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Preparation, Properties, and Application of Siloxane-Imide Block Copolymers

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Introduction

Many kinds of polyimides have been developed and used for microelectronic and aerospace applications as films, dielectric interlayer, and adhesives due to their excellent thermal, mechanical, and electrical properties. These polyimides, however, are generally insoluble and intractable in their fully imidized form, so that they show low processability. Therefore, soluble and processable polyimides have also been developed. On the other hand, polydimethylsiloxane (silicone) are well known as useful polymeric materials possessing many distinguished properties such as solubility, thermal and oxidative stability, dielectric behavior, surface properties, adhesion, gas permeability, and so on. In the last decade, several kinds of copolyimides containing polysiloxane (PSX) moiety have been developed in order to improve the properties of aromatic polyimides. Among the copolyimides, siloxane-imide block copolymers (SPIs) are generally soluble and processable polyimides and show thermoplasticity, which possess the superior properties of both polyimides and silicone.

Preparation

SPIs are prepared by the incorporation of polysiloxane oligomeric segments into a polymer backbone. Aromatic dianhydride, aromatic diamine and diaminopolysiloxane are reacted in organic solvents such as NMP or DMAc to yield polyamic acid containing SPX followed by thermal or solution imidization to afford SPI. The general preparation method of SPIs is shown in Fig.1.

Properties

SPIs consist of a microphase separated structure of imide phase and siloxane phase, and the properties of SPIs are controlled by the molecular weight and the content of PSX incorporated. The solubility of SPIs is improved by the introduction of PSX segments into the polymer backbone. The tensile strength and modulus are decreased and the coefficient of thermal expansion is increased with the increase of PSX content in the SPIs. When SPIs are coated onto silicon wafer, the residual stress on the silicon wafer is greatly reduced, which means the SPIs show the stress relaxation properties. The adhesion of SPIs is improved by PSX incorporation. The lap shear bond strength of SPIs is tremendously increased with increasing the content of PSX up to 10 wt%. SPIs show thermoplasticity, so that SPIs can be easily processed by hot press at comparatively low temperature. The gas permeability of SPIs is increased with increasing the PSX content of the polymer. The sorption behavior of SPIs is interpreted in terms of a dual-mode sorption theory. The gas separation properties of SPIs can be controlled by the structure and the content of SPIs.

Conclusion

SPIs are useful for coatings, adhesives and gas separation membranes due to the improved properties such as the stress relaxation properties by low modulus, low water uptakes, good electrical properties, good adhesive properties, and gas separation properties.

Application

Microelectronics / Adhesives / Gas separation membranes

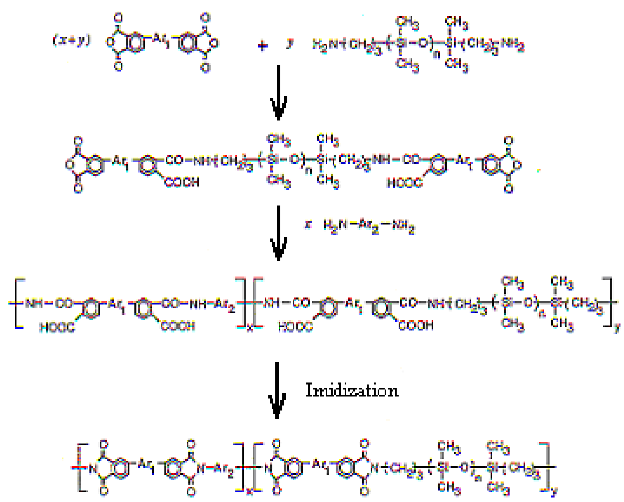

Fig. 1 Preparation of siloxane-imide block copolymers

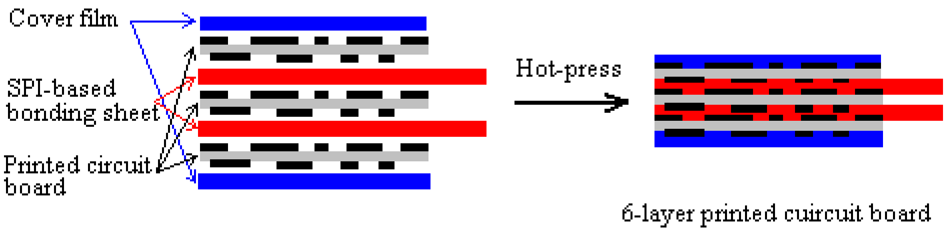

Fig.2 Application of SPI for multi-layer printed circuit board

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