New Options in Adhesive Film for Electronic Applications

In 1941 Forrest Mars introduced M&Ms, a coated candy that eliminated the mess normally associated with handling milk chocolate. Thanks to its candy shell, “the milk chocolate melts in your mouth, not in your hand.” The candy shell also kept the chocolate from melting in your pocket, on the shelf, and in other places where one would rather not deal with molten chocolate. The concept behind adhesive films is pretty much the same: take a tough-to-handle material and stabilize it for convenient use.

Available in a variety of forms, adhesive films are far easier to store and handle than adhesives in liquid or gel form. They stay right where you put them, they require little or no cleanup, they require less equipment and training to use, and they don’t slow down production processes as other types of adhesive can. These are all major concerns in the production of electronic devices. From both technical and esthetic perspectives, it’s a field in which neatness counts. A drop of spilled liquid adhesive in electronics it could turn a device into scrap (or at least require rework). The reduced need for training and specialized equipment gives manufacturers more flexibility in performing or outsourcing work. And the potential for increased throughput helps control costs and speed products to market.

Adhesive films come in three basic types—pressure sensitive (PSA), heat-activated film (HAF), and reactive—crosslinking—film adhesives (RFA). All typically come in rolls and are cut to size and shape. They share common advantages over liquid adhesives. On a per-unit-area basis, they can cost significantly more than liquid adhesives, though in many cases that cost can be more than offset by savings in the production process.

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Members of the Family

Traditionally, there have been three primary types of adhesive film available for electronic applications, each with its own characteristics and applications.

Pressure Sensitive Adhesive (PSA)

PSA is, in sheet form, similar to the familiar double sided tape one might find at the hardware store and is applied in much the same way. The operator removes the paper release liner from one side of the sheet, applies it to one of the substrates, and presses it into place with a tool or squeegee. The operator then removes the liner from the other side and presses the two substrates together. Bonding is immediate.

PSA is the easiest and least expensive form of film adhesive to use. It requires the fewest steps and uses no heat. It comes in a variety of film thicknesses and can be used to bond a range of materials including plastics, paper, textiles, metal, and foils. Its biggest disadvantage in electronic application is its low heat tolerance. No surprise there since it requires no heat for application and undergoes no chemical change in the manufacturing process. As a result, it does tend to lose adhesion under conditions of elevated temperature. Temperature rise in electronic devices became less of an issue half a century ago with the phasing out of the vacuum tube, and is even less of an issue for today's heat-sensitive devices, which are generously equipped with cooling fans. The big issue for PSAs is environmental. Mobility is king, and electronic devices travel with us everywhere. Unfortunately they sometimes get to stay in the car where, after an hour or so in the sun, a car seat can cause first degree burns and a PSA could easily lose its grip.

Heat Activated Film (HAF) Adhesive

These are thermoplastics in film form that work on the same principle as hot glue. It is solid and tack-free at room temperature, softens when heat is applied, adheres to the substrates and then solidifies when heat is removed, forming a bond between the substrates. The film is typically cut to size and shape, placed between the substrates and, depending on the material, run through a heated roll laminator or heated static press applying heat and pressure and then cooled back to room temperature. Other methods can be used when bonding three dimensional surfaces, and if necessary, the adhesive film can be tacked to one of the substrates before positioning the other substrate. Bonding with this material typically takes just a few seconds.

Thermoplastic HAFs typically require a lot of heat for activation, which limits, to a certain extent, how and where they can be used around heat-sensitive electronics and heat-sensitive substrates. The thermoplastic adhesive itself, because no curing takes place in its activation, re-softens when reheated. That's good if your concern is recycling, but can cause these adhesives, like PSAs, to lose adhesion when exposed to high heat. They can be adversely affected by a variety of chemicals and even by water. And finally, their adhesion to certain materials, nylon for example, may be limited unless that substrate is primed first, a potentially costly step to add to production.

Heat Activated Film vs. Reactive Film

At first it may be easy to confuse Heat Activated Film (HAF) with Reactive Film Adhesive (RFA) because both respond to heat.

But their responses are very different.

HAF is a thermoplastic, so heat softens it every time. RFA is a thermoset. Heat hardens it. You can see the difference in your kitchen.

Most plastic spatulas are thermoplastics, so if you rest one on the edge of your bacon pan you'll probably melt a groove in the handle. The floppy rubber muffin pan, on the other hand, is liquid silicone rubber, a thermoset, which is why you can bake it in a 350° oven without softening the rubber. That's the same difference between HAF (thermoplastic) and RFA reactive film (thermoset), which is why thermoset-bonded materials can handle heat better.

“Traditional” Reactive Film Adhesive

Like heat activated films, these are solid adhesive materials. Unlike the HAF’s, which are thermoplastics, however, traditional reactive adhesives are phenolics or epoxies. They are activated by heat and form bonds, which can then withstand heat and chemicals without losing adhesion. This makes them suitable for applications in which the finished product may be subjected to heat that would re-melt a hot melt adhesive or a spill of something as simple as a cup of coffee or sunscreen. The problem for electronics applications is that, until now, there have very few reactive film adhesives. Those that have been available have been very expensive. They also have worked in narrow temperature ranges. Some have required very high heat for activation, which is rarely acceptable in electronic applications and which significantly complicates manufacturing. Alternatively, there have been reactive films that require less heat for activation, but which must be protected from heat prior to use. These have had to be refrigerated until used, a costly and inconvenient requirement that might make sense for some specialized applications but that wouldn’t work in most electronics production lines. And finally, traditional reactive film adhesives increase in strength as they cure, which would be good, except they also decrease in elongation, which can make them too brittle for many applications.

“New” Flexel™ Reactive Film Adhesive (RFA)

There is now another option in reactive film adhesive. Like the traditional reactive film adhesives it is a thermoset (as opposed to thermoplastic) material that forms cross-linked bonds when heated. The chemical change is permanent, which significantly increased their resistance to heat once they are activated. But unlike traditional reactive film adhesives, these new reactive materials require significantly less heat for activation making them easier to use in production and safer to use with electronics and a wider range of substrates. Activation typically takes less than 60 seconds and may require as little as 75° to 90°C (167 - 194°F) for cure. Bonded parts can typically be handled and processed immediately after bonding.

Unlike traditional reactive films, RFA doesn’t lose elongation as it cures, so it stays flexible. And it gains significantly in tensile strength, making it extremely tough. Flexible and tough is a great combination for electronic devices and accessories or all kinds, including wearables.

These new reactive film adhesives come in a variety of formulations. They can be used on many different materials including aluminum, stainless steel, plastics, textiles, foils, and real and artificial leather, and will adhere to more materials than HAFs without priming. Some metal substrates require treatment to ensure adhesion. This may be as simple as an isopropyl alcohol wipe down.

H.B. Fuller Flexel™ EM9002 Reactive Film Adhesive

- One component, heat-activated adhesive film
- Available thickness 25 – 150 µm
- Solid content 100%
- Bonds plastic substrates, pre-treated olefins, metals, foils, and textiles
- Ideal for electronics and lamination
- Minimum activation temperature 75°C
- Can be handled, trimmed, or cut immediately after bonding and cooling
- High fracture toughness, peel, and shear strength
- High heat resistance after cure
- Elongation at break approximately 800%
- Tensile strength of free film: 30 MPa