



# Films and Adhesives

## So Many Choices!

Tom  
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While most of us may only be familiar with the names Kapton® or Pyralux®, there are different flex films, different flavors of adhesive and different types of copper to choose from. What's a designer to do? This article will discuss many of the choices available for films and adhesives and give some basic guidelines to help choose which materials will work best for different applications.

First a confession - I rarely specify materials beyond the film type, thicknesses and the type of copper. Why? Because over the years I've learned that each flex circuit manufacturer has their favorite brand of material. Some prefer DuPont, some prefer Rogers, some prefer Shin-Etsu, and the big guys like Nitto and NOK (aka Mektec) have their own home-brewed stuff. So my drawings will usually say something like this: Base material — 0.001 polyimide, 0.001 adhesive, 1.0 oz. rolled-annealed copper. Otherwise, if I put down a specific material I'll always get calls or e-mails from the flex vendor asking if they can use something they like better. So unless it's crucial to the application or it's an extremely high volume application where saving a few pennies per circuit can add up to big bucks I try to give the flex manufacturer as much leeway as I can.

## Sheldahl/IFT Still Trying To Sell Materials Division

### Negotiations With Morgenthaler Continue Exclusivity Agreement Expires

Speaking of materials, Sheldahl is still trying to spin off part of its circuit materials division. The part that is for sale makes adhesive-based laminates with polyester PEN, and polyimide films. They will be keeping their Novaclad™ adhesiveless materials lines, as well as the materials technology for deposition of indium-tin-oxide (ITO) and lithium onto plastic substrates. These materials are used in thin film displays and lithium batteries.

Sheldahl has been negotiating exclusively with Morgenthaler Venture Partners to buy the division. So far they have been unable to put a deal together and the thirty day

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exclusivity agreement with Morgenthaler has expired. Negotiations with Morgenthaler are continuing, but now Sheldahl can go and search for other potential buyers.

In other Sheldahl news, last week filed its second quarter results with the SEC, showing an EBITDA (earnings before interest, taxes and depreciation) loss of \$3.2 million in the second quarter. Looking at the gross profit numbers, it showed that the IFT portion of Sheldahl, which now includes its Longmont Colorado facility, had a loss of \$3.17 million, while the rest of Sheldahl had a \$2.1 million gross profit. Last year IFT on its own had a \$1.2 million gross profit in the second quarter. Could it be the Longmont facility is losing big money? I sure do hope they can turn it around.

You can view the full SEC 10Q filing for the second quarter by [clicking here](#).

Throughout *The Flex Circuit News* there are links to the web pages of those companies or individuals mentioned in the articles, as well as links to advertisers web pages. Look for the pointing finger.



That said, when do you need to be more specific in choosing materials? Ask questions such as:

- Does the circuit move or is it a flex-to-install application?
- What is the production volume of the flex circuit?
- Are there components that need to be attached to the circuit? Will there be any components wire bonded to the flex?
- Are there any special environmental concerns, such as very high or very low temperature?
- Does the material need to be UL rated?

Using this info, we can put limitations on the materials selection while still trying to give the flex manufacturer as much flexibility as possible. For example, if the only concern is that the material be rated UL VTM-0 I'll put that in a note on the drawing rather than picking a brand-specific UL rated material.

## Films

As far as number of applications, polyimide is the most common flex circuit film. It will handle very high heat so soldering is not a problem and will survive cold temperatures as well. It is resistant to most chemicals and is physically very tough.

Most folks use the terms Kapton® and polyimide interchangeably but Kapton® is the trademark of DuPont's brand of polyimide. Other polyimide films include Apical® which is manufactured by Kaneka and Upilex® which is manufactured by Ube Industries.

Laminates made with Upilex® are especially good for applications needing precise alignment of very fine circuit features because it doesn't expand or contract with the humidity as much as other polyimides. Upilex® is stiffer than other polyimides, making it better for applications like TBGA substrates, but not as well suited for circuits with very tight bends or dynamic flexing.



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Adhesive-based polyimide films are available from DuPont, Rogers, Sheldahl and Shin-Etsu.

Polyester is also a very good film that is resistant to most chemicals, is physically tough and has good electrical properties. It is also commonly known as Mylar® which is the trade name for DuPont's brand of polyester. Polyester is much less expensive than polyimide, making it a popular choice for circuits that are physically large. It can't handle normal soldering temperatures, but there are ways to solder to polyester using low temperature solders or heat sinks.

dashboard circuits. Polyester laminates made from rolled-annealed copper are very reliable in dynamic applications such as ink jet printers.

You can get copper-on-polyester flex circuits from Nitto Denko, NOK and Sheldahl — all three make their own polyester laminates. Sheldahl also sells polyester laminates with both electrodeposited (ED) and rolled-annealed copper to other flex fabricators. Rogers has just begun selling a polyester laminate with ED copper. Other fabricators that make lots of polyester flex circuits are Pressac in England and Allflex in Minnesota.

Polyester is used in very high volume, cost sensitive circuits such as automobile

Pressac is a very high volume manufacturer that sells almost exclusively to the automobile industry. Allflex is a prototype/medium volume shop.

There are new base films that are now available, such as polyethylene naphthalate (PEN) and liquid-crystal-polymer (LCP). PEN films are a lower-cost replacement for polyimide. They can handle normal soldering temperatures but cannot handle high heat as well as polyimide, so you have to be careful when soldering. PEN laminates are available from both Rogers and Sheldahl.

LCP films have excellent electrical properties similar to microwave materials and good dimensional stability. W.L. Gore is currently offering LCP laminates called BIAC™. This film has a

dielectric constant of only 3.0. You can get the data sheet by [clicking here](#).



Rogers is also supposed to be offering an LCP film shortly. It will be called R/max™.

Adhesives

Acrylic, epoxy, modified epoxy, polyester and phenolic butyral adhesives are used in flex circuit laminates. Polyester adhesive is typically used with polyester

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and PEN films. Acrylics are widely used and have good bond strength at ambient temperatures. However, they do tend to have a higher coefficient of expansion, reducing via reliability in multilayer flex circuits and rigid flex circuits. The bond strength of acrylic adhesives drop dramatically at higher temperatures, and they are not the best choice for wire bonding because they are the "softest" of adhesives and tend to absorb ultrasonic wire bonding energy.

Epoxy adhesives have the best bond strength at higher temperature and are very good for multilayer flex, rigid-flex and wire bonding. Phenolic butyral adhesives are a little stiffer than acrylics and more flexible than epoxies. They are the most reliable adhesives for high-cycle, dynamic flexing applications.

The adhesive determines whether a material can be UL rated. Epoxy and modified epoxy are the

most flame resistant adhesives. Acrylics must have a flame retardant filler added to make them flame resistant. This filler gives the material a milky appearance and reduces the reliability for dynamic flexing.

Rogers and Sheldahl sell laminates with every kind of adhesive. DuPont offers acrylic adhesives. Shin-Etsu sells epoxy adhesives.

### Adhesiveless Materials

Adhesiveless materials are available with rolled-annealed copper, ED copper and semi-additive copper (plated-up over sputtered copper). Adhesiveless materials work great in high temperature environments such as automotive under-the-hood applications. Laminates with semi-additive copper are available with copper thicknesses as low as a few microns! These materials are very useful for etching very fine circuit features.

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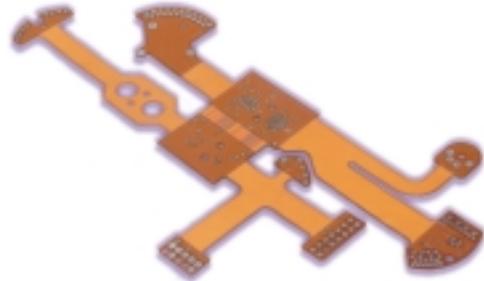
Electronic Materials Division

DuPont sells an adhesiveless material called Pyralux® AP which is rolled-annealed copper on polyimide. Gould Electronics offers semi-additive copper on either Kapton® or Upilex® in thicknesses from 2000 Angstroms to 35 microns (one ounce). They are available with either a nickel or chromium tie coat. Sheldahl also makes adhesiveless materials called Novaclad® that have semi-additive copper on polyimide. Rogers makes an adhesiveless materials called R/Flex®3100 that has rolled-annealed copper on polyimide, but it sells all it can make to Hutchinson for disk drive head suspensions. Rogers hopes to increase capacity to be able to sell this product to other customers. Finally, the BIAC™ LCP material from Gore that was mentioned earlier is also adhesiveless.

While this article is by no means exhaustive, I hope it gives you a better understanding of the choices available to you. As always, if you have any questions or need more information regarding your particular application please feel free to give me a call or send me an e-mail.

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## More Stuff

- While at the Semicon show in San Jose, I got to talk to some of the folks at Cicorel, a flex manufacturer in Switzerland. In addition to building very small fine line flex circuits for the watch industry, I found out they have a unique capability to make very large flex circuits, as large as 3 feet by 6 feet! The sales manager for Cicorel is Hans Wyss. His e-mail address is [hwyss@cicorel.ch](mailto:hwyss@cicorel.ch) and their web page is [www.cicorel.ch](http://www.cicorel.ch). 

- While searching the web I came across a company that does quick prototypes of polyester flex circuits using silver or carbon ink. RP Circuits of Tuscon, Arizona advertises 24 and 48 hour turns on proto orders, including membrane switches. Their phone number is 520-647-0190 and their web page is [www.rpcircuits.com](http://www.rpcircuits.com). 

- Sometimes it would be nice to have polyimide in sheets thicker than 5 mils. Robert Jung at Altaflex gave me info on a company called Fralock in southern California. They are a licensee of DuPont and they sell polyimide made by DuPont called Cirlex® in sheets from 8 mils to 125 mils. It's actually the same stuff as Kapton®, just thicker. Also, Fralock

can laminate copper onto the polyimide to create super thick adhesiveless laminate! You can call them at 800-372-5625 or visit their web page at [www.fralock.com](http://www.fralock.com). 

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## On A Personal Note...

# Four Wheels and a Cloud of Dust

For the past eight years or so my son Michael and I go on a camping trip by ourselves once every summer. These father-son campouts could be right out of a Mastercard commercial - "having time alone with your teenage son...priceless," and I look forward to them every year.

Usually we go camping by the ocean, but this year we decided to go camping at Hollister Hills State Vehicle Recreation Park. Why? Because ever since Mike has had his drivers license, he's been wanting to drive my Jeep Wrangler off-road.

Hollister Hills is like a ski resort for four-wheel-drive vehicles and dirt bikes. The mountain has numerous driving trails, and you choose them just as you would when skiing: green trails are easy, blue trails are more difficult, black diamond and double-black diamond trails are for experts only. It's definitely a fun place, especially after a rain when there is lots of mud!

As the trip approached I was filled with many conflicting emotions. As I mentioned before I really look forward to these trips — what I haven't mentioned yet is how much I love my Jeep. It's not like I sleep in the garage with it, but it's close! Was I really going to turn my son loose on the side of a mountain with my beloved Wrangler?

Going midweek we had the place pretty much to ourselves and the wild pigs, especially since the temperature was close to 100 degrees. The only bad part was the dust - dust everywhere! It was so deep in places it made some trails impossible to climb up - but going down was fun!

Mike turned out to be a pretty good driver. Actually the only one who got stuck during the whole trip was me. I was going up a ridge and I didn't know what was on the other side. Instead of stopping and looking I hit the gas and went over - landing with my left wheels hanging over the edge of a 45 degree hill (I guess they don't call it the stupid

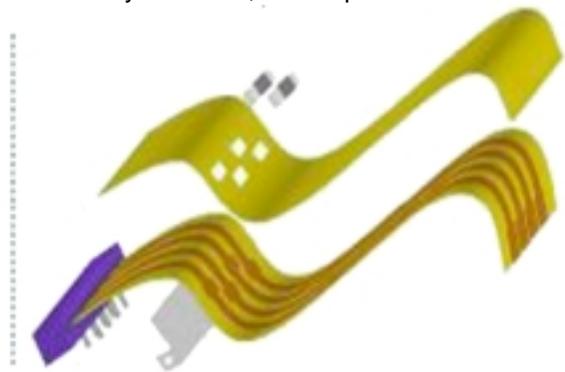


pedal for nothing!). Without a winch and no one around to pull us out, the only thing to do was go backwards down the hill through the brush to another trail below. The pictures on the next page show me sliding backwards into the trees.

After an afternoon of crawling over the mountain, we retreated to camp for the traditional steak dinner. On these trips there is no sissy food - only steak, stew, bacon, chips, beef jerky and whatever

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other “man food” we like. After the steaks, then it’s the campfire, smores and sleep.

Since I’m usually working right up to the moment we leave, I usually forget to pack something — this time it was the air mattress! Fortunately the night was warm and we could sleep on top of the sleeping bag. We slept pretty well until the wild pigs woke us up early next morning.

We came home without breaking anything major on the Jeep — we did bash the muffler a bit, but it needed a new muffler anyway. There was dust in every nook and cranny of the Jeep and Mike spent the better part of an afternoon washing and vacuuming when we came back.

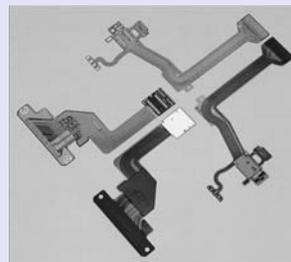
By next summer I hope to have a winch, a lift and some bigger tires on the Jeep. Then we can come back and take on some of those double black diamond trails! Hollister Hills is about 40 miles south of San Jose. You can get more info by calling 831-637-3874.

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