ARLON ELECTRONIC MATERIALS

APPLICATION NOTES

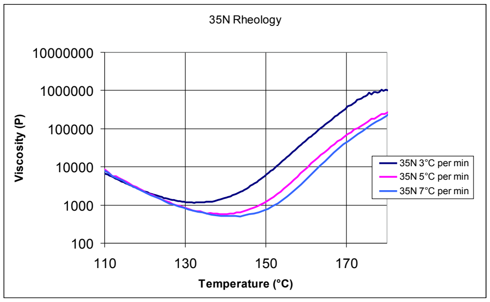
Low-Flow Prepregs – Defining the Beast!

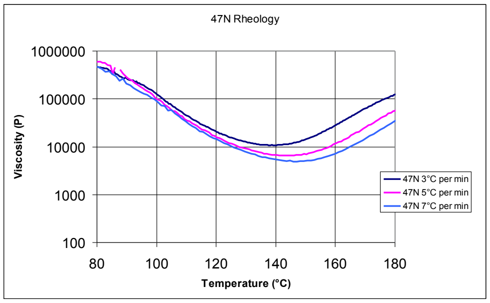
by Chet Guiles, Arlon 2013

One of my favorite authors once wrote about perception: “For now we see in a mirror, dimly…” speaking in an era when mirrors were at best polished metal surfaces. In the infancy of low flow products we used to speak about “No-Flow” prepregs as if “no-flow” was sufficient definition of the product, but as we have recently pointed out in our discussions of rheology, “Everything Flows,” and as we consider these increasingly essential but sometimes hard to define products, much consideration will have to be given to what the products need to do, how they do it, how we test them, what the testing means, and how or if the testing relates meaningfully to how the products work in a PWB rigid-flex production environment.

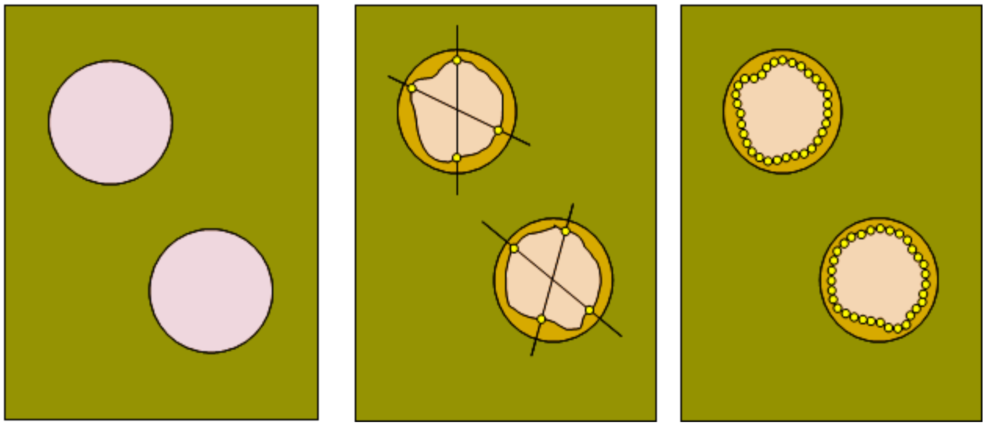
Let’s try to define “low flow” in terms that will make sense to both suppliers and users of the products. A “low flow” prepreg is a prepreg that flows sufficiently to wet out and adhere to bonding surfaces and to fill inner layer copper details, but that does not flow so much as to fill in cut-out areas in a heat-sink or run unevenly out of the interface between rigid and flexible elements of a rigid-flex PWB. That being said, how to define that flow quantitatively and to control it in such a way that the resulting product has wide applicability in a variety of PWB heat-sink and rigid-flex designs has been an issue with both producers and users of the products since the introduction of the concept. (My personal involvement in low flow materials began in the Early Mesozoic Period.)

How “low” is low flow compared to “normal prepregs? The charts identified as “35N Rheology” and “47N Rheology” are respectively a standard polyimide prepreg – 35N — (minimum viscosity about 800 poise at heatup rate 5°C/minute) and a standard epoxy low flow product, 47N – (minimum viscosity about 8000 poise at heatup rate of 5°C/minute). As you can see, the viscosity of the low flow product is about an order of magnitude higher than that of the full flow prepreg. Note also that as the heat-up rate is adjusted, the minimum viscosity of the low flow product behaves similar to that of a standard flow resin. As the heatup rate increases, the minimum melt viscosity is lower, and hence, the product will flow more, all other conditions being equal. If only it were practical to use a three temperature ramp rate test to characterize low flow products during manufacture! Instead, we have an IPC test procedure (IPC TM-650 2.3.17.2) that defines low flow in terms of average reduction of the diameter of a cut-out circle when the material is tested under “standard” conditions of temperature and pressure.





What this looks like is as follows. The sample involves three pieces of prepreg into which are punched two 1” diameter holes, as shown. After test, the resin has flowed into the circles (irregularly as shown in the middle diagram) and the average reduction in diameter of the circle as measured along several diameters is defined as the “flow. A typical low flow product may flow into the holes in a range of 0.030” to as much as 0.150” depending on the grade and type. Measuring this manually has proved to have a great deal of inherent variability (as much as +/- 30% of nominal!), so use of a computerized automated measurement system as is indicated by the test coupon on the far right has been developed in which 500 to 1000 individual measurements are taken



around the “diameter” of the flow bead and a statistical “best fit” circle is defined to determine the flow.

Although we have gotten something of a handle on the measurement method, the test itself remains somewhat variable, and correlation between test presses and between test facilities remains problematic. To be practical as a ‘real time manufacturing test, the test procedure needs to be able to be completed in a relatively few minutes. The quality of die punched holes in the prepreg is critical, since any damage to prepreg edges will result in irregular flow. The IPC method also results in unrealistically high heat-up rates (several hundred degrees F per minute!) and not unexpectedly, irregular flow. Users who employ test procedures based on normal PWB manufacturing processes with heat-up rates around 10°F/minute get better results, but the testing takes as long as a normal press cycle, far too long for a real-time prepreg manufacturing test. So what happens? We test using the IPC procedure. Many of our customers test in a realistic process simulation. And there is (Surprise, surprise!) often poor correlation and the potential for issues in terms of how and whether “specs” have been met.

One of the unintended consequences of test methods that relate only marginally to in-use parameters is that individual products (rather than generic slash sheet designations) become locked into processes because engineers and shop floor people become familiar with their use and make the necessary adjustments in pressure and temperature, prepreg cut-backs, etc. so that they will work with a variety of designs. They come to have the belief that the product itself is infinitely process-flexible, and so anything new seems never to work quite like “Product X.” Different products, even if they are “the same” according to IPC testing (remember, this is at several hundred degrees F/minute heat-up rate at 200 psi), do not necessarily “work” the same way in process and the only way to really get the best out of any low flow product is to work with it in your own process until you are sufficiently familiar with it to make it jump through hoops.

I’m sure there are a few “miracle” prepregs out there that have inherent organic bio-feedback loops that adapt flow and viscosity to the specific design being manufactured, but for the most part we in the business have to be constrained by the laws of chemistry and physics, the limitations of human-designed processes, and the constraints of “standard” testing. Doing “the best we can” with “what we’ve got” is not a cheap excuse to avoid getting better – over the years we’ve improved materials and methods, and so have the guys producing PWB’s. Working together we can evolve newer and better materials, provided we are willing to tune our processes to get the best out of them.

Next time: How Low-Flow materials work in-process and what kinds of modifications of flow and viscosity have been made to open the process window with a minimum of pain.

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