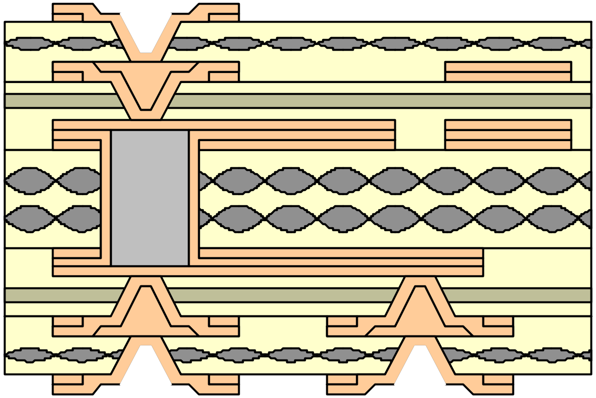
IPC Fall Meeting

Sept 30, 2003

A Novel Build-up PWB for Latest Mobile Phone



<Speaker>
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AIREX.inc

Current status of mobile phone in Japan (example)

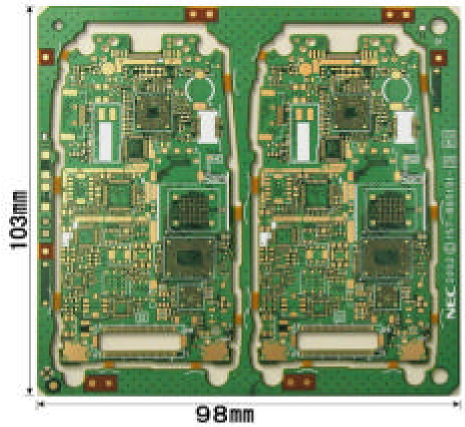
The size is only 95 ㎜×48 ㎜×19.8 ㎜
The weight is 105 g
Internet connection so-called “I-mode” service
Mega-pixel digital camera.

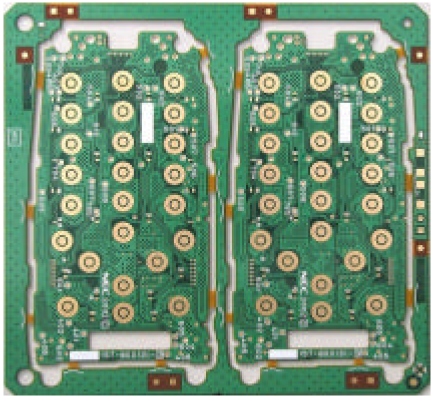
Requirements to build-up PWB for mobile phone

Requirements	Methodology	Solution
Portability	Lighter and Thinner PWB Higher density circuit	NWGF-PP & stacked via by Cu-filled via
Durability	Improvement of build-up layer strength	Combination of NWGF-PP & WGF-PP
Low cost	Process step reduction	Cu-filled via plaiting & NWGF-PP

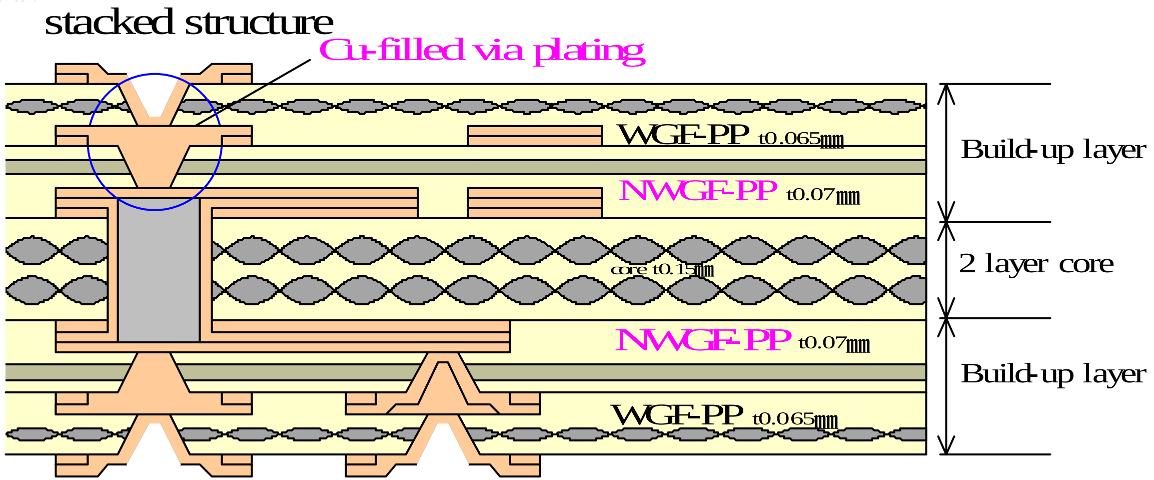
＊ NWGF-PP：Non-woven glass fabric prepreg
WGF-PP :Woven glass fabric prepreg

Developed build-up PWB for latest mobile phone





Line/Space = 75µm/75µm
Via diameter = f0.10mm
Stacked via structure by Cu-filled via plating



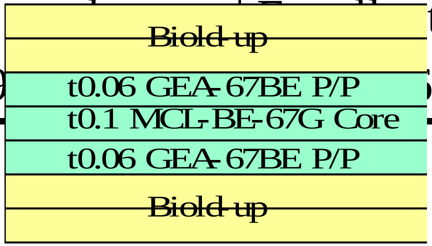
Cross-section diagram of 2+2+2 structure build-up PWB

Non-Woven Glass Fabric –Prepreg (NWGF-PP)

Comparison of mechanical properties (Build-up Structure)

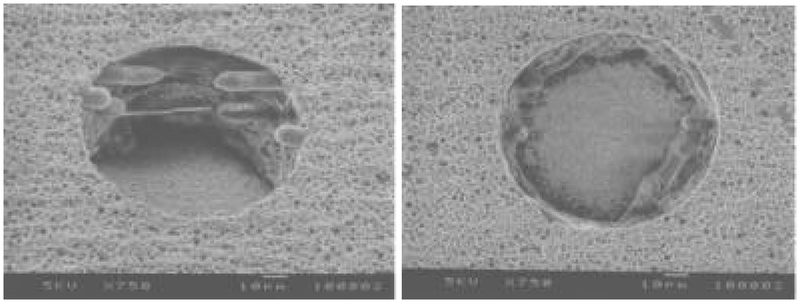
Item		Unit	AS-5000GP NWGF-PP	GEA-BE-67G WGF-PP	MCF-4000G RCC
Impact Strength	32g	cm	>150	>150	85
	50g		65	145	30
Flexual Modulus	25deg. c	Gpa	1402	2213	1031
Flexual Strength	25deg. c	Mpa	24.2	48.8	18.6
Specific gravity			Good (1.6-1.7)	No [illegible] (1.9[illegible]	[illegible]t [illegible]5)

Data are provided by Hitachi Chemical Co., LTD.

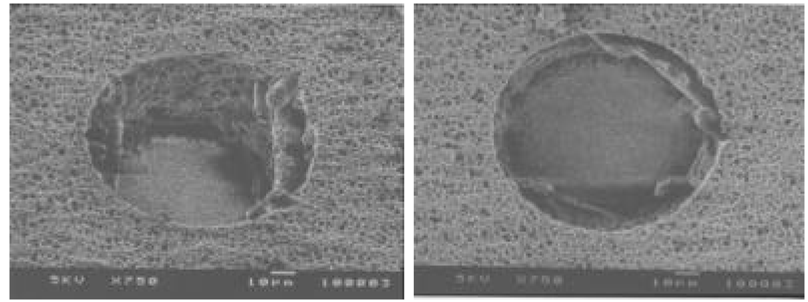


Laser drilling of build-up layer(ƒ100µm)

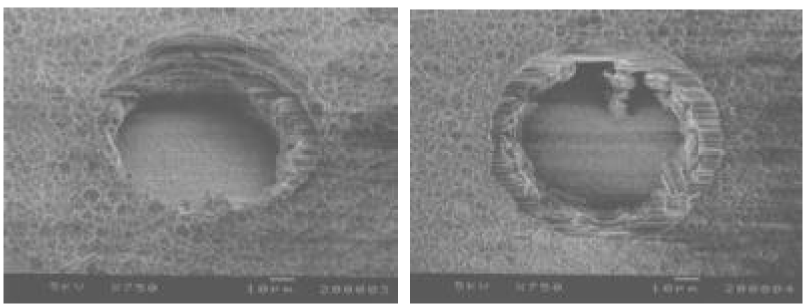
NWGF-PP : 2Shots



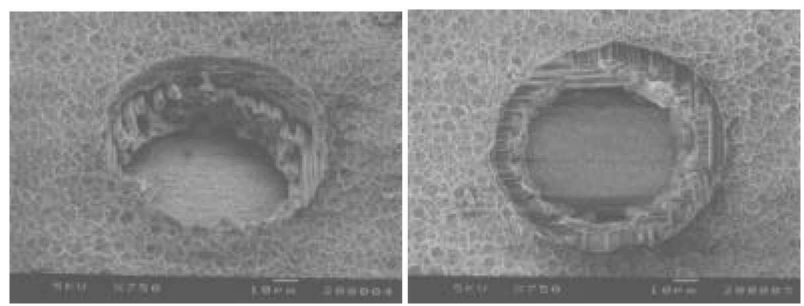
NWGF-PP : 3Shots



WGF-PP: 3Shots

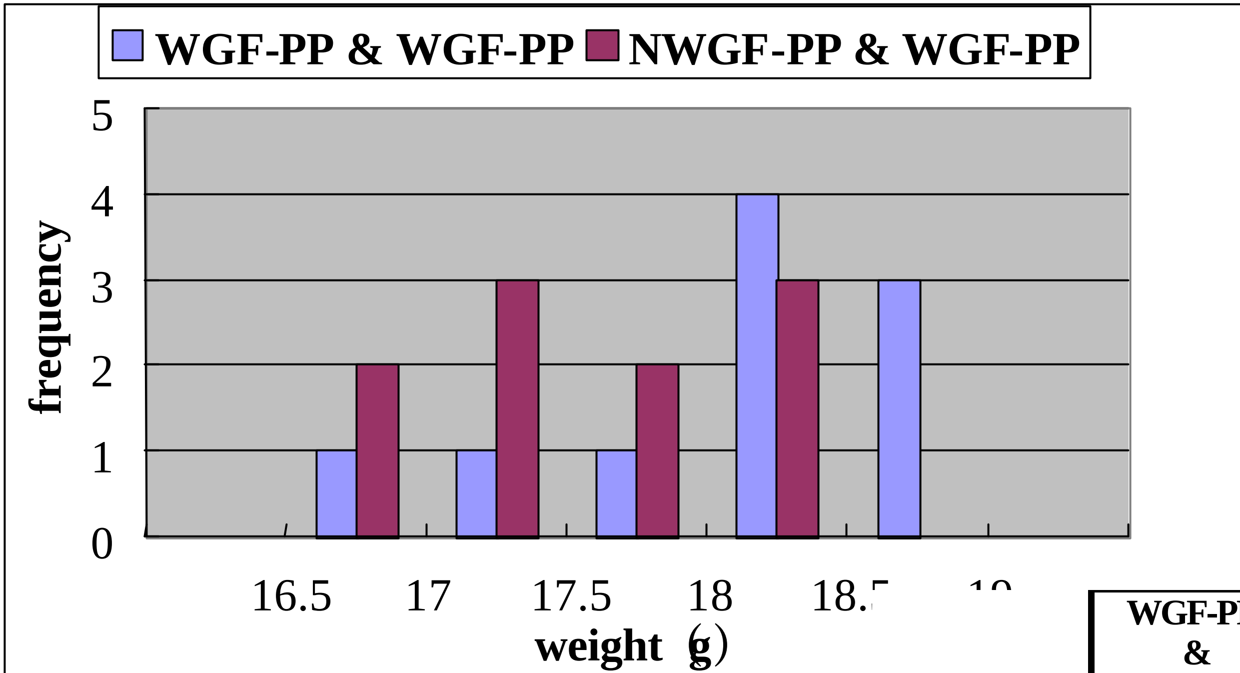


WGF-PP: 4Shots



Laser Conditions
Machine : Hitachi Via Mechanics LCO-1C21
Frequency : 2000Hz(Cycle Method)
Pulse Width : 14 micro sec

Comparison of build-up PWB weight



speciman(1)WGF-PP & WGF-PP

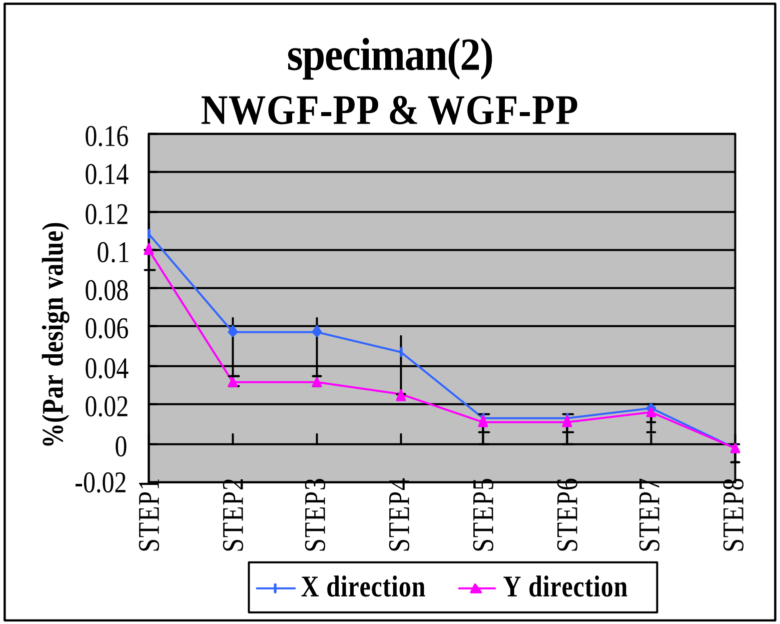
woven glass fabric t0.065mm
woven glass fabric t0.065mm
core t0.15㎜
woven glass fabric t0.065mm
woven glass fabric t0.065mm

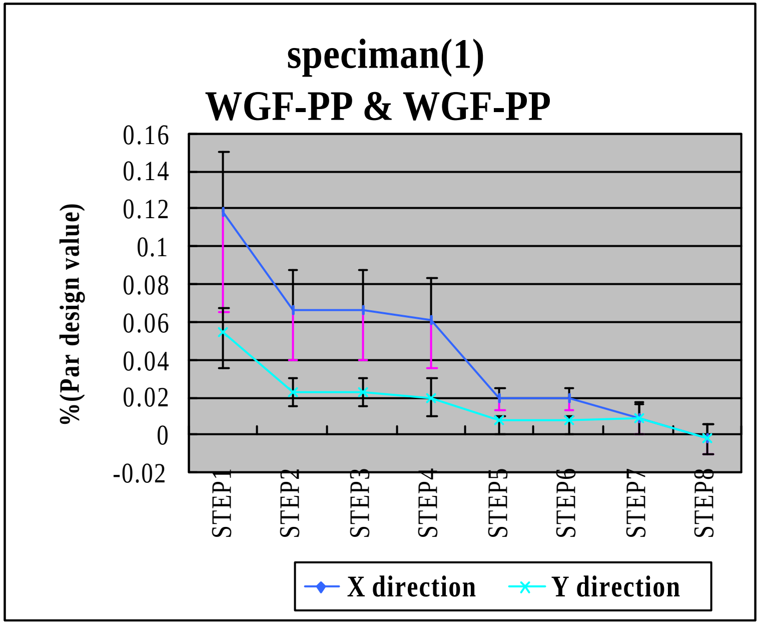
speciman(2)NWGF-PP & WGF-PP

woven glass fabric t0.065mm
non-woven glass fabric t0.07mm
core t0.15㎜
non-woven glass fabric t0.07mm
woven glass fabric t0.065mm

	WGF-PP & WGF-PP	NWGF-PP & WGF-PP
Average	18.0g	17.6g
Minimam	16.7g	16.8g
Maximam	18.6g	18.3g
Standard deviation	0.64	0.58

Comparison of base material for build-up layers





STEP1.Layer 3-4 Imaging → STEP2.Window formation → STEP3.laser drilling → STEP4.Layer 2-5 Imaging → STEP5.Window formation → STEP6.laser drilling → STEP7.Layer 1-6 Imaging → STEP8.Solder resist

Comparison of three major base materials for build-up printed boards

Items	NWGF-PP	WGF-PP	RCC
Handling	Excellent	Excellent	No good
Laminating performance	Excellent	Excellent	Good
Thickness tolerance	Good	Excellent	Fair
Laser drilling performance	Fair	No good	Excellent
Mechanical Strength	Good	Excellent	No good

Some data are provided by Hitachi Chemical Co., LTD.

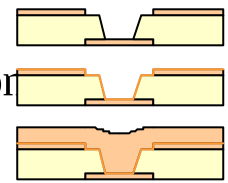
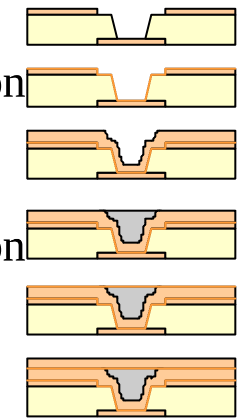
Summary of base materials

·The combination use of non-woven glass fabric material and woven glass fabric materials makes build-up PWB of high strength with the increase of minimum weight

·Non-woven Glass Fabric has better processing nature in Laser processing than Woven Glass Fabric, Therefore the processing of the 100μm via needed for Cu-filled plating and the reduction of the processing cost were materialized

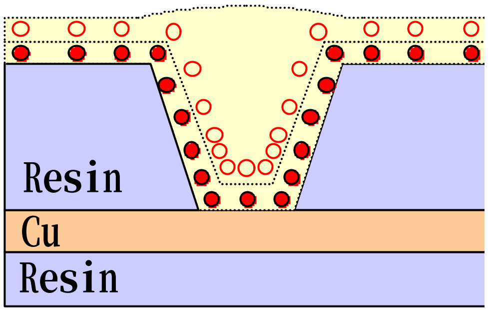
Cu-filled via plating

Why Cu-filled via plating?

Plating process	Plugging process
Process step 1.Laser processing 2.Electroless copper deposition 3.Copper electroplating To Imaging step 	**Process step** 1.Laser processing 2.Electroless copper deposition 3.Copper electroplating 4.Plugging 5.Electroless copper deposition 6.Copper electroplating To Imaging step 
Cost(index) 100	**Cost(index)** 316

Principle of Cu-filled via plating

Memory theory

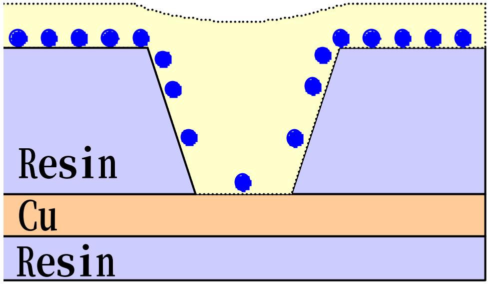


Promotion medicine (DCA) as accelerator absorbs evenly at the initial stage of plating. However, according to growth of plating, adsorption amount becomes thick as surface area of concave part becomes smaller.

DCA:Depolarizing Control Agent

Deposition at concave part is accelerated.

Dispersion theory



Inhibitor (PCA) as inhibitor adsorbs rich on flat part having thin diffusion layer, and less in concave part having thick diffusion layer.

PCA:Polarizing Control Agent

Deposition to flat area is suppressed and plating will deposit in concave part preferentially.

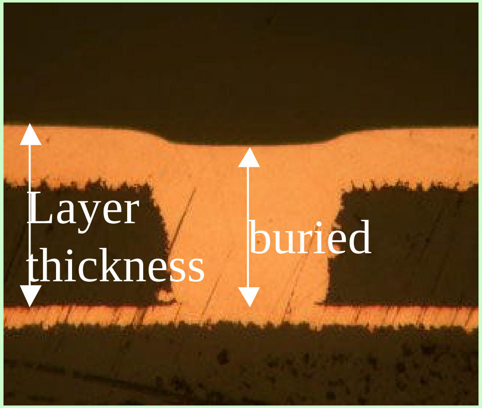
By OKUNO CHEMICAL INDUSTRY CO.,LTD.

Plating bath control

Bath composition	Copper sulfate	Supplying copper-ion needed for plating
	Polymer	Inhibits the copper separates
	Brightener	Promotion of the electrodeposition reaction Small separation particle Gloss and flexible plating
	Leveler	Inhibits convex electrodeposition reaction Even plating tunic
Current density		Copper ion consumption →Maintain the balance of the supply and consumption of the copper ion in Via.
Diameter of Via top		Supply for copper ion
Bath agitation		Supply for copper ion

Cu-filled rate

Cu-Filled Plating is to full up (bury) inside of Via by copper plating. The evaluation index can be express as Cu-filled rate as following the formula. The value would indicate how much the via is filled up by copper.

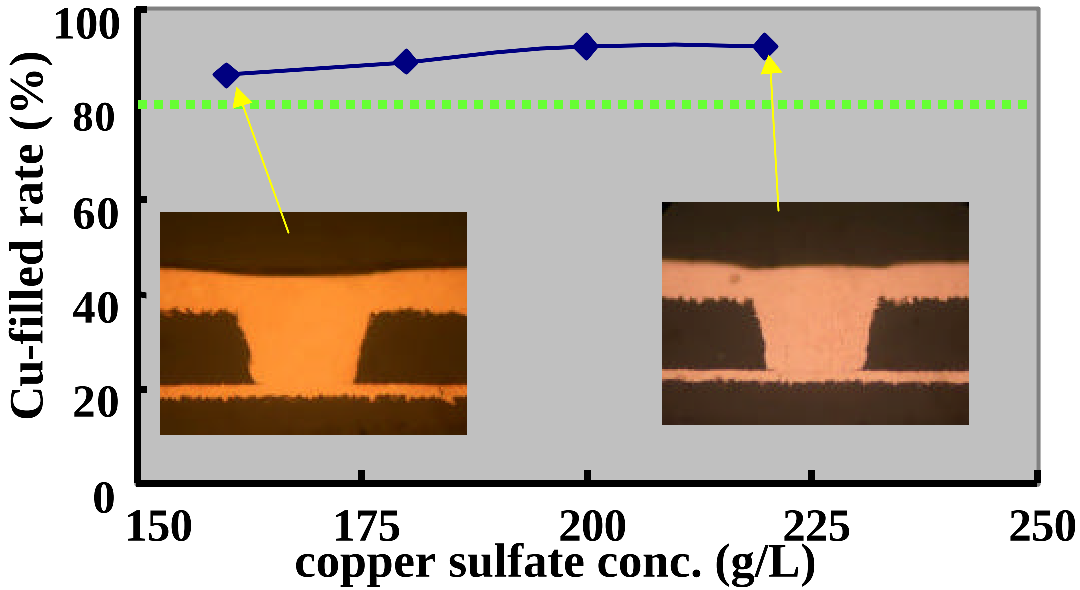


$$\text{Cu-filled rate} = \frac{\text{buried}}{\text{Layer thickness}} \times 100(\%)$$

*) Layer thickness
=Insulation layer+Upper copper thickness

Copper sulfate conc. vs. Cu-filled rate

When sulfuric acid copper density is high even the Cu-filled rate high



Plating condition

Current density :1.0A/dm^2 Plating time :120min

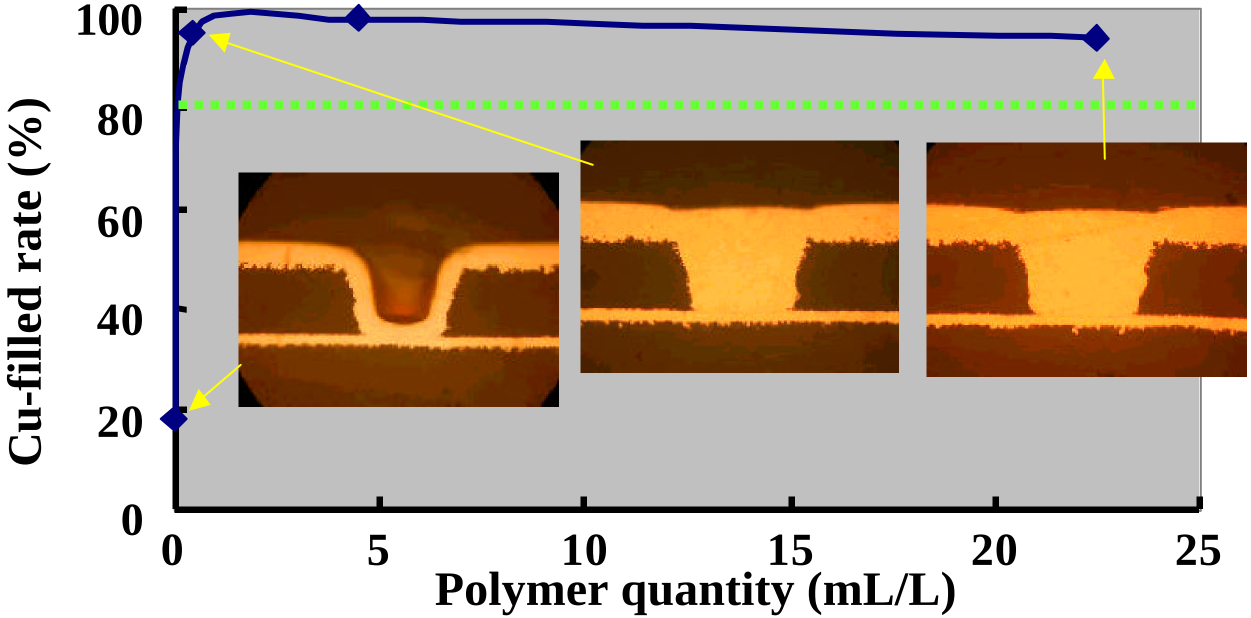
Temperature :23℃ brightener conc. :α-M 4.5mL/L α-2 1.0mL/L α-3 3.0mL/L

Sulfuric acid conc. :50g/L Chlorine conc. :50mg/L

Plating thickness:20μm Under copper thickness:12μm Layer thickness:80μm

Polymer quantity vs. Cu-filled rate

The influence of the polymer quantity to the Cu-filled rate is small in the range of 4.5mL/L and 22.5mL/L of polymer quantity.



Plating condition

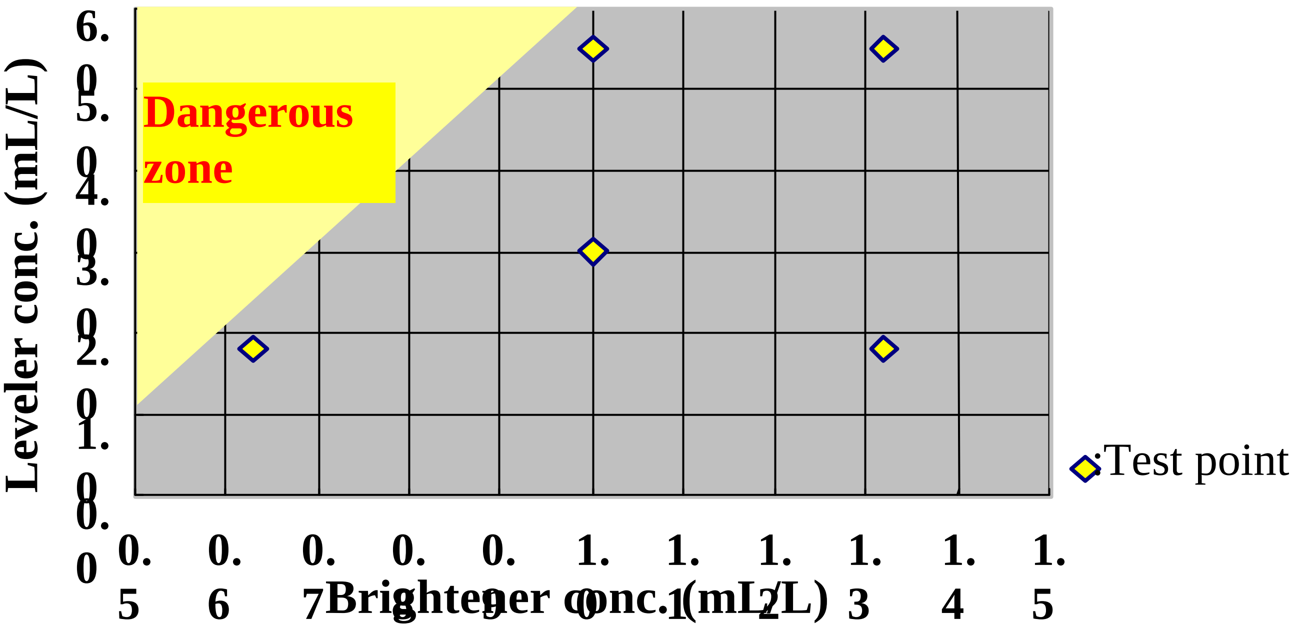
Current density :1.0A/dm^2 Plating time :120min

Temperature :23℃ brightener conc. :α-2 1.0mL/L α-3 3.0mL/L

Plating thickness:30μm Under copper thickness:12μm Layer thickness:80μm

Brightener/Leveler vs. Cu-filled rate

Balance of brightener and leveling agent is critical.



Plating condition

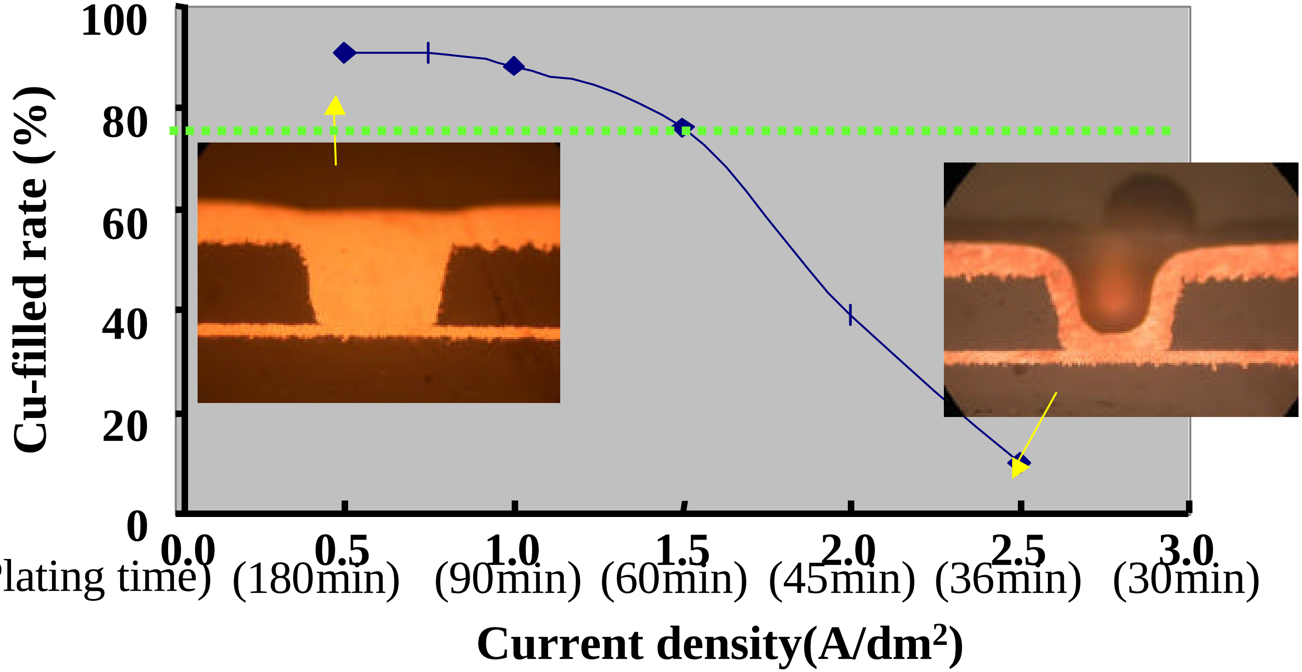
Current density :1.5A/dm^2 Plating time :82min

Temperature :23℃   brightener conc.: α-M 4.5mL/L

Plating thickness:30µm   Under copper thickness:12µm   Layer thickness:80µm

Current density vs. Cu-filled rate

Cu-filled rate falls off when current density becomes high. Cathode current density needs to make below 1.3A/dm^2.



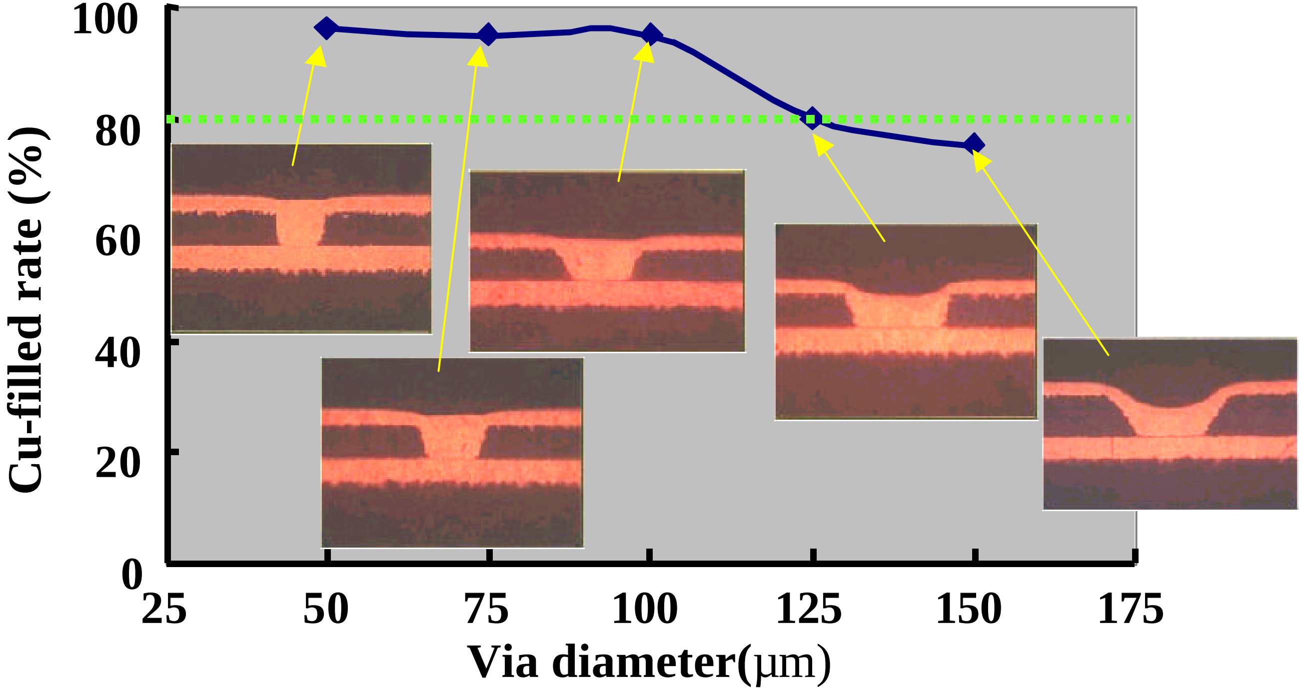
Plating condition

Temperature :23℃ brightener conc.: α-M 4.5mL/L α-2 1.0mL/L α-3 3.0mL/L

Plating thickness:20μm Under copper thickness:12μm Layer thickness:80μm

Via diameter vs. Cu-filled rate

Preferable via diameter is less than one hundred microns



Plating condition

Current density :1.0A/dm^2 Plating time :90min

Temperature :23℃ brightener conc.: α-M 4.5mL/L α-2 1.0mL/L α-3 3.0mL/L

Plating thickness:20μm Under copper thickness:12μm Layer thickness:60μm

Control point of Cu-filled plating

- **Bath composition**
  - **Copper sulfate** — High copper sulfate conc. gives high Cu-filled rate high.
  - **Polymer** — Influence of polymer quantity to Cu-filled rate is small
  - **Brightener**
  - **Leveler** — Attention is necessary in balance of brightener and leveling agent.
- **Current density** — Cathode current density should be 1.3A/dm2 or less.
- **Diameter of Via top** — Via diameter should be one hundred microns or less.
- **Bath agitation**

Summary of Cu-filled via plating

·Cu-filled via plating has come to be able to stabilize by optimizing of plating bath condition, plating work and via diameter.

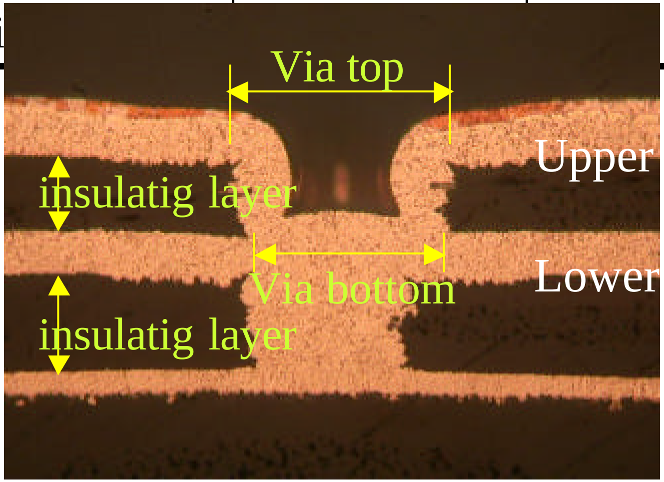
·Cu-filled via plating technology has enable stacked structure with low cost.

Reliability evaluation result of the stacked structure

Reliability evaluation of the Stacked structure

Via shape

		Diameter of via top	Diameter of via bottom	Thickness of insulating layer
Upper build-up layers	Average	133.8µm	117.6µm	51.5µm
	Standard deviation	4.6	8.0	3.4
Lower build-up layers	Average	99.9µm	78.0µm	63.2µm
	Standard deviati	2.5	6.2	1.9



Test result

Items	Condition	Standard (Resistance change rate)	Result	Judge
Temperature cycle Test(in liquid)	125℃ to -60℃ Immersion time : each 30 min 100cycle	Within 10%	1.9%	Passed
Hot Oil Test	1.260℃ and 5sec 2.cooling 15sec 3. 20℃ and 20sec 100cycle	Within 10%	0.6%	Passed
Reflow Test	Peak temperature :260℃ Three times processing	Within 10%	1.1%	Passed
Composite Test	Reflow Test and Temperature cycle Test	Within 10%	0.4%	Passed

Conclusion

(1).By the combination use to woven and non-woven Glass Fabric PP for each build-up layer mass production of build-up PWB has been stabilized and enabled to achieve higher performance such as thinner, stiffer dielectric layers with lower cost.

(2).Since build-up PWB with stack structure has enabled to produce by Filled Via Plating processes, higher density circuit design has become simpler and shorter lead-time.

(3).Novel build-up PWBs using afore mentioned technology have been manufactured largely for the latest model mobile phone.