System H
H100 Multilayer Dielectric
Thick Film Composition
Preliminary Data Sheet

DuPont
Electronics

Ceramic Circuit Materials and Technologies

Dielectric Composition H100 is intended to form an insulating layer in large complex hybrid and multilayer interconnect circuits. It is applied to ceramic substrates by screen printing, and fired in a conveyor furnace in an air oxidising atmosphere.
H100 is a new dense dielectric based upon a high softening point, partially crystallisable glass, coupled with unique inorganic filler combination to minimise bowing, to reduce dielectric thickness and to allow construction of complex multilayers with high yields and high reliability.

H100 is an integral part of system H, a new high reliability system for gold multilayer interconnects.

Other system components:

- ☐ H120 gold conductor for inner layer of multilayer circuits.
- ☐ H130 gold conductor for top layer of multilayer circuits, suitable for gold and aluminium wire bonding.
- ☐ H140 via fill conductor.
- ☐ H150 solderable platinum gold conductor.

Future system components:

- ☐ Series H1000 high reliability resistor series qualified on top of dielectric H100.

Compatibility

Du Pont has tested this composition with the materials specified above and under the recommended processing conditions.
It is, however, important that customers thoroughly evaluate this material in their specific situations, in order to completely satisfy themselves as to the overall quality and suitability of the composition, for its intended application(s).
Consult your Du Pont representative for recommendations on design and processing if silver bearing conductors are being considered for use with system H materials.

Typical fired dielectric properties[1]

Property	Value
Via Resolution[2]	250 μm
Fired Thickness between conducting layers[3]	27-32 μm
Dielectric Constant (K)	9-11
Dissipation Factor[4]	<0.3%
Insulation Resistance[4]	10^{12} Ω at 100 VDC at 27-32 μm thickness
Breakdown Voltage[4]	>2 k VDC/25 μm
Bowing[5]	<50 μm

Test Procedure

1 Typical fired properties are based on laboratory tests. Unless expressly noted elsewhere, the following processing conditions have been used to form a total fired thickness of 27-32 μm:
Top and bottom conductor: Gold conductor composition H120
Printing: 325-mesh stainless steel screen, 2 layers.
Firing: separately fired to a peak temperature of 850°C using a 60 minute cycle.
Measurements were made at 25°C and at 1 kHz.
See Du Pont Dielectric Testing Procedure: G-2.2.3 (Sch. B).

2 To achieve 250 μm via resolution, it is necessary to wipe the screen periodically. Via size will typically reduce by 50-100 μm on extended print runs and will vary according to screen quality printing conditions, nature of underlying circuits etc.

3 2 fired layers, 325-mesh stainless steel screen.

4 Average values

5 Bowing is determined by testing the simulated construction of a multilayer hybrid with five conductor layers, where each layer of dielectric is printed, dried and fired separately.
Substrate dimensions: 25.4 mm × 101.6 mm × 0.635 mm.

Composition Properties

Viscosity

(Provisional specifications)

@0.5 rpm: 1500-3000 Pa.s
@10 rpm: 200-270 Pa.s.

Brookfield HBT utility cup and spindle (SC4-14), at temp. 25° C ± 0.2° C. Refer to Du Pont test monograph A-1.7.1.(s) for further information on viscosity measurement.

Thinner

H100 is optimised for screen printing and thinning is not normally required. Du Pont Electronics Composition Thinner 9179 may be used sparingly for slight adjustments to viscosity or to replace evaporation losses. However, the use of too much thinner or the use of a non-recommended thinner may affect the rheological behaviour of the material and its printing characteristics.

Coverage

120-140 cm^2/g based on an average fired thickness of 15 μm.
Note: Recommended thickness between conductor layers: 27-32 μm.

Typical shrinkage values

Wet to dry	Dry to fired
10-20 %	35-40 %

Wet to dry % shrinkage calculations:

$$\frac{\text{Wet thickness} - \text{Dry thickness}}{\text{Wet thickness}} \times 100$$

The variability of thickness measurement techniques, particularly of the wet film, means that the above figures are given for guidelines only.

Recommended Processing Procedure

Storage

Containers of H100 may be stored in a clean, stable environment at room temperature (< 25° C), with their lids tightly sealed. Storage in freezers (temperature < 0° C) is NOT recommended, as this could cause irreversible changes in the material. Jar rolling is unnecessary and is NOT recommended, as this could change the rheology of the material.
For guidance regarding storage of material in refrigerators (0° C to +6° C), consult Du Pont Technical Note EUT 7.2 "Shelf Life Policy".

Shelf life

Dielectric H100 has a shelf life of 6 months from date of shipment, for factory-sealed (unopened) containers stored under room-temperature conditions.

Substrates

Properties are based on tests on 96% alumina substrates. Substrates of other compositions and from various manufacturers may result in variations in performance properties, as may different lots of substrates, and any subsequent processing of substrates (e.g. laser scribing/drilling) prior to printing. It is the responsibility of users to determine the effects of any of the above variables in their particular situations.

Printing

Dielectric composition H100 should be thoroughly mixed before use. This is best achieved by slow, gentle hand stirring with a clean burr-free spatula (flexible plastic or stainless steel) for 1-2 minutes. Care must be taken to avoid air-bubble entrapment.
Printing should be carried out in a clean and well ventilated area. Additional information on requirements for printing areas is contained in Du Pont Technical Guide EUT 7.3 "Processing - Screen Printing Rooms" available on request.
Note: optimum printing characteristics of H100 are generally achieved in the temperature range 20° C-23° C. It is therefore important that the material in its container is at this temperature, prior to commencement of printing.
Class 10,000 printing area is recommended for building complex hybrid and multilayer circuits, otherwise severe yield losses could occur.
Print individual dielectric layers with a 200 - or 325 - mesh stainless steel screen.
Two separate printings of H100 are necessary to achieve the fired thickness of 27-32 μm when 325-mesh-screens are used. For best via resolution a 325-mesh stainless steel screen is recommended. Use of a double wet pass of the squeegee may help to minimise pinholes when printing the dielectric, although at the expense of via resolution.

Drying

Allow prints to level for 5-10 minutes at room temperature in a clean, draught-free environment, followed by drying for 10-15 minutes at 150° C in a well ventilated oven or conveyor dryer.

Firing

For optimum results, each print should be fired separately in a well ventilated conveyor furnace, in air. Care must be taken to ensure that any gases/vapours from other chemicals/materials (e.g. halogenated solvents) do not enter the furnace muffle. It is also essential that the air supply to the furnace is clean dry and free of contaminants.
Air flows and extraction rates should be optimised to ensure that oxidising conditions exist within the muffle, and that no furnace exhaust gases enter the room.
A 60-minute cycle with a peak temperature of 850° C held for 10 minutes should be used for gold multilayer circuits. Full information on requirements for firing is contained in Du Pont Technical Guide EUT 7.4 "Process Guide - Firing".

99%

Substrate bowing
The thermal coefficient of expansion (TCE) of H100 is closely matched to that of 96 % alumina substrates. This TCE match minimises "bowing" of large substrates, which facilitates processing of upper layers and assembly of components. Tests were made by printing and firing successive layers of H100 on 25 mm × 100 mm × 0.635 mm, 96 % alumina substrates.

The results are shown in Figure 1.

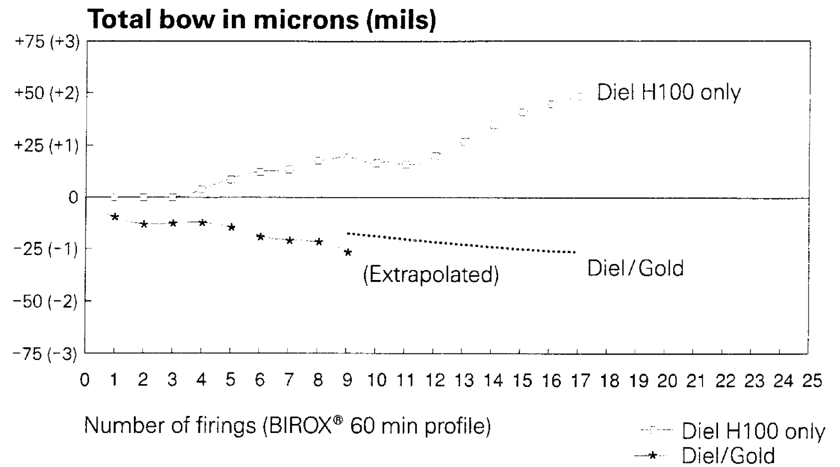
Build sequence in Figure 1

Stage N°	Diel Only	Diel/Gold
1	-	PDF Gold
2	PDF Diel.	PDF Diel.
3	PDF Diel.	PDF Diel.
4	Refire	Refire
5	Refire	PDF Gold
	etc.	

PDF = Print, Dry, Fire

In the figure, the level of bow is measured after each stage of the circuit build. The bow in microns (mils) is measured at the centre of the 25 mm × 100 mm (1" × 4") substrate. If large substrates are used, the bowing will be greater as the amount of bow is proportional to the square of the substrate diagonal.
In this case, the conductor pattern has approximately 45% coverage and the bow is shifted slightly negative. If the conductor coverage had been greater, the bowing would have been shifted more negative, if conductor coverage had been less then the bowing would have approached zero.

Figure 1



General
Yields and performance will depend to a large degree on the care exercised during processing, particularly in screen printing. Scrupulous care should be taken to keep the dielectric composition, printing screens and other tools free of metal contamination. Dust, lint, and other particulate matter may also contribute to poor yields.

Health / Safety Considerations
Du Pont microcircuit compositions are intended for use in an industrial environment by trained personnel. All appropriate health/safety regulations regarding the storage, handling and processing of such materials should be complied with. For information on health/safety regulations, please refer to the specific MSDS for H100 and to the Du Pont Safety Guide EUT 7.1 "Practical Safe Handling of Thick Film Compositions".

® Du Pont's registered trademark