EFFECT OF THERMAL CURING ON STRESS IN RODLIKE POLYIMIDE FILMS FORMED ON A SUBSTRATE

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When microelectronic devices such as semiconductor chips and multichip modules are made by the use of polyimide films, the thermal stress is generated by the thermal coefficient of expansion (TCE) mismatch between the polyimide and substrate through thermal cycles. Some polyimide films with rodlike molecular skeletons have TCEs as small as silicon or ceramics. [1] It can be expected that the thermal stress in the device should be minimized by the use of these low TCE polyimide films. However, it was shown that the thermal stress of poly(*p*-phenylene biphenyltetracarboximide) (BPDA/PDA polyimide) film, which had a typical rodlike molecular skeleton as shown in Fig.1, cured on a silicon substrate changed with film thickness.[2] This stress change resulted from the fact that the TCE increased with increasing film thickness. The TCE increase must be attributed to the decrease in the degree of in-plane orientation.

In this study, the effect of the thermal curing on the stress in BPDA/PDA polyimide films formed on a silicon substrate was investigated. The solution of BPDA/PDA poly(amic acid) in 1-methyl-2-pyrrolidinone (NMP) was spin coated onto the silicon wafer pretreated with an aminosilane. After the

Fig.1 Molecular structure of BPDA/PDA polyimide.

wafer had been dried on a hot plate at 80 °C for 30 min, it was placed in a stress measuring apparatus (F2300, Flexus) and heated at 80 °C for 30 min in a nitrogen atmosphere. The wafer in the nitrogen atmosphere was then heated to 400 °C at several different incremental rates, held at 400 °C for 30 min, and then cooled to 25 °C.

Fig.2 Stress in the BPDA/PDA polyimide film at 25 °C vs heating rate. The number beside the symbol shows the film thickness.

Figure 2 shows the relationship between the stress after the curing cycle and heating rate. The stress in the film increased with increasing heating rate. Here the dependence of the stress on the heating rate was larger for the 26- μm thick film than for the 10- μm thick film. The rate of evaporation of the residual NMP in the poly(amic acid) film relative to the rate of imidization decreases with increasing heating rate.[3] Moreover, the rate of evaporation of the residual NMP decreases with increasing film thickness due to the decreasing surface-to-volume ratio. Since the degree of the film stretch by the volume shrinkage which accompanies the NMP evaporation during the process of imidization decreases, the degree of in-plane orientation decreases with increasing heating rate and film thickness. Therefore, the stress related to the TCE in the BPDA/PDA film is dependent on the rate of heating.

References

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