Strategies for Beating the Heat:

Recent Developments — LED Thermal Management 2.0

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IN SUMMARY

With the LED market exploding while still in its infancy, both PCB producers and end users can expect to see consistent evolution in not just standard MCPCB materials, but also potentially disruptive and game-changing technologies and applications.

For the past two and half years, the PCB industry has been beating the heat as if we were Dirk Nowitzki and the Dallas Mavericks. Speaking from the PCB fabrication link in the supply chain, the approach taken has been one of refining loose methods of operation into a finely-tuned best practice methodology.

Prior to the recent rise of the LED, PCB thermal management was an afterthought and an obstacle—like one too many required fields on an online registration form. With the rise of LEDs, however, thermal management's role is now prominent and designers are proactively addressing this discipline from the beginning.

The process has been analyzed, taken apart and put back together while examining the inter-relationships between each element in the finished product stack-up. We've come a long way, but there are still looming challenges.

We believe that there is always a solution. You joined us in checking that long-dormant thermal management requirement box…now we're ready to start looking outside of it. For that, we turn our attention to Technology Evolution: LED Thermal Management 2.0.

Where We've Been

For the past two years, we've invested a significant amount of resources into educating the industry to properly calculate their needs based on commonly accepted methodologies and materials. Instead of calling out thermally-conductive MCPCB materials by brand name (or no name at all), we have had industry experts define material properties and show us how to calculate our needs. (We've made a year of promises, but the online version of the LED Thermal Resistance Calculator is finally up-and-running.)

The central purpose asserted in each of these various presentations was constant: Calculate your needs in terms of maximum thermal resistance, minimum electrical insulation and any other properties you felt were critical to product performance. Then, let your supplier search the globe for the most competitive solution both in terms of pricing and lead time that meets your needs.

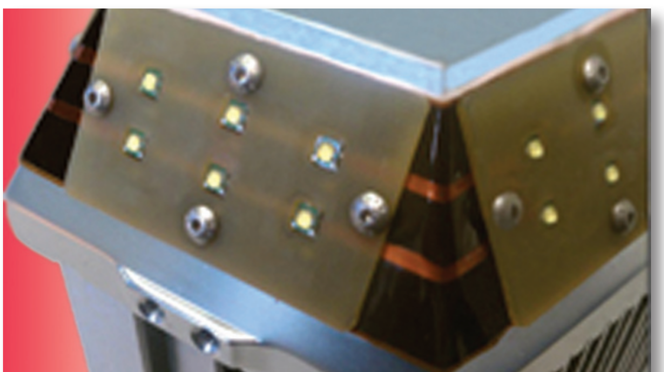
Now that we've firmed up the ground we've been walking for years, it's time to shake things up and rely on the innovation that has helped our industry survive for decades. As with any other successful industry, we foresee materials and product evolution to change the current landscape in the coming years.

Here are a few product innovations that, I believe, will emerge to address technology refinements: 1) product design; 2) material improvements; and 3) alternative materials/methodologies.

Product Design

One gripe about MCPCBs is that they are entirely two-dimensional and the product must be designed to conform around the PCB. We came across one such limitation in regards to a three-dimensional lamp post application with a customer who was using four separate MCPCBs and connecting them around the corners of the post using soldered wires.

Now, thermally conductive substrates, regardless of brand, are all polymers. Thus, these thin materials (commonly used in the flex and rigid-flex PCB industry) proposed a reasonable alternative.



Keep in mind that thermal conductivity values are almost meaningless without taking thickness into account. Most thermally conductive materials have a minimum thickness of 0.003" to 0.004". However, on a daily basis flex shops are using materials as thin as 0.001". Therefore, even with a lower thermal conductivity value, a material this thin would pose very little thermal resistance.

Moreover, the flex PCB wraps around the four sides of this light post while the FR4 stiffener ensures thermal transfer by allowing the PCB to be directly screwed to the metal lamp housing.

Initial tests showed that the time to equilibrium was approximately half that of the prior design.

Click here for Flex LED PCB Kit.

Material Improvements

Thermally Conductive Dielectrics

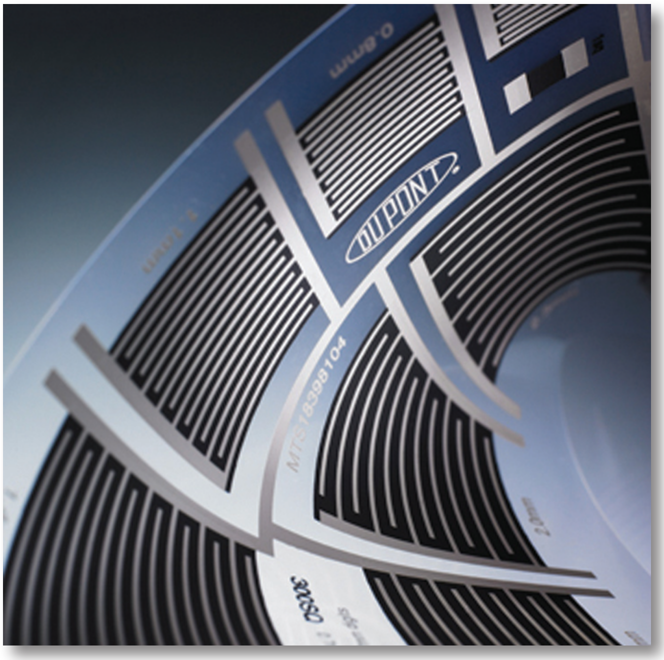
As end users become emboldened with their newfound calculators and materials testing methods, thermally conductive material manufacturers have been coming out of the woodwork with either new or improved alternatives to those offered by the current establishment. We are approached almost on a weekly basis with new products offering lower cost or increased performance, or both. We try to keep our materials comparison chart updated but, with the frequency of new materials being offered, it's certainly a difficult task.

For the most part, continued innovation has enabled materials manufacturers to improve the filler's performance in increasing thermal conductivity, while simultaneously reducing thermal resistance by laminating dielectrics in thinner layers.

While these are not game-changing technologies, if you will, at the end of the day they represent incremental improvements to the currently accepted technology base. Remember when you thought your two-pound Walkman was the cat's pajamas? Don't be surprised to see mainstream laminate manufacturers enter this market within the next six to 12 months with product offerings that reduce cost and increase performance.

Inks for Printed Electronics

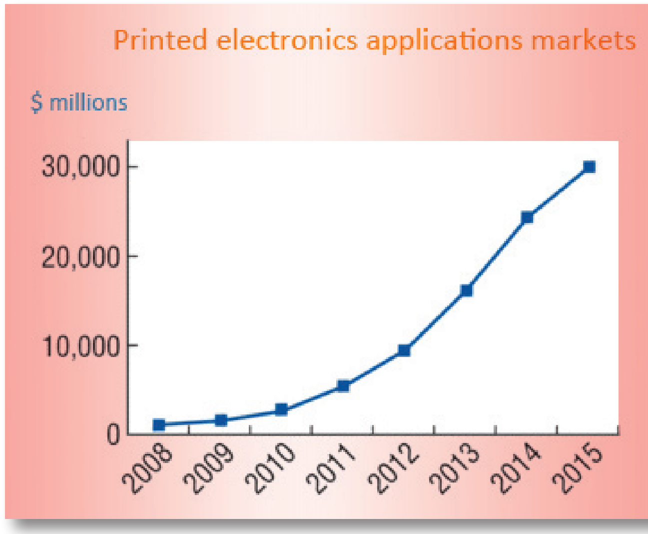
Over the past decade, the disruptive technology of printed electronics has been making significant gains in flexible display/touch screen, smart label and flex PCB market share.



Printed electronics involves screening electrically conductive inks (as opposed to etching copper circuits) and is used primarily on low-voltage applications since the inks to date have had too high an electrical resistance.

As evolution dictates, there has been significant progress in reducing the electrical resistance of inks. We were approached by one of these manufacturers to help evaluate their ink for LED applications. While this is still in progress, the benefits of printing directly to a coated metal substrate are clear: The elimination of the often expensive and hard-to-procure thermally-conductive dielectric that is common to MCPCBs.

At the moment, thermal and electrical material properties (responsible for electrically insulating the barrier between the conductive ink and the metal base) prevent this realization; for this purpose, prepreg, anodizing and even a simple coating of soldermask are being considered.

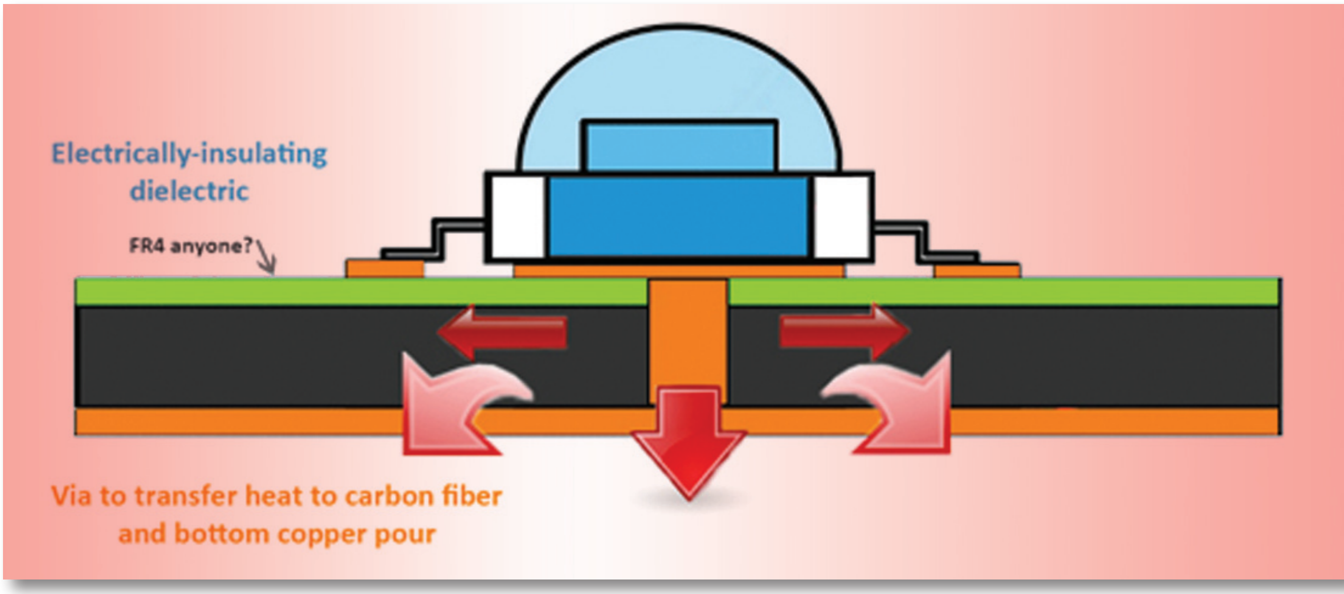


Regardless of medium, the potential for direct materials savings and streamlined production accounts for a motivating one-two knockout punch.

Alternative Materials/Methodologies

One of the most interesting ideas we've played around with was the use of Pyrolytic Graphite embedded into FR4 material to achieve thermal conduction to the heatsink. With a thermal conductivity value four times

"Tucker, the Man and His Dream" Paramount Pictures.



that of pure copper, Graphite PCB seemed like a home run; however, cost and process limitations represented challenges.

I was about to submit this concept to the Tucker Motor Cars Hall of Fame when I received a phone call from a materials manufacturer with a novel idea: Replace the fiberglass yarn* with carbon fiber that has a thermal conductivity in excess of 200 W/mK. Hold that Tiger! Not only can you drill and plate through nicely, but the carbon fiber acts as a heat spreader in the X, Y and Z axes.

While the material for this particular is still under development, with some creative process applications it could surely be a game changer offering the potential for both significant performance increases as well as modest cost reductions.

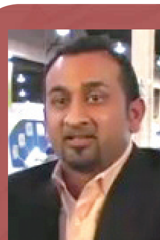
Conclusion

With the LED market exploding while still in its infancy, both PCB producers and end users can expect to see consistent evolution in not just standard MCPCB materials, but also potentially disruptive and game-changing technologies and applications.

The main concern is whether or not we are keeping an open enough mind to see the value proposition in these, and what are we going to do to foster and encourage out-of-the-box thinking?

It may no longer be the Wild West, but let's not get comfortable with the status quo! Let's make a commitment to keep the burr in our saddles. **SMT**

**Standard PCB materials are comprised of a weave of fiberglass coated with epoxy (typically FR4 or Polyimide).*



Yash Sutariya received his BBA from the University of Michigan's School of Business Administration. After graduation, he worked in Valuation and Bankruptcy/Turnaround Consulting. He is currently Vice President of Corporate Strategy at Saturn Electronics Corporation (SEC) and Owner/President of Saturn Flex Systems, Inc.

Since joining the team, SEC has successfully navigated from a low-mix, high-volume automotive supplier to a high-mix, medium- to high-volume diversified supplier. As a result of the company's transformation, manufacturing capabilities now range from quick-turn prototypes to scheduled volume production while attending a broad cross-section of industries to include industrial controls, telecommunications, aerospace and power supply industries.