCC Process Flow Steps

Process Flow

The process flow for LTCC is very similar to that of HTCC, but without the complex firing conditions, flattening fires and required plating steps.

Figure 4 illustrates a simplified process flow for a typical LTCC build. Depending upon the complexity, some build applications may deviate slightly from the process steps shown below.

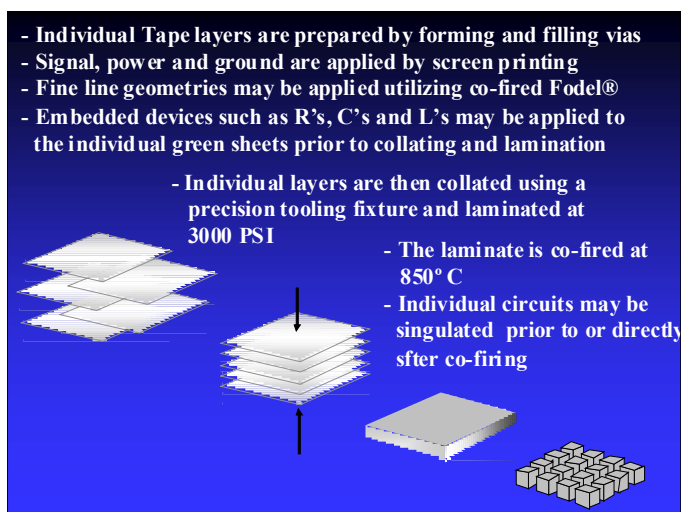


Figure 4: Simplified Typical Build Process Flow

Processing Variations:

GreenTape™ 951 vs. GreenTape™ 9K7

Aside from differences in the recommended co-fire profile and the firing setter tile materials, GreenTape™ 951 and GreenTape™ 9K7 follow the same LTCC process flow steps as outlined below. The firing profile and setter tile exceptions are detailed in the Co-firing section of the process flow steps.

Green (unfired) Sheets

DuPont™ Green Tape™ is supplied in a variety of sheet sizes and thicknesses. GreenTape™ 951 is available in thicknesses of 2.0 (50.8 um), 4.5 (114.3), 6.5 (165.1 um) and 10.0 mils (254 um). GreenTape™ 9K7 is offered in 5.0 (125.0 um) and 10.0 mil (254.0 um) sizes.

Both tape product families are cast on a punchable backing carrier film that's suitable for processing along with the individual layers. The punchable backing must be used with the 2.0 mil version of GreenTape™ 951 to maintain maximum green sheet dimensional stability during processing. Use with the other GreenTape™ 951 and GreenTape™ 9K7 tape sizes offerings will provide improvements in dimensional stability as well.

Preconditioning

Depending upon the circuit complexity and density, it is often recommended to have the green sheets first undergo a thermal preconditioning step prior to the blanking or via punching step. The thermal treatment drives off any residual solvents and releases any stresses that may be attributed to the tape casting operation.

This step can be accomplished in one of several ways. For sheets processed on punchable backing, dry in a forced hot air oven for 45 to 60 minutes at 100°C. Do not exceed 100°C, as this could result in a slight curling of the sheet during the drying process.

When processing without punchable backing, precondition green sheets at 120°C for 20 to 30 minutes or store 24 hours in a nitrogen dry box. Slight variations in preconditioning time and temperature are common depending upon processing requirements.

Via Formation / Cavity Formation

To minimize differential X-Y shrinkage during co-firing, the orientation of the individual tape layers within the build stack-up should alternate between the machine and transverse direction of the tape casting. The individual tape layers should be orientated as such during the green sheet blanking and via/cavity punching steps.

Mechanical punching is typically used to form vias in each tape layer for electrical connections and holes for the automated vision alignment print registration and lamination processes. Laser drilling may also be used, but the quality and consistency of the punched openings will not be as good as one being punched mechanically. Cavities cutouts are formed in the individual green sheets with a secondary set of punches/die.

Via Fill

Maintaining the green sheet via fill print registration is typically accomplished using an automated or semi-automated vision alignment printer system or extrusion via filler. A vacuum and porous stone is used to assist with the via filling process as well as securing the green sheet to the tooling fixture.

The via pastes are specially formulated to fully fill the via hole and are shrinkage-matched for each tape. A sheet of coated tissue paper is placed under each green sheet prior to the via fill step to prevent contamination and damage to the porous vacuum stone.

Brass or stainless steel stencils can be created for each tape layer using a programmable CNC punch.

Conductor Printing

Conductor printing is performed using a conventional thick film screen printer with mechanical registration or an automated vision alignment system. Print screens are standard emulsion type used for conventional thick film screen printing. As with the via filling process, a vacuum and porous stone are also used to hold the tape in place during the printing sequence. The conductor pastes are formulated to be compatible with the (x-y) shrinkage of the applicable GreenTape™ product. Printing of the conductor tends to be easier and have a higher resolution than standard thick film conductors on alumina. This is due to the flatness and solvent absorption properties of the unfired tape. A Fodel® photo-patternable, co-firable internal silver (Ag) conductor material is also available. See the GreenTape™ 951 Selector Guide.

Via and Conductor Drying

Via and conductor drying is accomplished in a box oven at 80 to 100°C for ~5 minutes.

Green Sheet Inspection

Inspections of the printed green sheets can be performed with the aid of a suitable light source, zoom microscope or any number of commercially available automated inspection systems. Low angle, oblique lighting is recommended to prevent a "white-out" of the surface features.

Layer Registration for Lamination

Collation and registration for lamination can be accomplished using an automated "Stack and Tack" type process or a precision lamination fixture with registration pins.

Lamination

Lamination is accomplished using one of the following options.

- Uniaxial

Lamination in a hydraulic press with heated platens. The laminate is pressed at 70°C, 3000 psi for 10 minutes. A 180° rotation of the lamination die is required after the first 5 minute time period.

- Isostatic

Lamination in a specially designed press which uses heated water. Parts are vacuum sealed in a plastic bag to prevent the water from coming into contact with the GreenTape™ laminate. Time and temperature are the same as with uniaxial pressing, however, no rotation of the die is required.

Note: Time, temperature and pressure can be altered from the above recommendations to achieve the desired lamination results.

Co-firing

As noted earlier, the recommended co-fire profiles for GreenTape™ 951 and GreenTape™ 9K7 are not identical.

Larger, high layer count, GreenTape™ 951 builds may use the same firing profile as a GreenTape™ 9K7 build. However, smaller, low layer count GreenTape™ 9K7 builds would not be fired at the same profile as a similar GreenTape™ 951 design.

- GreenTape™ 951

Laminates are fired in a single step on a smooth, flat setter tile. Various tile compositions may be used. Organic burnout takes place between the temperatures of 200°C and 550°C. It is recommended that the laminates soak in this temperature range for a minimum of one hour to ensure complete burnout of the organic constituents. The recommended peak firing temperature is 850°C for 17–23 minutes.

Green laminates less than 6"x6" in size and 0.070" thick may be fired at the standard 3.5 hour belt furnace profile. For larger parts and optimum dimensional control, a longer co-fire profile and a programmable box furnace is often recommended.

To further optimize dimensional control and virtually eliminate (x-y) shrinkage the use of DuPont's proprietary "Constrained Sintering" process may be used for certain applications. Please contact your local DuPont Technical Representative for further information related to Constrained Sintering technology for GreenTape™ 951.

See **Figures 5 and 6** for 3.5 hour belt furnace co-fire profile control points and output graph.

3.5 Hour Belt Furnace Profile			
Segment	Temperature (°C)	Time (min)	Ramp Rate (°C/min)
1	25-400	-	13.5
2	Hold 400	45-60	-
3	400 to 600	-	4.5
4	600 to 850	-	7.2
5	Hold 850	20	-
6	850 to 50	-	-20.4

Figure 5: 3.5 Hour Co-fire Profile Control Points

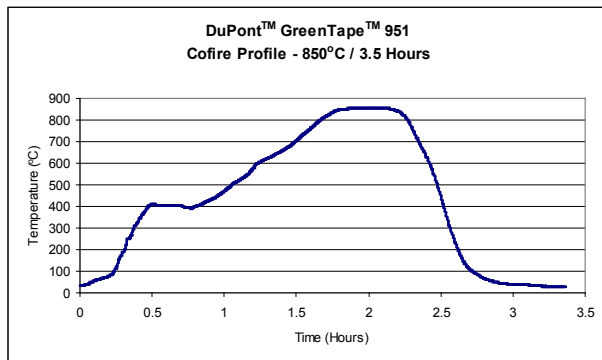


Figure 6: 3.5 Hour Co-fire Profile Output Graph

- GreenTape™ 9K7

To achieve the desired dielectric constant and low loss performance properties with GreenTape™ 9K7, the material should be co-fired at the recommended 26.5 hour furnace profile.

Due to its unique glass chemistry, 9K7 requires the use of dedicated, specially coated setter tiles in order to prevent parts from sticking during the co-fire and subsequent post fire processes. Please contact your local DuPont Technical Service Representative for detailed information regarding setter recommendations.

Co-firing takes place over a 26.5 hour temperature profile. Burnout of the organic constituents occurs between the temperatures of 200°C and 550°C. Peak temperature is 850°C for 17-23 minutes. For optimum dimensional control and repeatable dielectric constant, it is recommended that 9K7 be fired in a programmable box kiln.

See **Figures 7 and 8** for 26.5 hour box furnace co-fire profile control points and output graph.

3.5 Hour Belt Furnace Profile			
Segment	Temperature (°C)	Time (min)	Ramp Rate (°C/min)
1	25-195	260	0.7
2	Hold 195-210	95	-
3	210-265	80	0.7
4	Hold 265-275	110	-
5	275-415	150	0.9
6	Hold 415-420	115	-
9	420-530	58	1.9
10	Hold 530-535	105	-
11	535-850	125	2.5
12	Hold 850	20	-
13	850-300	420	-1.3

Figure 7: 26.5 Hour Co-fire Profile Control Points

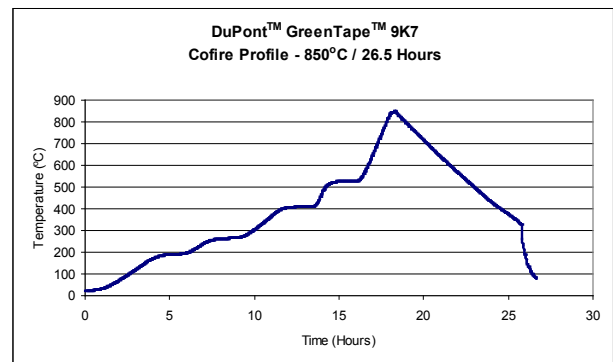


Figure 8: 26.5 Hour Co-fire Profile Output Graph

Post Fire Processing

Standard DuPont thick film resistors, dielectrics, conductors, and specialty ceramic processes may be incorporated as a post fire operation. They would be applied according to their specifications following the co-firing of the GreenTape™ substrate.

Electrical Testing

After co-firing and subsequent post firing operations have been completed, the fired laminates may be tested to characterize the fired module's physical and electrical properties.

Singulation

The singulation or dicing of large, multi-up laminates into the individual circuit components can be performed prior to or immediately following the firing step(s). A number of different singulation methods can be used.

- Hot Knife Cutting or Scribing

This method is used for very high volume component size modules or for larger circuits with less stringent discrete component assembly requirements. There is some sacrifice of overall dimensional tolerances.

- Dicing Saw

A common post fire method that works very well for rectangular-shaped parts. Tight outside dimensional tolerances are produced as well as high quality edges.

- Ultrasonic Cutting

A post fire operation that produces tight dimensional tolerances of unusually shaped parts. The quality of the edges is exceptional. However, the process is very expensive and very slow.

- Laser Cutting—Post Fired

Produces tight tolerances, at a relatively low cost. The edge quality is generally coarse.

- Laser Cutting—Unfired Laminate

Laser cutting green, unfired laminates results in a quality edge, however there is some sacrifice of outside edge tolerance following co-firing.

- Green State Punching

Either by punching unusual shapes into the individual layers at the punch step or punching the parts out at the laminate step, green state punching allows for quick fabrication of unusually shaped parts. The quality of the parts is good and costs are relatively low. There is some sacrifice of overall dimensional tolerance.

Final Inspection

Inspection and testing of the fired laminates is performed in accordance with applicable standards determined by the customer. The process could be performed using manual or automated inspection and test equipment.

Material Properties and Performance

Figures 9 and 10 illustrate the typical physical and electrical performance properties associated with GreenTape™ 951 and GreenTape™ 9K7 tape dielectrics when fired at their recommended co-fire profiles.

Fired Physical Properties	GreenTape™ 951	GreenTape™ 9K7
Fired thickness, (um)	45.7 (951C2)	106.7 (9K7PV)
	96.5 (951PT)	213.4 (9K7PX)
	139.7 (951P2)	
	215.9 (951PX)	
X, Y, shrinkage, (%)	12.7 +/- 0.3	9.1 +/- 0.3
Z shrinkage, (%)	15.0 +/- 0.5	11.8 +/- 0.5
TCE, (23°–300°C)	5.8	4.4
Density, (g/cm³)	3.1	3.1
Camber, (um/25 mm)	25	25
Surface roughness, (um)	0.35	0.52
Thermal conductivity, (W/m-K)	3.3	4.6
Flexural strength (MPa)	320	230
Young's modulus, (GPa)	120	145
Poisson's ratio	0.24	0.25

Figure 9: Typical Co-fired Physical Properties

Electrical Properties	GreenTape™ 951	GreenTape™ 9K7
Dielectric constant, (10 GHz)	7.8 +/- 0.2	7.1 +/- 0.2
Loss tangent, (10 GHz)	0.0140	0.0010
Insulation resistance, (Ohms)	> 10 ¹²	> 10 ¹²
Breakdown voltage, (kV/25 um)	>= 1100	>= 1100

Figure 10: Typical Co-fired Electrical Properties

Design Parameters and Considerations

Tape Compositions

DuPont offers two distinctly different tape compositions. The GreenTape™ 951 system of materials is a general purpose, high strength glass/ceramic composite with very wide processing latitude. It is ideally suited for applications with operating frequencies below the 20 GHz range. Higher frequency applications have been demonstrated.

GreenTape™ 9K7 is a lead-free*, low loss glass-ceramic composition specially designed for high GHz frequency applications. Testing has been performed up to 100 GHz with outstanding results.

While both compositions have the same basic design layout and processing recommendations, each has its own set of unique processing considerations based on design complexity, layer count and module size. We recommend you contact a DuPont Microcircuit Materials Technical Representative early in the application's design phase to discuss your proposed design and become aware of any related considerations or recommendations.

Figure 11 lists a summary of some basic design parameters, and associated features to take into consideration when designing an application for the GreenTape™ system.

Feature	Typical	Demonstrated Capability
# Tape Layers	20	100
*Substrate X,Y Dimension (Green)	8" x 8"	18" x 18"
Substrate Thickness		
<4.0" x 4.0"	.025" min	0.0038"
>4.0" x 4.0"	.050" min	0.02"
Lines/Spaces		
Co-fired	005/.005" min	.002/.002"
Post Fired	.007" min	.003"
Via Diameter	1:1 Aspect Ratio	<1:1 Aspect Ratio
Via Cover Pad	2x Via Dia	1x Via Dia
Via Pitch (min)	3x Via Dia	2x Via Dia
Via Center to Center	.005" min	No Pad
Via Stagger (min)	2x Via Dia	No Stagger
Thermal Via Diameter/Pitch		
Option I	.010"/.030" min	Thermal Slots
Option II	0.15"/.040" min	—
Space from Gm/Pwr/Sig to Part Edge	.010" min	0
Gnd/Pwr Plane Coverage	70% Gridded	100%
Gnd/Pwr Plane Openings for Feed Throughs		
Thermal Via	.070" min	0.05"
Signal Via	.050" min	.025"
Post Fired Resistors		
Length	.030" min	.010"
Width	.030" min	.010"
Overlap	.005" min	.005"

Figure 11: Design Parameters and Considerations

Dielectric Tape Considerations

The two GreenTape™ product lines are available in several different thickness ranges to meet a variety of application needs, (see Section IV).

Any tape thickness can be used to fabricate parts with high layer counts. The combining of different thickness versions is common to meet package height targets and capacitance requirements within the structure. When the use of different tape thicknesses is necessary, care should be taken to position the layers in a symmetrical fashion around the mid point of the substrate thickness in order to minimize any effects associated to tape lot shrinkage variations. Shrinkage variability can also be reduced when fabricating modules with multiple tape layer thicknesses through the use of lots having the same or very similar (+/- 0.1%) fired X-Y shrinkage properties.

The combining of different LTCC tape types is not recommended, unless otherwise stated.

Metallization Considerations

The GreenTape™ 951 and GreenTape™ 9K7 systems have their own distinct set of compatible silver (Ag) and gold (Au) co-fired metallizations. Each tape system is also compatible with a number of standard DuPont thick film post fired metallization conductor and dielectric compositions.

The GreenTape™ 951 system also offers a mixed metal system for applications where circuit cost considerations make the combination of internal silver conductors and external wire bondable gold conductors desirable. The barrier transition via fills were developed to serve as the interface connection between the internal silver and external gold materials. At the present time, a mixed metal system has not been developed for the low loss GreenTape™ 9K7 product line.

GreenTape™ 9K7 Silver Conductor System Design Considerations

There are several guidelines and recommendations the designer should take into consideration when designing an application utilizing the Ag-based version of the GreenTape™ 9K7 conductor system.

- Thin Part Conductor Distortion
 - a. Part builds less than 0.050" in thickness may show conductor distortion in unbalanced builds. Recommend using balanced metal loading in the designs X-Y and Z directions.

- b. Unbalanced or thin laminate designs may show conductor distortion or cupping. Recommend balanced metal loading in the Z direction to minimize/eliminate cupping.
- c. Recommendation for minimum thickness of overall part or cavity floor: 0.050"

- LL617 Ag Pd Soldered Adhesion

- a. Use in co-fire only, solderable Ag conductor applications where refires are not required.
- b. Recommended dry print thickness: ~ 25 um
- c. Typical co-fired initial adhesion: ≥ 25 N.
- d. Typical 48 hour aged adhesion: ≥ 15 N.
- e. Efforts addressing the development potential of a co-fire, refire solderable Ag are in progress
- f. Recommend 7484 AgPd (3:1) or 6277 AgPd (6:1) as a post fired conductors for any solderable applications requiring multiple 850°C firings
- g. Evaluation of the LF171 (Pb-free*, post fired) conductor is scheduled for ATG evaluations

- X-Y Shrinkage of Conductor Lines

- a. Co-fired HF612 Ag composition displays approximately 0.0005–0.0008" of conductor line width pullback after cofire. R&D efforts are underway to address the issue.
- b. Conductor width pullback data may need to be taken into consideration for sensitive, high frequency part designs.

High Metallization Coverage Considerations

Unbalanced metal coverage in laminates may cause differential shrinkage issues, as shown in the EXAGGERATED figure below. If this can not be avoided, process variables or additional tape layers (referred to as "dummy layers") may be added to minimize this effect.

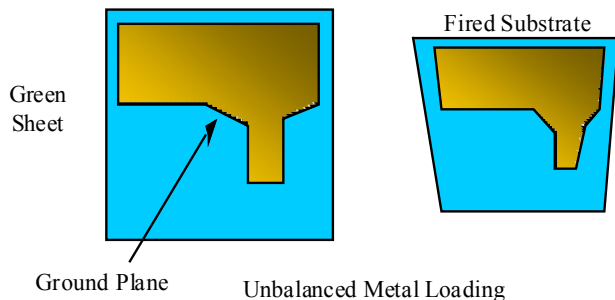
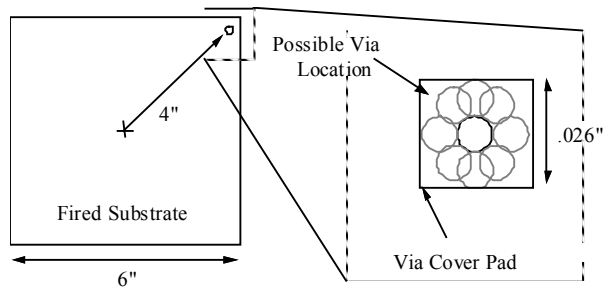


Figure 12: Differential Fired Shrinkage

Shrinkage Considerations

The (x-y) shrinkage tolerance of the DuPont GreenTape™ 951 and Green Tape™ 9K7 systems is $\pm 0.3\%$. This is better than other commercially available co-fired systems, however, the positional variation of features must be considered when designing a substrate.



Example of Via Cover Position Tolerance

Figure 13: Via Cover Pad Position Tolerance

As a worst case example: If a post-fire printing operation is required and coverage of an entire via is necessary, **Figure 13** demonstrates how shrinkage will affect the design. In this example, a fired 6" square part has 0.008" vias, 4" away from the center of the part. A 0.026" square (or round) cover pad may be required to cover all possible locations of the via position.

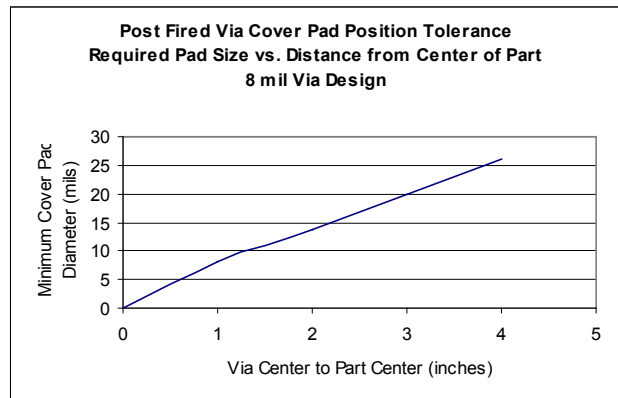


Figure 14: Cover Pad Size Required for 8 mil via

Figure 14 shows an example of the cover pad sizes required to completely cover an 8 mil via as a function of distance from the center of the part. Neither of these figures takes into account possible variations related to screen printing, green sheet distortion, artwork variables, etc.

DuPont's proprietary "Constrained Sintering" technology is recommended for optimal dimensional control and virtually "zero," (x-y) shrinkage of large panel Green Tape™ 951 laminates less than 0.070" in thickness.

Using the pressureless assisted sintering process (PLAS), X-Y shrinkage of thin Green Tape™ 951 can be controlled to 0.20% with a tolerance of 0.05%. Average Z shrinkage is 40.0% with a tolerance of +/- 0.5%.

Figure 15 illustrates a simplified view of constraining process where the green sheets are laminated between two layers of release tape. The part is then co-fired and the outer release tape layers are removed using manual removal method or bead blast operation. Contact your local DuPont Technical Representative for additional information.

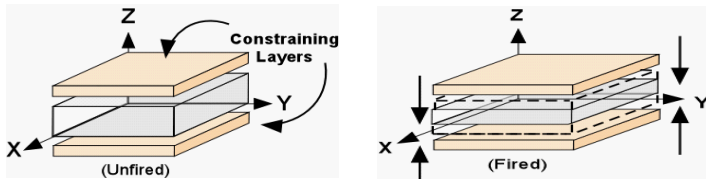


Figure 15: Constrained Sintering (PLAS) Stack-up

Via Design Considerations

If possible, vias used for electrical connections should be staggered every 2 tape layers. This will minimize surface topography variations on the external surface.

Thermal vias typically range from 6 to 35 mils in diameter and are stacked through the entire thickness of the substrate. With stacked via designs, one should expect to see surface topography variations of up to 1 mil above the surface of the substrate.

Cavity Design Considerations

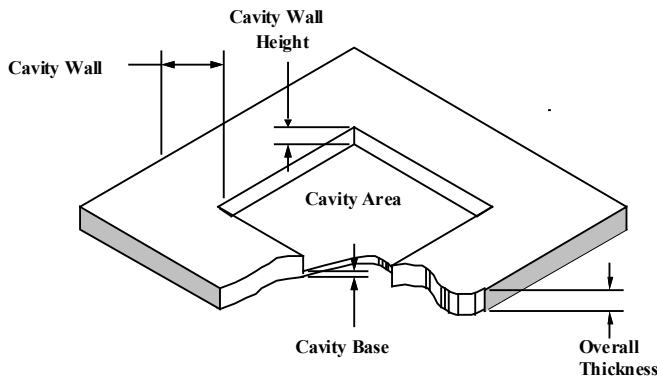


Figure 16: Cavity Terminology

Most high reliability LTCC design applications require one or more external cavities to provide hermetic environments for integrated circuits and other active devices. The DuPont™ GreenTape™ 951 and DuPont™ Green Tape™ 9K7 material systems can satisfy this need.

The following identifies a list of parameters the designer should take into consideration when designing cavity layouts for the DuPont™ GreenTape™ LTCC Systems.

Definition

Cavity - >0.200" square, blind, cavity wall height not to exceed 0.120"

Mechanical Considerations

Cavity corner radius:

- 0.005" min. for cavities <0.5" sq.
- 0.010" Min for cavities 0.5" to 1.0" Sq.
- 0.020" Min for cavities >1.0" sq.

Cavity area is not to exceed 50% of the of the finished part size unless the cavity base is 0.05" or greater.

* Cavity floor or overall part thickness should be greater than 50 mils for applications employing the Ag-based GreenTape™ 9K7 system.

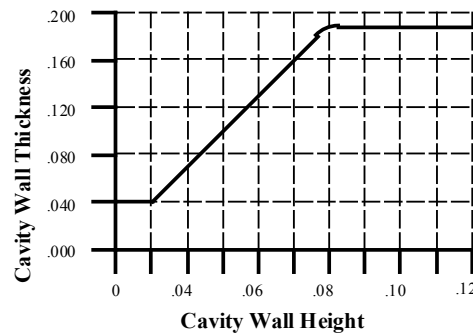


Figure 17: Cavity Wall Height vs. Wall Thickness

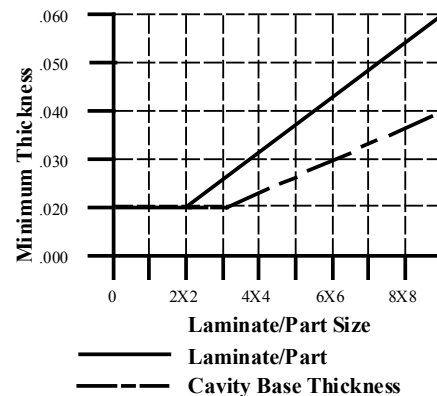


Figure 18: Cavity Floor Thickness vs. Laminate Size

Product Enhancements

Higher Layer Count Capability

Stack-ups above 100 layers have been demonstrated in R&D evaluations. High layer count structures may require special laminations and firing techniques to ensure optimum material performance..

Larger Substrate Size

Parts larger than 8.0" X 8.0" have been demonstrated, but may require special tooling, lamination and firing considerations.

Other Developments

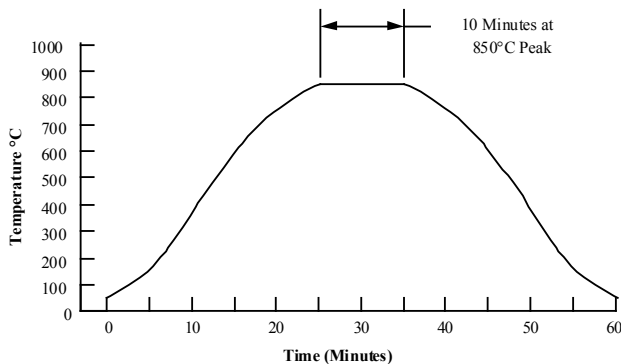
DuPont is continually enhancing GreenTape™ materials and processes. If you have a packaging need that is not addressed here, contact one of our Technical Representatives to explore the possibilities.

Brazing Design Guidelines

Using Au 5062D/5063D and Ag 5081/5082 thick film pastes, brazing of window frames, pins and leads is accomplished using a specially formulated, two paste system. The first metallization layer is called the adhesion layer and the second, the barrier layer.

The adhesion layer is screen printed onto the fired substrate (GreenTape™, alumina, thick layer and fired. The barrier layer print is then applied over the top of the adhesion and fired. The barrier layer is then applied over the top of the adhesion layer, dried and fired.

The preparatory materials are designed to fire in air using a 60 minute furnace cycle at a peak temperature of 850°C.



- Ramp rate - 50°C/min from 300° to 500°
- Dwell at 850°C for 10 minutes
- Ramp down - 50°C/min from 700° to 300°

Figure 19: Standard 850°C/60 Minute Profile

The recommended fired thickness for the adhesion layer (5062D and 5081) is 12-15 microns. The recommended thickness of the barrier layer (5063D and 5082) will depend on the brazing peak temperature, required dwell time and the brazing alloy being used.

The following are general guidelines:

- 20–30 microns for brazing temperatures below 600°C
- 30–50 microns for brazing peak temperatures between 600 and 700°C
- 40–60 microns for brazing peak temperatures between 700 and 800°C

The materials are applied using standard screen printing practices. It is important to apply the barrier layer in a manner that completely covers the exposed areas of the adhesion layer. This is accomplished with exact screen registration and a slight spreading of the barrier layer or by using a slightly larger printing pattern for the barrier layer e.g. barrier layer pattern width of 70 mils compared to an adhesion pattern width of 68 mils. Several print/dry/fire steps may be needed to obtain the desired thickness of the barrier layer material. Standard 325 mesh screens with 0.5 mil emulsion are recommended and can be obtained from a variety of vendors.

The metal components to be brazed such as pins, leads, window- frames and heat sinks are the same as those used on high temperature co-fired ceramic or high fire alumina substrates. Kovar and Alloy 42 are commonly used for pins, leads and window-frames, while copper/tungsten, copper/molybdenum/copper and copper/Invar/copper are used for heat sinks and heat spreaders.

These materials are used because their TCE is closely matched to that of alumina and GreenTape™. This helps minimize the residual thermal stresses produced during the brazing operation and during power-on/power-off cycles of the package. Finally, these materials retain their mechanical integrity following furnace brazing.

Kovar, Alloy 42, copper/tungsten and copper/molybdenum/copper require plating prior to their attachment to the preparatory metals. It is recommended that these materials be plated with 50 to 100 micro-inches of nickel followed by an over-plating of 50 to 100 micro-inches of pure gold.

The gold brazing filler metal alloys (weight percent compositions), brazing temperatures and atmospheres are listed below:

Brazing Alloy	Temp	Atmosphere
82Au/18In	580°C	N ₂ /3.7%H ₂
88Au/12Ge	430–440°C	N ₂
80Au/20Sn	350°C & up	N ₂

Brazing alloy preforms can be obtained from several vendors, the range of recommended thickness are 0.002" to 0.005". The correct preform thickness depends on the clearance between the metal component, the brazing pads and seal ring over the entire surface of the part. Common RMA fluxes can be used in nitrogen up to approximately 500°C. Above 500°C it is recommended that a Hydrogen/nitrogen fluxing atmosphere be used.

Fixtures

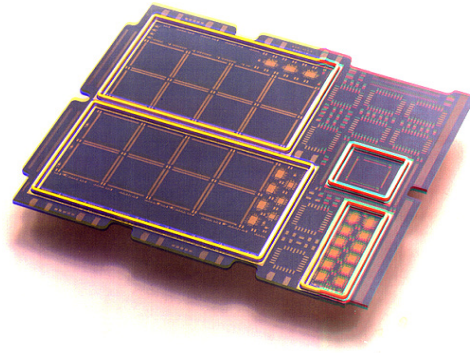
Components to be brazed are usually assembled in a fixed position during the brazing operation to ensure proper placement. Surfaces to be joined should be spaced properly to preserve joint clearance at room and brazing temperatures in order for the braze materials to adequately fill the joint and achieve maximum performance characteristics. High density graphite is recommended for brazing fixtures.

The type of fixture selected is determined by the brazing method employed, the materials being brazed, temperatures, atmospheres and the dimensional requirements of the completed package. The metal components and metallized substrate must be cleaned prior to the braze operation to achieve maximum adhesion. Boiling isopropanol or equivalent is recommended to clean the parts.

All surfaces must remain clean until the brazing operation is complete. The use of latex gloves is advisable when handling the parts.

Furnace Conditions

Conventional belt furnaces are recommended for brazing. Brazing in a belt furnace allows for large scale production, low cost and consistent quality. Parts are brazed in a nitrogen/3.7% hydrogen atmosphere when using 82Au/18In brazing alloy. The 3.7% hydrogen is below the explosive limit, so special furnaces or safety precautions are not generally required. Alloys such as 88Au/12Ge and 80Au/20Sn are brazed in a pure nitrogen atmosphere with no more than 15 PPM of O₂. Actual braze temperature depends on the braze alloy being used, furnace type, heat capacity of the metallized ceramic, metal components and the fixture assembly.



Above is an example of brazed seal ring rings using the complete DuPont braze system. (Photo courtesy of Martin Marietta)

Figure 20: Example of GreenTape™ 951 with Brazed Seal Rings

Brazing Design Guidelines

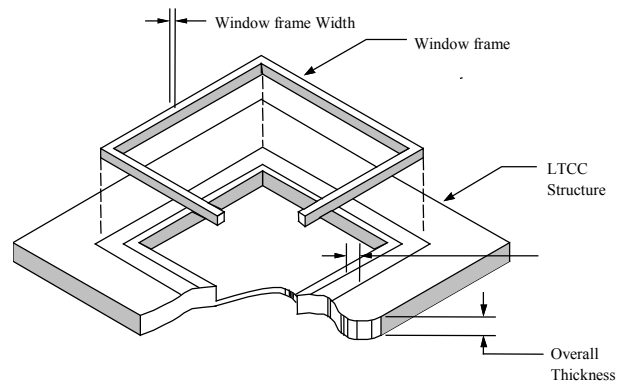
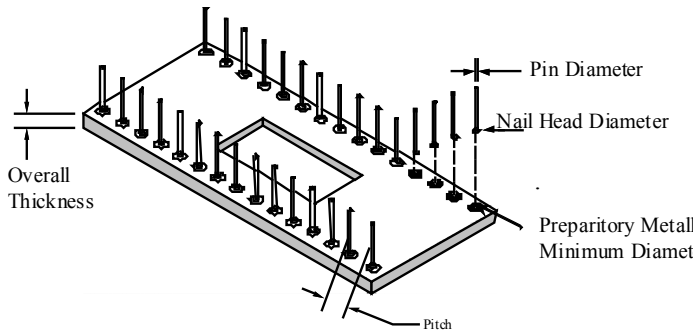


Figure 21: LTCC Substrate and Braze Ring

- Preparatory metallization width should be a minimum of 80 mils wider than the window frame.
- For brazed pins, the braze pad should be twice the diameter of the nail head.
- Braze paste is used for window frames and lead-frames while preforms are used for pins.
- Overall part thickness should be a minimum of 40 mils.
- Follow cavity design guidelines when brazing to parts containing cavities.



Product Selector Guide Attachments

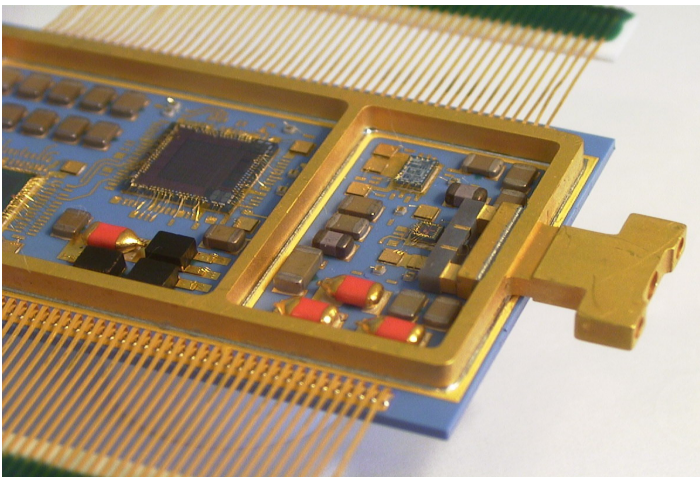
- GreenTape™ 9K7
- GreenTape™ 951

Lead-free* Notation

* "Lead free" as used herein means that lead is not an intentional ingredient in and is not intentionally added to the referenced products. Trace amounts however may be present.

Figure 22: LTCC Braze Pin Pull Test Vehicle

Braze dams have been used when the preparatory material cannot be printed to the recommended width relative to the seal ring to be brazed. This consists of a narrow strip of dielectric, printed over the edges of the preparatory paste. This braze dam approach has also demonstrated improvements in thermal cycle adhesion of brazed components.



Advanced Avionics Module using 951 Green Tape™ along with the DuPont braze system for seal ring and lead attach Advanced Avionics Module using 951 Green Tape™ along with the DuPont braze system for seal ring and lead attach

Figure 23: HIREL GreenTape™ 951 w/Brazed Au

For more information on the DuPont™ GreenTape™ low temperature co-fired ceramic system or other DuPont Microcircuit Materials products, please contact your local representative:

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