560 ton/Japan
160 ton/U.S.

N7989 [illegible]
FPC 600 400

CURRENT ACTIVITIES OF POLYIMIDES ITS MARKET AND TECHNOLOGY

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Abstract:

Polyimide market has achieved remarkable growth in recent years. This remarkable growth mainly depends on the Flexible Printed Circuits Boards(FPC) markets . Recently demands for the fine pattern FPC are increasing, so dimensional stable polyimide film becomes important. In this presentation, the mechanism of dimensional changes in the FPC manufacturing process are discussed. In this several years, there is a new movement. The application of thermoplastic polyimide is increasing. In this presentation, as an example of thermoplastic polyimides, we will introduce KANEKA PIXEO^{TM}.

1. Introduction

1.1 The market activities of polyimide films

In the US market and Europe markets, main application of polyimide films are insulation for motor or magnet wire cable. In the Japanese and Asian market, FPC is a main application of polyimide film.

The application of FPC has been changing in these 20～30years, in 1970's FPC is mainly used for parts of cameras, in 1980's used for parts of video cameras, and 1990's application for computer is noticeably increasing.

According to this change of application of FPC, the demands for fine pattern FPC is increasing. The demands to polyimides films have been changing, too. Recently, the dimensional stability becomes an important character for polyimide films

1.2 Thermoplastic polyimides KANEKA PIXEO^{TM}

As mentioned above, FPC have been increasing their thermal resistance and electrical reliability during the past two decades. For these increased demands in FPC applications, higher heat resistance and lower ionic impurities containing adhesives instead of a variety of conventional non-polyimide thermosetting adhesives, such as acrylics, epoxies, and phenolics, have been strongly needed. It has been recognized that polyimide adhesives meet the needs of this on-going trend.

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KANEKA PIXEO™ has been successfully developed as thermoplastic polyimide hot-melt adhesives aimed at the heat resistant usage of FPCs. In this presentation, newly developed polyimide adhesives; PIXEO™ thermoplastic polyimide adhesive will be discussed along with properties of some of application form.

2. Discussion

2.1 Dimensional stability of FPC

Figure 1 shows an example of FPC manufacturing process and the dimensional change in the process. Polyimide film and copper foil are exposed to the high temperature and the highly humidity condition. And with the purpose of adopting a continuous process, polyimide film and copper foil are exposed to the high tensions.

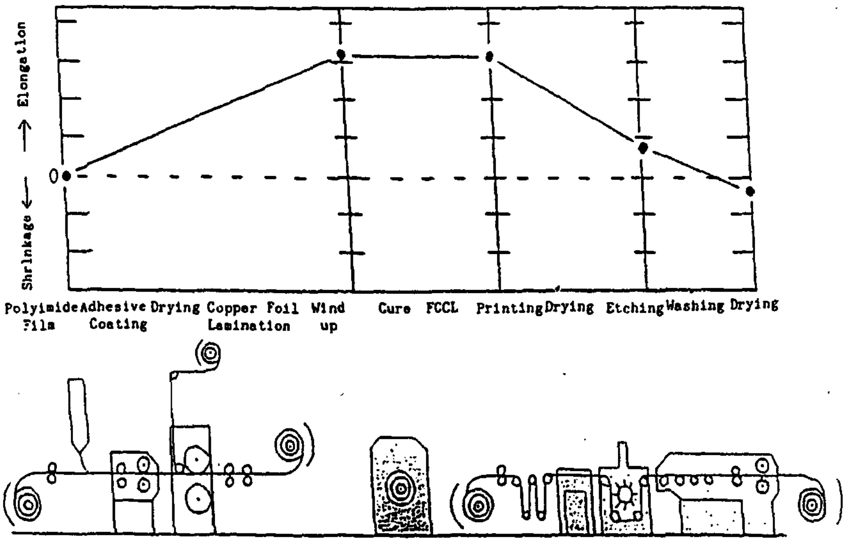

Figure 1 Schematic FPC manufacturing process flow(Dimensional change during FPC process)

Figure 2 shows the calculation model for dimensional change of polyimide film and copper foil. The difference in the degree of dimensional change of polyimide film and copper foil makes the manufacture of fine pattern FPC difficult.

Two points of following are important to make a manufacture of fine pattern FPC possible. The first point is related to the mechanical properties of polyimide films. It's important to design the properties of polyiide films similar to the copper foil. The second point is related to the processing condition of laminating of polyimide films and copper foils. It's important to set a laminating process conditions low temperature and low tension.

$$\text{Dimensional change (MD)} = -\left[+\left(\frac{1}{Ef}-\frac{1}{Ec}\right)\sigma + (\alpha f-\alpha c)\Delta T + (af-ac)P\right]$$

$$= -\left[+\frac{\sigma}{Ef} + (\alpha f-\alpha c)\Delta T + af\boxed{P}\right]$$

$$\text{Dimensional change(TD)} = -\left[-\left(\frac{\gamma f}{Ef}-\frac{\gamma c}{Ec}\right)\sigma + (\alpha f-\alpha c)\Delta T + (af-ac)P\right]$$

$$= -\left[-\frac{\gamma f\sigma}{Ef} + (\alpha f-\alpha c)\Delta T + afP\right]$$

Abbreviation: (Material properties)E: modulus, α: thermal expansion/℃, a: coefficient of compression, γ: Poisson ratio, f: film, c: copper

(Processing conditions) σ: tension, ΔT: temperature, P: pressure

Laminate temp

Figure 2 Model of dimensional stability of FPC

2.2 Novel thermoplastic polyimide KANEKA PIXEO™ and it's properties

Generally, thermoplastic polyimide films are prepared by curing polyamic acid film formed after coating polyamic acid varnish on PET film. PIXEO™ has been successfully prepared by chemical or thermal imidization and can be provided as a film with a thickness of 0.5mil to 4mil. It has controlled bulk physical, chemical, and mechanical properties. Multiple layer construction film, combinations of core/base layers with thermoplastic layers made by a thermal lamination technique are also available. This allows control of properties such as thermal expansion coefficient (CTE) and high dimensional stability. PIXEO™ shows excellent properties as a thermoplastic polyimide film. Table 1 summarizes various properties of PIXEO™. PIXEO™ has three Tg variations of TP-D, TP-T, and TP-E with 151° C, 190° C, and 225° C, respectively. Each variant shows softening behavior around Tg+100° C, but film integrity is well maintained over 400° C, well above Tg. In addition, PIXEO™ maintains high initial polymer decomposition temperature of 460° C to 500° C, tensile modulus of 2GPa, tensile strength of 93 to 121MPa, elongation at a break of 60 to 83%, and CTE of 49ppm to 51ppm(20° C to 100° C). Electrical properties such as volume resistance and dielectric constant are almost the same as those of conventional polyimide films(i.e., APICAL™, KAPTON™, and UPILEX™). PIXEO™, however, shows very low water absorption of 0.4 to 0.5% and very low ionic impurity levels of 0.1 to 0.2mg/l, respectively. It is assumed that these typical properties are caused by the very unique molecular design of the polymer chemical structure, which will be briefly discussed in this presentation.

PIXEO^{TM} adheres with various materials such as copper, steel, silicon wafer, aluminum, and polyimide film. The adhesive strength at different temperature by using copper foil and each of three PIXEO^{TM} films as an adhesive layer was evaluated. PIXEO^{TM} showed good adhesive strength with copper foil (for example, electrodeposited; ED, roughened side). Adhesive behavior with various materials will be also mentioned in this presentation.

Table 1 Summary of KANEKA PIXEO^{TM} Properties.

Items	Units	KANEKA PIXEO^{TM} Grades			Conditions	Methods
		TP-D	TP-T	TP-E		
Tg	°C	151	190	225		DMA
Td	°C	460	490	500	in N_2	TGA
CTE	ppm	51 78	51 70	49 65	20 to 100° C 100° C to Tg	TMA
Thermal Conductivity	cal/cms° C	6×10^{-4}	6×10^{-4}	6×10^{-4}		
Water Absorption	%	0.5	0.3	0.4		ASTM D570
Ionic Impurities Na^+	mg/l	0.2	0.2	0.2	Sample10g	ICP
K^+		0.1	0.2	0.1	Water100g	ICP
Cl^-		0.1	0.1	0.1	PCT-96/121	Ion chromato.
Tensile Strength	MPa	93	102	121	20° C	ASTM D882
Tensile Modulus	GPa	2.1	2.2	2.3	20° C	ASTM D882
Elongation at a break	%	62	83	60	20° C	ASTM D882
Volume Resistively	Ω-cm	$>10^{15}$	$>10^{15}$	$>10^{15}$	20° C	ASTM D257
ε	-	2.9	2.9	2.9	20° C, 1MHz	IPC-TM-650
tan δ	-	0.008	0.008	0.008	20° C, 1MHz	IPC-TM-650

3. Conclusion

31 The market activities of polyimide films

To make the manufacture of fine pattern FPC possible.

(1)To design the property of polyimide films similar to the copper foils

(2)To set a laminating process conditions; low temperature and low tension.

3.2 Thermoplastic polyimides KANEKA PIXEO^{TM}

PIXEO^{TM} thermoplastic polyimide adhesive film was developed with various characteristics mentioned below.

(1)PIXEO^{TM} showed combinations of properties such as very low water absorption and good mechanical properties.

(2)PIXEO^{TM} can be chosen based on the required the lamination temperature due to having of Tg variation.