

All-Polyimide Flexible Laminates for Displays

by KURT D. ROBERTS

Flexible circuits for cellular phone liquid crystal display (LCD) and plasma display panel (PDP) demand the properties of All-Polyimide (also called adhesiveless) flexible laminates to deliver sharp, crisp flawless images. These consumer electronic applications demand flexible circuits with fine pitch for chip on flex (COF) attachment and high-density interconnection capability. All-Polyimide flexible laminates are ideally suited for producing these dense, high-performance flexible circuits.

HIGH GROWTH IN DISPLAYS

LCD and PDP displays are the fastest growing segments of consumer electronics. Explosive growth in the internet and cellular phone wireless networks, along with the requirement of instant communications worldwide, are creating the demand to transmit and display color and text on larger, higher resolution displays for handheld devices. The growth and adoption of HDTV standards, the need for space-saving displays that can hang flat on the wall, and dropping prices are driving the growth of PDP as CRT replacements.

The worldwide market for displays today is \$57.7 billion with a compounded annual growth rate (CAGR) of 8%. The LCD segment is \$15.5 billion with a 16% CAGR. PDP are poised for growth with over 400,000 displays shipping this year, and a CAGR of 56% over the next five years assuming prices continue to drop.

CHIP ON FLEX (COF)

Technology to handle more graphics in smaller and lighter handheld devices requires the placement of driver integrated circuits close to the LCD display to obtain high screen refresh speeds and resolution. Conventional adhesive based copper clad laminate (CCL)

circuits utilizing TAB, and TAB plus flexible printed circuits (FPC) are thick, not flexible, and do not allow for component attachment. Therefore conventional circuits require additional connection (TAB + FPC), and do not allow for easy installation into small cell phone cases.

LIMITATIONS OF (TAB) LCD DRIVER CIRCUIT

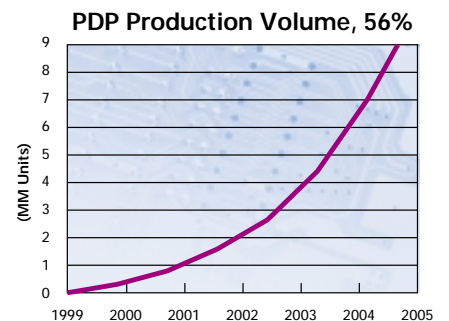
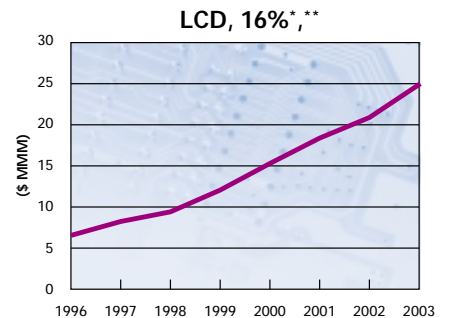
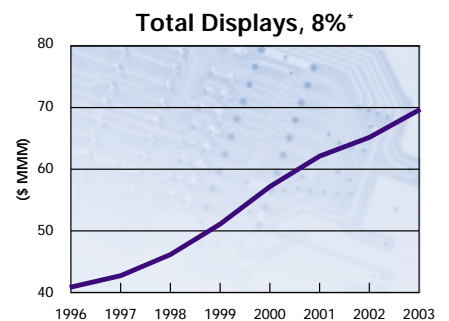
To solve these problems COF and chip on glass (COG) are starting to be used. COF has an advantage of using conventional assembly equipment and enables inclusion of peripheral circuits for color LCD. In addition to enabling SMT mounting, flex substrates also provide thin circuit profile, low modulus for easy flex to install, pattern capability of 50-60 µm pitch, thermal stability, and dimensional stability for both flip chip and anisotropic conductive film (ACF) bonding processes.

CHIP ON FLEX FOR PDP DRIVE MODULES

PDPs on the other hand must handle the heat generated by higher-powered driver circuits required to achieve picture brightness and longevity. The market trends for manufacturers are towards lower panel cost through miniaturization and lower IC cost through die shrink. Driver IC manufacturers are also reducing cost by developing lower voltage ICs, as well as, shrinking the die. FPC has been used for connection between the panel and drive circuit. COF circuit modules offer a cost-effective way to combine IC driver attachment and panel connection thereby eliminating the additional FPC. Further standardization of Flex COF will continue to drive cost out of the circuit.

ALL-POLYIMIDE FLEX PROPERTIES

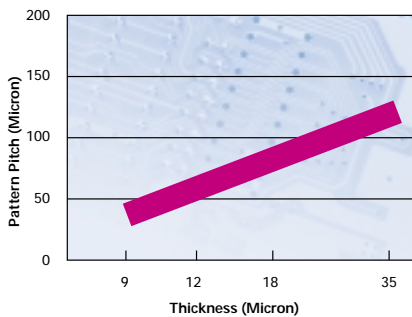
Fine pitch is required to produce today's displays



LCD and PDP Displays Market, \$MM and CAGR%
Source: *Electric Components Report 1999/2000*
Chunichi Co.

*2000-2003

**PC/Monitor/LCD TV/Cellular phone/PDA

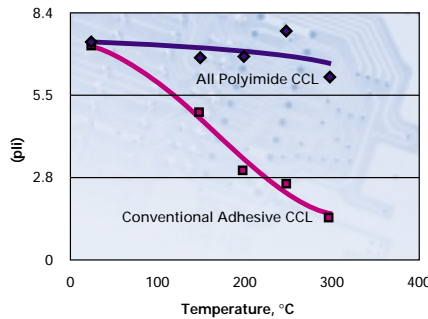


Minimum Pattern Pitch Versus Copper Thickness

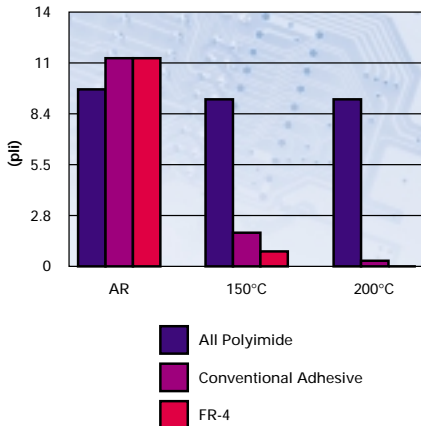
play circuits, driven by the need for direct chip attachment. All-Polyimide CCL is available in a wide array of copper thickness, from 3 μm to 70 μm , and a variety of types; roll annealed (RA), electro deposited (ED), or electro plated (EP). Thinner copper foil is the primary factor to get fine line resolution. Results will depend on many factors involved with fine line imaging. Typically you can obtain 25 μm or greater L/S with 9-12 μm copper. 50 μm L/S rulings can be accomplished with 12-18 μm copper. L/S rulings greater than 100 μm utilize 35 μm copper.

EASIER FLEX TO INSTALL AND LIGHTER WEIGHT

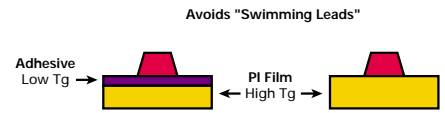
With any cellular phone it becomes readily evident that space and weight are at a premi-



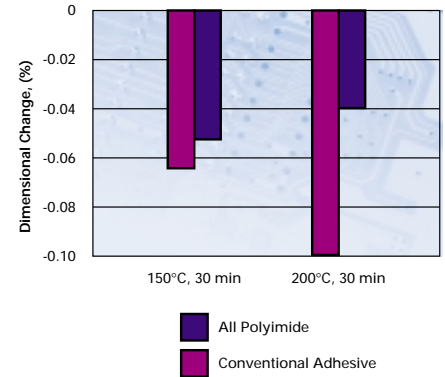
Thermal Stability (Peel Strength at Elevated Temperature)



Thermal Stability (Peel Strength After Thermal Storage)



Stable dielectric for COF, F/C or ACF Processes



Thermal Stability (Film Stability After Thermal Treatment)

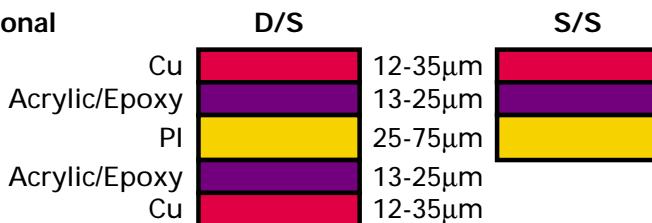
um. The cell phone's drive flex is no exception. Today's typical circuit is folded over in back of the LCD so the flex must be thin, light weight and low in modulus, all to allow for easy installation. All-Polyimide CCL, by eliminating either the epoxy or acrylic adhesives, provide up to 20-30% thinner circuit profile and lighter weight.

HIGHER PRODUCTIVITY AND YIELD (COF), WIRE BONDING, FLIP CHIP AND ANISOTROPIC CONDUCTIVE FILM (ACF)

All of these processes require the properties of thermal stability and retention of high peel strength after multiple thermal cycles. High peel strength after thermal values improves circuit reliability. Conventional CCL do not hold up under high temperature resulting in poor peel strength and yields. All-Polyimide CCL has excellent thermal stability.

Thermal stability at elevated temperature also plays an important roll in processes like wire bonding, Flip Chip bonding and ACF. The short elevated temperatures can cause traces to lift with conventional adhesive based clads. All-Polyimide Flex CCL fine circuit traces stay put and do not swim or deform during high speed, high temperature processes avoiding swimming leads.

3 Layer-Conventional



2 Layer-Adhesive/All Polyimide



Total CCL Construction Thickness Comparison

Property to be tested	AP1	AP2	AP3	Test Method
AR	7.0	8.0	8.0	IPC-TM-650,2.4.9
AS	6.3	5.0	8.0	IPC-TM-650,2.4.9
Solder Float Resistance	Pass	Pass	Pass	IPC-TM-650,2.4.13
Dimensional Stability				
After Etch %	-0.03	-0.04	-0.03	IPC-TM-650,2.2.4 B
After Thermal %	-0.04	-0.04	-0.03	IPC-TM-650,2.2.4 C
Dielectric Constant	3.5	3.4	3.3	IPC-TM-650,2.5.23
Dissipation Factor	0.007	0.005	0.003	IPC-TM-650,2.5.23
Volume Resistivity Ohm	1 x 10 ¹⁶	1 x 10 ¹⁷	1 x 10 ¹⁶	IPC-TM-650,2.5.17
Surface Resistivity Ohm	1 x 10 ¹⁴	1 x 10 ¹⁷	1 x 10 ¹⁶	IPC-TM-650,2.5.17
M&IR Ohm	1 x 10 ¹²	1 x 10 ¹¹	1 x 10 ¹¹	IPC-TM-650,2.6.3.2
Dielectric Strength Volts/mil	5400	6000	6500	ASTM-D-149

Typical AP Properties

MINIATURIZATION AND DESIGN FLEXIBILITY

Designers and fabricators are looking for a combination of all the previous properties plus lower moisture absorption, which improves dimensional stability. All-Polyimide CCL is the clear choice. Even after all of the high temperature processes All polyimide CCL still keeps its shape.

OTHER IMPORTANT PROPERTIES FOR CONSIDERATION

Property	All Polyimide	Conventional
Moisture Absorption	1%	3%
CHE, ppm/%RH	10	20
Modulus, kpsi	700 – 1100	690
Elongation, %	25 – 50%	50%

SUMMARY

All-Polyimide laminates offer the thinnest constructions delivering weight and overall thickness reduction required for today's smallest handheld devices. All polyimide laminates are halogen free, environmentally friendly and tailored for the stringent demands of the consumer display market.

REFERENCES

1. "Electric Components Report 1999/2000," Chunichi Co.
2. H. Tanji and K. D. Roberts, "Advances in All-Polyimide Flexible Laminates for Fine Pitch Consumer Electronic Applications," Taiwan Printed Circuits Association, Nov. 2000.