Low-Temperature Curable Positive-Tone Photosensitive Dielectric Materials

Akitoshi Tanimoto Yu Aoki Mika Kimura Sangchul Li Mamoru Sasaki

Photosensitive Materials R&D dept.,
Electronics-related Materials Development Center,
R&D Headquarters

1 Abstract

Recently, packages for semiconductors with a redistribution layer (RDL), such as fan-out wafer level packages (FOWLPs), have been developed to achieve downsizing; increasing the pin count and lowering cost. Dielectric materials used for FOWLPs are needing to meet requirements such as low warpage, high reliability and adhesion strength for metals used as RDL. We developed low-temperature curable positive tone dielectric material AH series for FOWLPs. The AH-3000 has low residual stress to reduce substrate warpage, as well as high tensile strength and low CTE for more reliable FOWLPs.

2 Characteristics

- Low residual stress contributes to the reduction in the substrate warpage.
- High resolution is suitable for the refinement of redistributed wiring.
- High thermal-cycle resistance and high-temperature-storage durability improve reliability of devices.

3 Background of the Development

Recently FOWLP (**Figure 1**) has attracted attention with capability of many I/O pins by redistribution of bump position which could expand beyond the chip area. Since redistribution layer is formed after molding, materials for FOWLP are required to have a variety of characteristics, such as low-temperature curability, low residual stress, thermal cycle resistance, and adhesion to copper. We promoted the research and development of positive-tone photosensitive materials as dielectric materials for redistribution layers and launched AH-1170.[1)] Since this product shows low stress and has excellent adhesion strength to copper, it is applied as redistribution layer of FOWLP.

In recent years, an increase of the number of redistribution layers to increase more pin counts, even lower stress and more thermal-cycle resistance are required.

We improved thermal stability of the base resin to increase thermal cycle resistance.

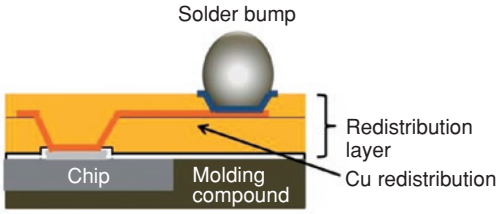


Figure 1 The FOWLP structure

4 Technical Details

The properties of the AH series are shown in **Table 1**. AH-3000 has even lower residual stress and can be expected to relieve warpage in a multilayer redistribution structure. In addition, the resolution of AH-3000 has been improved. **Figure 2** shows the cross-sectional shape of patterns after curing. The pattern shape of the cured AH-3000 can be controlled by ramp-up conditions during cure process. Therefore, AH-3000 can be used for various structures such as through-silicone via and bumps.

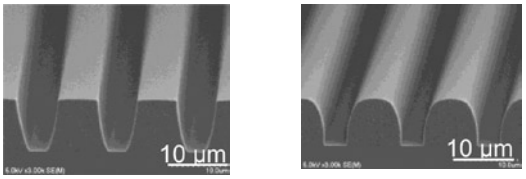
Moreover, AH-3000 shows high thermal cycle resistance by its improved tensile strength and reduced CTE. Mechanical properties after thermal cycle testing and high temperature/high humidity tests are shown in **Table 2**. The mechanical properties of AH-3000 were not deteriorated by the thermal cycle test or the high temperature/high humidity test and maintained its initial properties.

Thus, AH-3000 has excellent photosensitive characteristics and high reliability. It is suitable for redistribution layer of FOWLP.

Table 1 General Properties of the AH Series

Item	Unit	AH-1170	AH-3000
Tone	—	Positive	Positive
Film thickness	μm	2～20	2～35
Exposure dose*	mJ/cm^2	400	440
Resolution*	μm	10	3
Curing temperature	℃	180～240	←
Glass transition temperature	℃	> 200	> 200
Young modulus	GPa	2.0	2.3
Elongation	%	50	50
Tensile strength	MPa	115	147
CTE	ppm/K	58	45
Residual stress	MPa	20	16

*Film thickness after curing: 10 μm



Rectangular Smooth

Figure 2 Cross-section of the cured AH-3000 (10μm[1])

Table 2 Mechanical properties of the AH-3000 after the reliability test

Item	Unit	Initial	After thermal cycle test*	After high temperature/ high humidity tests*
Tensile strength	MPa	147	147	147
Elongation	%	50	49	50
Young modulus	GPa	2.3	2.3	2.3

*−65℃ to 150℃ for 200 cycles

5 Future Business Development

・Development of dielectric materials which is curable at even lower temperatures

【Reference】

1) A. Tanimoto, S. Nobe, H. Matsutani, Abstract of 15th The Symposium on Polymers for Microelectronics, 2012, 12.