Development of Heat-resisted Polymer for Magnetic Powder Coating

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1 Abstract

Recently, soft magnetic composites (SMC) have been developed as magnetic parts for high performance motors and actuators utilized in the wide field of automotive and industry. Previously, we developed several resins and inorganic materials[1-2] as binders for SMC which can make them heat-resistant. Furthermore, these kinds of binder materials will be widely used in near future, not only for soft magnetic materials, SMC and bonded magnet, but also for hard magnetic materials used under tougher conditions.

Accordingly, it will be needed for binder resins of magnetic resins that the functional properties should be improved in heat- and weather-resistance than ever before.

In this report, we describe the further development of the heat-resistant binder resin acquired in our development of epoxy molding compounds for semiconductor packages, which can give the optimized properties, especially higher mechanical strength of green compacts, even under higher temperature more than 150°C.

2 Key Product Features

- Significantly improved heat resistance of cured resins by optimizing the compounding ratio of thermoset resins, and the selecting the hardening accelerator.
- Molded and cured magnetic core made of magnetic powder coated with our binder resins showed superior mechanical strength in the range of higher-temperature more than 150°C.

3 Development Background

For many years, we have been engaged in developing solid epoxy encapsulation materials for electronics components and in-house technologies for curing behavior and cured products, which were accumulated during their development processes. By replacing fillers with magnetic powders, we assumed that these technologies in their current form could be applicable to binder materials capable of boosting magnetic component performance.

In general, resin-bonded magnets include injection-molded magnets, which show superior productivity and corrosion resistance and in which Nylon and PPS [Polyphenylenesulfide] are often used as binder resins for them. However, issues of compressibility and dimensional stability remain pending. Conversely, compression-molded magnets, which show excellent compressibility and magnetic property, are drawing attention under current circumstances amid soaring demand for high performance magnets. Widely used and well-known, conventional, epoxy resins have often been used as binder resins for manufacturing of compression-molded magnets, but room for improvement remained in various aspects of performance, including dimensional stability, heat resistance and corrosion resistance. Developing compression-molded magnets at our company could be traced back to our developmental work on material compositions as we were in a position to be able to develop binder resin coating technology for magnetic powder and molding technology comprehensively. In this development, we engaged in a thorough examination of traditional binder resins and finally developed a new resin composition “HC-Re01”, which shows no decline in mechanical strength, even at a temperature range beyond 150°C and good operability, by taking into account material performance issues derived from tests relevant to operability during coating, cured condition and thermal decomposition behavior.

There are a few performance requirements for binder resin coated on the surface of magnetic powder, including no unwanted progression of curing reactions within the powder handling temperature range, effective mold-releasing characteristics after the compression molding of magnetic powder, short curing time of green compacts and cured them with high mechanical strength.

We designed the composition of epoxy-based thermoset resins to meet these performance characteristics as mentioned above, the design concept for which is indicated as follows:

4 Product Design

Binder resins for cured green compacts with high mechanical strength

To achieve cured green compact with sufficient strength (as crushing strength), even at temperatures of 150°C or more, cured epoxy resins with a higher glass transition temperature will be required. To do so, the greater the branching degree and the more functional groups exist on a molecular level (i.e. the more reactive sites per molecule), the more favorable the selection of epoxy resin and hardener (curing resin) becomes. If so, when these resins react sufficiently on a molecular level, they can give highly cross-linked cured green compacts to generate mechanically strong them. It is also important for these resins to rapidly kick-start reactions in the curing process (heating step) and complete the curing reactions to the full extent. In fact, even if the resin composition is optimized but the cross-linking reaction has not progressed sufficiently, a cured green compact of sufficient expected strength cannot be produced due to incomplete cross-linking. In other words, to have a complete curing process (cross-linking reaction), the resin system should be kept unreactive until just before starting the curing process but rapidly activated once the curing process (heating step) started. Therefore, we thought that using hardening accelerators with so-called "thermal latent generation (a performance property to rapidly facilitate reactions above a certain temperature)" may be effective. Figure 1 shows schematic drawings of the molecular design concept for binder resins which we developed, while Figure 2 displays mechanical strength performance graphs of cured green compacts of magnetic powders applied to new binder resin.

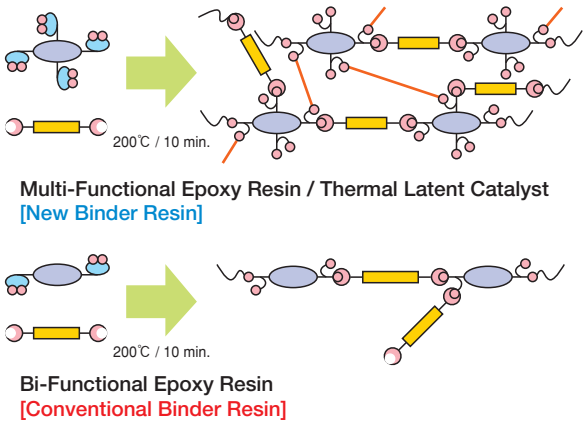

Figure 1 Designing of binder resin on the molecular level

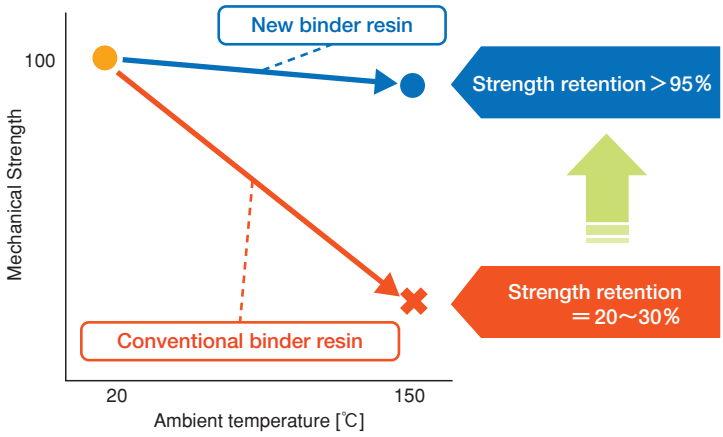

Figure 2 Strength property of cured green compact applied to new binder resin

As shown in Figure 2, the mechanical strength of the cured green compacts of magnetic powders using a new resin composition HC-Re01 is sufficiently retained in the high-temperature zone (near 150°C) where the cured green compact using conventional resin products would have rapidly lost mechanical strength. It was therefore verified that the cured green compacts of magnetic powders applied to new binder resin composite, HC-Re01, can show sufficient mechanical strength stability, even if used as magnetic components within a high-temperature environment.

5 Future Business Development

- Study on the applicability of binder resins of various magnetic powders.
- Sales expansion of various stators and rotor cores using our new binder resin, which is operable within a high temperature range.

[References]

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