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임프린트 공법적용을 위한 절연재료의 열적, 기계적 성질

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Thermal stabilities and dynamic mechanical properties of dielectric materials for thermal imprint lithography

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Abstract: Recently, imprint lithography have received significant attention due to an alternative technology for photolithography on high performance microelectronic devices. In this work, we investigated thermal stabilities and dynamic mechanical properties of dielectric materials for thermal imprint lithography. Curing behaviours, thermal stabilities, and dynamic mechanical properties of the dielectric materials cured with various curing agent and spherical filler were studied using dynamic differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), rheometer and universal test machine(UTM)

Key Words : Epoxy, Dielectrics, Imprint

Introduction

Increasingly complex tasks are performed by computers or cellular phone, requiring more and more memory capacity as well as faster and faster processing speeds. This leads to a constant need to develop more highly integrated circuit systems. Therefore, there have been numerous studies by many engineers investigating circuit patterning. In particular, PCB including module/package substrates such as FCB (Flip Chip Board) has been developed toward being low profile, low power and multi-functionalized due to the demands on miniaturization, increasing functional density of the boards and higher performances of the electric devices [1]. Imprint lithography have received significant attention due to an alternative technology for photolithography on such devices. The imprint technique [2]-[6] is one of promising candidates, especially due to the fact that the expected resolution limits are far beyond the requirements of the PCB industry in the near future. For applying imprint lithography to FCB, it is very important to control thermal properties and mechanical properties of dielectric materials. These properties are very dependent on epoxy resin, curing agent, accelerator, filler and curing degree(%) of dielectric materials. In this work, the epoxy composites filled with silica fillers and cured with various accelerators having various curing degree(%) were prepared. The characterization of the thermal and mechanical properties was performed by thermal mechanical analysis (TMA), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), rheometer, an universal test machine (UTM).

Experimental

Materials DGEBA (commercial name: YD-011) with an epoxide equivalent weight (EEW) of 475g, Phenol novolac type epoxy (commercial name: YDPN-638) with EEW of 180g, Cresol novolac type epoxy (commercial name: YDCN-500-10P) with EEW of 206g, and Non-halogen flame retardant epoxy (commercial name: KDP-550) with EEW of 590g was supplied by Kuk Do Chemical Co., Ltd., Korea. The curing agent of phenol novolac (commercial name: TD-2090) with EEW 105 was supplied by Kang Nam Chemical Co., Ltd., Korea. The imidazol type accelerator was supplied by shikoku chemicals Co., Ltd Japan. The fillers used (Admatechs Co., Ltd.) were spherical type silica (SiO2) which treated with silane coupling agent prior to improve dispersion in epoxy and solvent systems

Blending The epoxy resins were mixed with stoichiometric amount of curing agent(TD-2090) in 2-methoxy ethanol. The mixture is heated in flaske at 90℃. After mixing for 3hr, the mixture was cooled to room temperature. And the accelerator was added. The mixture was completely mixed by a mechanical stirrer for 30min and degassed in a machine to eliminate air bubbles before film casting.

Sample preparation The preparation of the specimens for thermal and mechanical tests was as follows: bubble-free mixtures were casted on PET film and cured at 90℃ for 30min and at 180℃ for 90min in a vaccum press.

Characterization The mechanical properties of the dielectric materials were determined in terms of the young's modulus, tensile strength and elongation. In order to understand imprinting mechanism of the epoxy resins, the rheological behaviors such as viscosity changes at elevated temperature and time of the epoxy resins were observed using rheometer (ARES, TA, USA). The width, space and depth of stamp and imprinted patterns were measured using SEM (S3000N, Hitachi, Japan) and optical microscope (BX-51M, Olympus, Japan).

Results and discussion

Fig. 1 shows the obtained young's modulus values of the systems for different content of spherical type filler up to 30wt%. The young's modulus of the systems are increased with increasing the filler content.

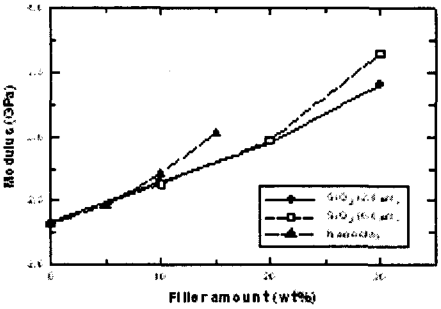

Figure 1. Young's modulus of the systems with increasing the filler content.

Also, the viscosity values of the system for different content of accelerator was investigated. The viscosities of the systems are increased with increasing the accelerator content.

The temperature is very important factor in imprinting process. It should be high enough for resin to flow into the gap of the stamp. It should be not also too high, since as shown in Fig. 1, time to reach the minimum viscosity value is getting shorter at higher temperature. In other words, when the temperature is too high, curing reaction would complete rapidly before resin fill the gap of the stamp. In this work sheet type epoxy resins were imprinted at two different temperatures; at lower temperature resins filled the gap then were cured at higher temperature. Imprinting template and sheet type epoxy resin are loaded and vacuumed in the loading chamber then the loading chamber is heated up to 100 °C then 5 MPa of pressure is applied. Softening process begins and the mobility of resins is increased during this step. Epoxy resin becomes softened and flows to fill the gap of the stamp. After imprinting, temperature increases to 180 °C and holds for 90 min in order to harden the imprinted epoxy pattern. 5 MPa of imprinting pressure is maintained during hardening to avoid possible degradation of pattern.

Conclusions

Mechanical properties of system for different content of spherical type filler and different material composition were investigatied. The young's modulus of the systems are increased with increasing the filler content And the viscosity values of the system for different content of accelerator was investigated. The viscosities of the systems are increased with increasing the accelerator content. Thermal imprinting method for thermo-set materials was developed for micro patterning on PCB. Polymer stamp patterns with the feature size ranging from 10 μm to 60 μm were successfully transferred into epoxy thermo-set resin with high fidelity. After imprinting at 100 °C, the imprinted resin was heated to 180 °C for curing.

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