Low moisture absorptive polyimide and the application

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<Introduction>

As electrical appliances are becoming smaller, the demand of flexible print circuit(FPC) is continuously increasing, which enables to fold the circuit board and then to save space[1]. Polyimide film is often used as FPC application because of its high heat-resistance, electrical insulation, and folding endurance. About 70% of polyimide film is applied as FPC use and the demand of polyimide film for FPC application is expected to grow at the rate of 10%/year [2].

<Low moisture absorptive polyimide>

These days, the pitch of circuit on FPC is becoming increasingly fine, and in the view of dimensional stability and electrical insulation, low moisture absorption and low coefficient of humidity expansion (CHE) are required for polyimide film in addition to its original properties (high tensile strength, high tensile modulus low coefficient of thermal expansion(CTE),etc.). In processing FPC, polyimide film is handled under the various humidity conditions. Therefore, without high dimensional stability, several problems as follows may occur:

(1) Low accuracy in making fine patterns
(2) Gap between electrical parts and the circuit based on polyimide film caused by the dimensional change of the polyimide film due to the variation of humidity
(3) Void in soldering(lead-free)
(4) Important electrical properties of FPC are easily influenced by its moisture absorption.

So far, the attention have been paid to the dimensional stability caused by the heat exposure during the process. However, as even higher accuracy is demanded nowadays, the dimensional change caused by humidity expansion should not be neglected. In addition, moisture absorption itself affects the properties of FPC.

Considering the problems mentioned above, low moisture absorption and low CHE are becoming essential for the FPC applications. Polyimide shows relatively high moisture absorption among plastic films because of the polarization of imide group(table 1).Therefore, materials such as Liquid Crystal Polymer(LCP) which shows lower moisture absorption than polyimide, are getting attention[3].

Table 1. Moisture Absorption of various plastic films.[4)]

Plastic Film	Moisture Absorption / % (23℃, 24 hr, ASTM D570)
PPS	0.02
PET	<0.8
PEEK	0.14
PC	0.35
PI	2.9
Nylon6	9.5
PVA	80

In order to control the moisture absorption of polyimide film, the following techniques are conventionally proposed:

(1) to decrease the content of imide group which shows high polarization

(2) to introduce the hydrophobic group [5)6)]

(3) to decrease the polarization of polyimide main chain

In order to apply polyimide film to the FPC use, it is necessary to apply the techniques mentioned above and to design molecules appropriately, taking cost into consideration. And the quality must be designed to minimize the dimensional change caused by several stress on materials. In this report, we showed the trends of the technology and the market of low moisture absorptive polyimide.

<Application of low-absorption polyimide>

Copper Clad Laminates(CCL) which is used in Chip On Flex(COF) for IC drivers of liquid crystal display and folding hinge used in mobile phones are changing from conventional three-layer CCL (polyimide film/ epoxy adhesive/ copper foil) to two-layer CCL (adhesiveless : polyimide/ copper foil).

Two-layer CCL is mainly divided into three types: 1) by casting; polyimide formed on copper foil; 2) by lamination; thermal plastic polyimide formed on either or both sides of polyimide film, and after that, laminated with copper foil; and 3) by plating; metal-seed layer formed by spattering or electroless plating on polyimide film, and after that, plated copper layer. The two-layer CCL indicates high reliability compared with the three-layer CCL in use of FPC, because it consists of polyimide and copper layer .

The companies which supply polyimide film make efforts to develop the two-layer CCL with low moisture absorption. So far, polyimide film with about 1% moisture absorption rate and 10ppm coefficient of humidity expansion(CHE) is supplied for practical use.

The development status of polyimide materials for two-layer CCL with low moisture absorption and their application are described.

Table 2. Properties of general-purpose polyimide films (Apical AH and NPI) and the polyimide film with low moisture absorption (Apical HP).

Properties	Apical 25AH	Apical 25NPI	**Apical 25HP**	Conditions	Methods
Coefficient of Thermal Expansion/ppm	32	16	**11**	100～200℃	TMA
Moisture Absorption/%	2.5	2.5	**1.2**	D24/20	ASTM D570
Coefficient of thermal Absorption/ppm	14	14	**7**	50℃,30-90%	HMA
Tensile Strength/MPa	280	304	**350**	20℃	ASTM D882
Tensile Modulus/GPa	3.2	4.1	**6.0**	20℃	ASTM D882
Elongation/%	100	90	**40**	20℃	ASTM D882
Volume Resistivity/Ω·cm	$>10^{15}$	$>10^{15}$	**$>10^{15}$**	20℃	ASTM D257
Dielectric Constant/ -	3.2	3.2	**3.2**	20℃,1 MHz	IPC-TM-650
Dielectric Breakdown Voltage/ $V \cdot \mu m^{-1}$	320	320	**320**	20℃,60 Hz	ASTM D149

<Conclusion>

In this report, polyimide film for FPC application is mentioned. It is predicted that the demand of mobile appliances such as mobile phone continues to increase and FPC would be required more fine pitch. Therefore, high dimensional stability, transition feature in high frequency and surface mountability will be required for FPC. At the same time, the properties of polyimide film should be almost independent of the variety of environment, and even lower moisture absorption will also be required. We, as one of the polyimide film suppliers, would respond to the trend of technology and contribute to the development of electrical and electronic machines.

<Reference>

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