Material Properties of LCP Film and Its Board Applications in IT-Related Devices

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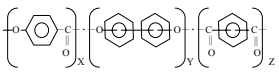
Liquid Crystal Polymer Film/Substrates

Type- Thermotropic LCP

- *One of the super engineering plastic materials*
- *Thermoplastic film*
- *All-aromatic polyester*



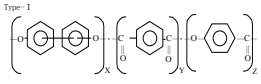
What is LCP ?

Types of Liquid Crystal Polymer Films

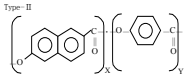
- *Low-molecular liquid crystal*
  - *Liquid under room temperature・ optical liquid crystal material・ LCD*
- *High-molecular liquid crystal*
  - *Solid under room temperature・ plastic material・ fiber, non-woven, film, injection molding*
    - ***Rheotropic LCP***
      - ***Aramid (all-aromatic polyamide)***
        - ***Moisture resistance: not good / heat resistance: excellent***
          Kevlar (DuPont)・Technora (Teijin)
    - ***Thermotropic LCP (all-aromatic polyester)***
      - ***Moisture resistance: excellent / heat resistance: good***
      - ***Type I: BIAC (Japan Gore-Tex)***
      - ***Type II: Vecstar (Kuraray)***
      - ***Type III: Novaccurate (Mitsubishi Chemical), Rodran (Unitika)***

Molecular Structure of Thermotropic LCP

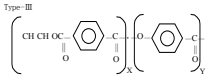
Type- I



Type- II



Type- III

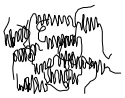


Heat Resistance of Thermotropic LCP

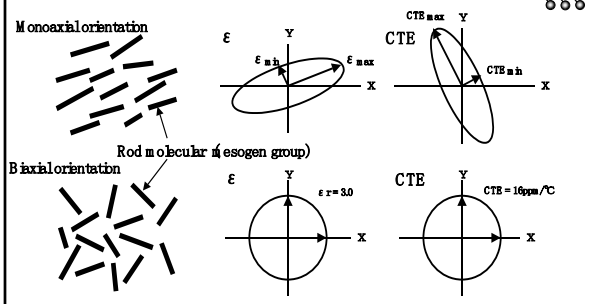
	Liquid crystal transition point (C)	Solder heat resistance (C)
I	350	280
II	300	230
III	250	180

How is Thermotropic LCP film made ?

Formation of Rod Molecular and Domain

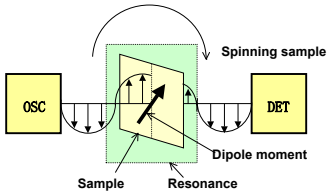
	Thermotropic LCP	*Crystalline polymer*	*Non-crystalline polymer*
		PE, PET, PEEK, PPS	*PS, PC, PES*
Molten state			
Extrusion Molding			
Solid state			

Molecular Orientation and Properties of the Film



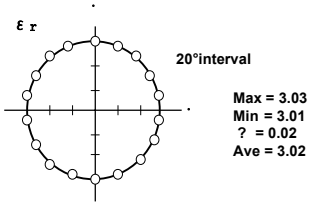
Principle of Molecular Orientation Analyzer

- *By inserting a sample into a cavity resonance analyzer and spinning it, the transmitting microwave intensity is changed due to anisotropy of the dielectric constant. The orientation of the molecular chain of polymer material can be determined.*
- *Analyzer:* microwave molecular orientation analyzer *(Oji Paper made), 12 GHz*



In-plate Orientation of LCP Film

- *Liquid crystal polymer film for high frequency performance test:*
  - ***Orientation is controlled very accurately***
  - ***In-plate dielectric constant is uniform***



Max = 3.03
Min = 3.01
? = 0.02
Ave = 3.02

Material Properties of LCP Film

- ***Great heat resistance***
  - Solder bonding is possible· 280c·
- ***Low moisture absorption · 0.1% ·***
  - Stable dielectric constant
- ***High dimensional stability***
  - The CTE of dielectric matches the CTE of conductive material- copper(16ppm/ C)· no warp in substrate
- ***Environmentally conscious***
  - No flame retardant such as halogen, UL-94· VTM-0
  - Potential recyclablity
- ***Adhesive-less bonding***
  - Thermal press bonding with copper foil is possible
  - · 2-layer CCL

Comparison of LCP Film and Polyimide Film

	LCP (BIAC)	Polyimide Film
Pattern Accuracy	good	OK
Water Absorption	good	not good
Stiffness	OK	good
Heat Resistance	OK	good
Insulation	good	OK
High Frequency Properties	good	not good
Thermal Conductivity	good	OK
Chemical Resistance	good	good
Flexibility	good	OK
Peel strength from metallic foil	not good	OK

Coefficient of Thermal Expansion

(ppm / C)

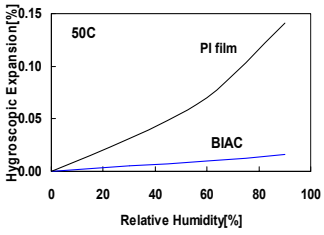
	BIAC (LCP)	Polyimide film
23～100 C	16	14
100～200 C	16	16

Coefficient of Hygroscopic Expansion

(ppm / %)

	BIAC (LCP)	Polyimide film
50 C 20～80%RH	1.5	14

Hygroscopic Expansion for Relative Humidity

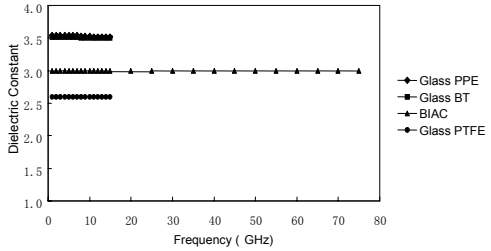


Moisture Absorption

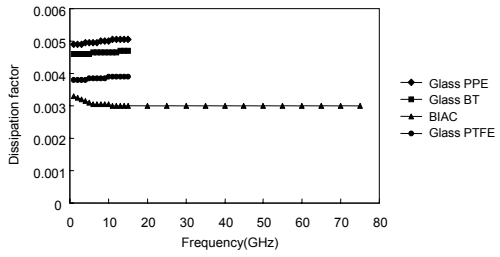
(%)

	BIAC (LCP)	Polyimide film
23C,24hrs immersed in water	0.1	1.5
85C,85%RH 96hrs in atmospheric air	0.1	1.2
PCT 96hrs (121C,2atm)	0.2	2.0

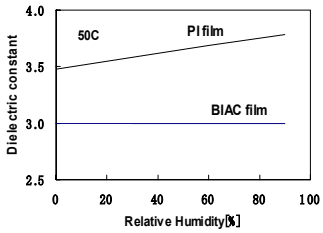
Dependence on Frequency
(Dielectric Constant)



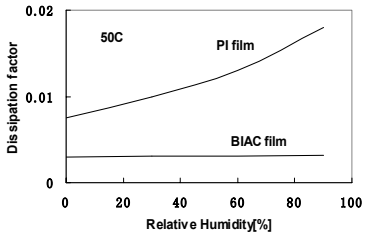
Dependence on Frequency
(Dissipation Factor)



Moisture Dependence· Dielectric Constant)



Moisture Dependence· Dissipation Factor·



Applications

Advantages of LCP "BIAC" in PWB Applications

- ***Controllable CTE***
- ***Low water absorption***
- ***Superior heat resistance***
- ***Great insulation property***
- ***Great high frequency characteristics***
- ***Recyclable material***
- ***High heat conductivity***
- ***Flexibility***
- ***Adhesiveless bonding property***
  (thermoplasticity, heat-bonding is possible)

Applications in Electronic Materials Field

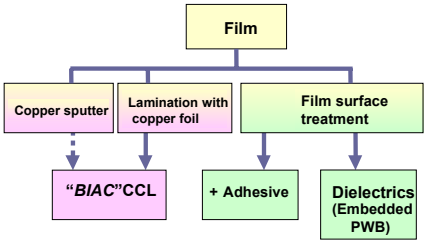
1. Flexible circuit

2. Insulation tape for IC package

3. High frequency

4. Multi-layer PWB for high density interconnects

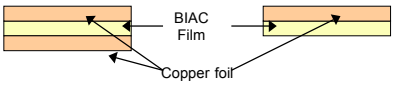
Product Lineup



Liquid Crystal Polymer Film *"BIAC"*

- *LCP film* "BIAC"
  - ***Film (Available on Controlled sale basis in US)***
  - ***Copper clad laminate*** *• single or double-sided CCL •*
    - *(Only selectively distributed to specific clients)*
- *Film thickness: 25, 50, 75, 100 , 125 µm*

Structure of 2-layer CCL



Double-sided copper clad laminate Single-sided copper clad laminate

No Adhesive !

Applications in High Density, Flexible Circuit

1. TAB application

1.1. Cumulative dimensional stability test of LCP-based COF

1.2. Moisture resistance test of LCP-based Tape-BGA

1.3. Reliability test of LCP-based 2-metal TAB

Courtesy of Shindo Electronic Inc.

2. New technologies for TAB

2.1. Copper sputtered CCL

2.2. Chemical etching technology for LCP film

Courtesy of 3M

3. Application in "NMBI" technology

3.1. Tape Interposer for NMBI technology

3.2. 3D Multi-Stack Package

Courtesy of North Corporation

1. TAB Applications

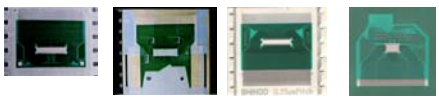
1.1. Cumulative dimensional stability test as COF

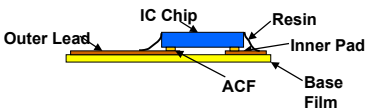
1.2. Moisture resistance test as Tape-BGA

1.3. Reliability tests as 2-metal TAB

COF - LCD Driver Mounting Structure

COF Pattern

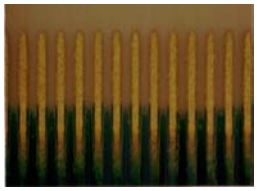




COF Technology Roadmap

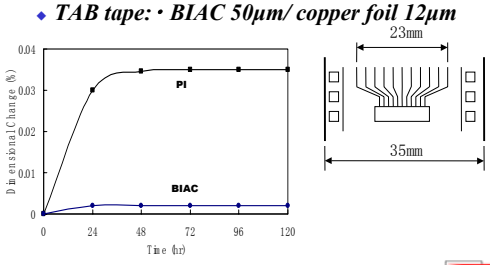
	2000	2001	2002	2003	2004
Pattern Pitch [μm]	50	40	30	25	20
Base Film Material	Polyimide Film	Polyimide Film	High Dimensional Stability New Film	High Dimensional Stability New Film	High Dimensional Stability New Film

40micron Pitch COF



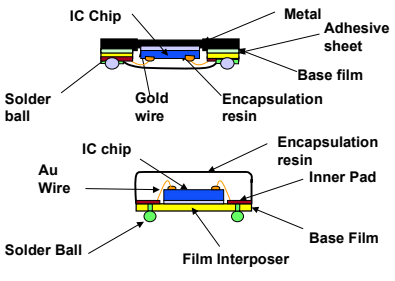
Cumulative Dimensional Stability

- *Cumulative dimensional change ・60C・60%RH ・*
  - ***TAB tape:・BIAC 50μm/ copper foil 12μm***



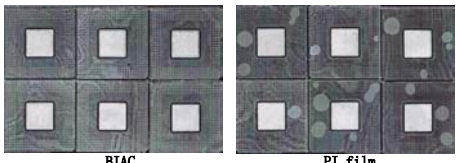
WB Type CSP & T-BGA

Tape material: 1-metal CCL



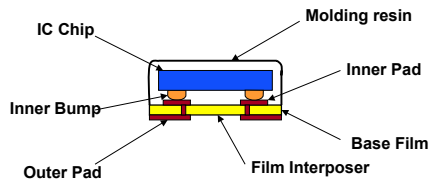
Results of Reliability Test

- *Moisture resistance of packaging substrates*
  - *Samples used: WB type TBGA・after heat sink attached・ ・TAB tape; BIAC 50μm/ copper foil 18μm*
  - *Test condition: JEDEC level 1 (85C・85%RH・168hr・240C, re-flow/3 times・*
  - *Tested by: checking existence of bubbles by supersonic flaw detector*



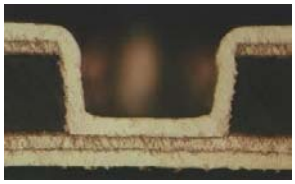
Structure of FC Type CSP

Copper Foil : Double-sided



CO2 Laser Drilling

CO2 Laser Driling / Plating



Results of Reliability Tests

- *Reliability of BVH*
  - ***Sample used: TAB tape; copper foil 18μm/BIAC 50μm/ copper foil 18μm***
  - ***Hole: φ0.15mm ・CO_2 laser , 200 holes, daisy chain***
  - ***Test items:***
    - ***Heat shock test***
      260C・10sec・ transporting 10sec・ IPA 25C ・10sec 100 cycle
    - ***Heat cycle test***
      -55C・30min・ 125C・30min 100 cycles
    - ***PCT***
      121C・2atm・100%RH 100hr

2. New Technologies for TAB

2.1. Copper sputtered CCL

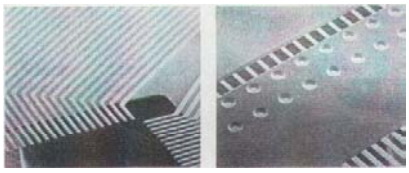
2.2. Chemical etching technologies for LCP film

Copper Sputtering Technologies

Copper vapor-metallized LCP film **Copper foil laminated substrate**

Courtesy- 3M Corp Microflex Div.

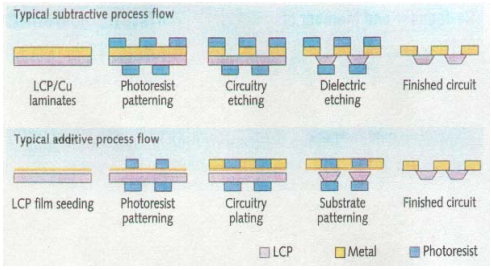
Chemical Etching Technologies



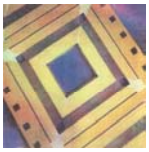
Etched IC device hole **Etched through hole**

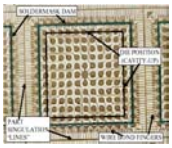
Courtesy- 3M Corp Microflex Div.

Additive Process for LCP



Test Patterns Made by New Technologies





Results of Reliability Tests

Battery of Reliability Tests			Coverlayer	Soldermask*
Test	Condition	Time	(LCP)	
Pressure Cooker Test (PCT) [6]	121°C, 100%RH	168 hours	**PASS**	**PASS**
Thermal Shock: Liquid-to-Liquid [9]	-55 – 125°C	500 cycles	**PASS**	**PASS**
		1000 cycles	**PASS**	**PASS**
HAST [7,8]	130 °C, 85%RH, 5 & 0 volts	96 hours	**PASS**	**PASS**
Thermal Shock: Air-to-Air [10]	-65 – 150°C	500 cycles	**PASS**	**PASS**
		1000 cycles	**PASS**	**PASS**
Level 1 MRT [4]	85°C, 85%RH + 3X Reflow 260°C	168 hours	**PASS**	Not tried
Level 3 MRT [4]	30 °C, 60%RH + 3X Reflow 260°C	192 hours	Not tried	**PASS**
Liquid Immersion (e.g., solder) [5,11]	280°C	5 – 10 sec.	Not tried**	**PASS****

* 5 soldermasks evaluated on LCP film (including epoxy, epoxy-acrylate, and urethane polymers)
** Raw Circuits – **PASS** (metal adhesion and dimensional stability)

Thanks