B-Staged Epoxy

The term “b-stage” in relation to epoxy is not well defined, and, in fact, the term doesn’t exist in many dictionaries. It is widely used though and this paper seeks to clarify what it is and why it is important.

A typical epoxy assembly process is to blend the two parts (resin and hardener), deposit the liquid on a substrate, attach a second part, and immediately cure with time and / or heat. But in many cases it may be beneficial to separate the blending / depositing process from the curing process. This could be driven by in-plant logistics, or the need to run each process in separate facilities with specialized capabilities, or even the desire to process at different companies. B-stage epoxies enable this separation and play a unique role adding flexibility to the manufacturing process.

Most commonly, b-stage refers to an epoxy that has been heat cured for a short period of time and then cooled (quenched) to prevent complete polymerization of the resin system. At this point it is a solid that has been partially cured (typically less than 10%) and still available for bonding parts together. That is, it has been “staged” for convenience of an overall process. At some later point it is heated to reactivate polymerization and complete the curing cycle. As an alternative to partial heat curing, there are also systems designed for b-staging with exposure to UV light.

Another way to create a “b-stage” epoxy is to blend solid resins in a solvent carrier, preparing a homogeneous liquid slurry that can be coated on a surface. Most of the excess solvent is then evaporated at a temperature below the activation point of polymerization. This process creates a stable solid in the desired configuration, which can then be cured at a later time with exposure to heat. Technically, it has not been advanced and is arguably not a true b-stage epoxy, but form factor and subsequent processing are the same. An advantage of this approach is that the quenching process for stopping polymerization is avoided, thus eliminating a step with high variability.

B-staged epoxies are most commonly available in film form, either as rolls, sheets, or custom preforms. Suppliers can produce a b-staged epoxy film with a variety of coating techniques, all focused on producing very uniform product with well-controlled thickness. Solid epoxy films frequently have properties that cannot be achieved with conventional liquids. For example, a primary characteristic of liquid epoxies is their viscosity, which drives the dispense method by the end user. This frequently limits the amount of fill material that can be added, fundamentally limiting the electrical or thermal conductivity. While film production also has viscosity limits, the fill limits are generally higher and film products are found at the top end of electrically and thermally conductive epoxy product lists. The film preform pictured is an example of a highly silver filled product used in microwave board assembly. In addition, film adhesives can readily be obtained with mechanical support built in, such as fiberglass or carbon fibers.
A key advantage of b-stage epoxy film is the ability to precisely control both bond line thickness and placement location of the adhesive. Preform patterns are produced by die cutting, screen printing, or laser cutting. X,Y dimensional tolerances can vary from ±10 mils for die cutting to ±2 mils for laser cutting. The control of lasers has improved significantly in the last few years and a modern system will make preforms with no evidence of melting or charring.

A good example of b-stage epoxy usage is in seal lids for electronic packages. These lids require adhesive precisely placed around the outer edge for bonding to the top of the package sidewalls. This photo shows a seal lid preform that has been die cut from a sheet of 3 mil thick silver filled epoxy. In this case, the silver provides electrical conduction, enabling a fully grounded package. Deposition can be either with placement of a solid b-staged film that has been cut into a preform of the required dimensions or with a well controlled dispense system. In either case, a b-staged material often fits the assembly logistics better than a conventional adhesive. In fact, lid suppliers often provide lids pre-applied with b-staged epoxy, providing additional convenience and cost savings to the end user.

As mentioned, b-staged epoxy is commercially available in film form, either as bulk rolls, sheet stock, or custom preformed for the specific application. An advantage of epoxy in film form is that coating and cutting are done under well-controlled conditions, with equipment specifically designed to produce high quality films and custom preforms. This photo shows an assortment of preforms made from b-staged epoxies with different fillers.

In summary, a b-staged epoxy is a solid form of uncured epoxy. This solid state can significantly expand assembly options for the user, either through timing of process steps or handling of material. In addition, commercially available b-staged epoxies are available in a wide variety of film format options including both filled and unfilled products for establishing electrical and thermal properties and carrier options for mechanical and handling properties.