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Roundtable Discussion

IMS Laminates in Multilayer Designs

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Real Time with... Ventec Roundtable: IMS Laminates in Multilayer Designs

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Introduction

The dissipation of heat from electronic power modules is increasingly critical to maintain their functionality and increase their reliability. Insulated metal substrates (IMS) offer a proven route to thermal management, and this specialist technology is increasingly employed in multilayer stack-ups for power applications.

This ***Realtime with...I-Connect007*** roundtable discussion brings together the expertise of Ventec International Group's Global Head of IMS Technology Chris Hanson and Technical Manager Denis McCarthy. Rax Ribadia of Excello Circuits provides hands-on fabrication experience from a specialist PCB manufacturer, and I-Connect007 editors Andy Shaughnessy and Pete Starkey contribute to a conversation that explores applications, materials, design considerations, and mechanisms of heat transfer. The benefits of technical and engineering support from a one-stop laminate supplier become clearly apparent.

ROUNDTABLE DISCUSSION FEATURING:

Chris Hanson
Ventec International Group

Denis McCarthy
Ventec International Group

Rax Ribadia
Excello Circuits

Pete Starkey
I-Connect007

Andy Shaughnessy: Hi. I'm Andy Shaughnessy with I-Connect007. Welcome to the ***Real Time with...*** Ventec roundtable. We're here to discuss the use of IMS laminates in multilayer designs. Welcome, Gentlemen. I appreciate you taking the time to do this. So why don't we get right to it, Chris? Why don't you just start off by giving us some background and a little history of IMS, especially in power applications.

Chris Hanson: Thank you, Andy. So with respect to IMS, in my opinion, IMS really gained market acceptance in the early 1990s. So we're going back almost 30 years, and its acceptance was almost exclusive to power supply applications. Our customers like Artisan, AZTECH, Lucent and Vicor were some of the main players that really took a chance and invested in IMS materials and they invested in the material in their product line called DC/DC power bricks. The bricks are still quite popular today, used in many applications, and they use a naming convention with these bricks to really identify the wattage output of these things based on a footprint. So the common terms in the industry today are quarter brick, half brick, full brick, and these modules back in the early 1990s were very well established and operating just fine with conventional FR-4 circuits, but as is the case with just about every product in the market, cell phones, being a perfect example, the industry pushes for higher output, better performance in a module that's either the same size or smaller.

So for example, I have a half-brick module in footprint size is 2.3 inches in length, 2.3 inches in width, and a half inch in height. So if you look back to the '90s, these modules maybe reached a level of 50-watt output, but if you look today, you can get a half-brick module from many suppliers that is at 300 watts or higher. So with that much wattage into a small package that's 2.3 inch square, you're going to generate some heat.

And these DC/DC designers got to a level where they couldn't dissipate enough heat using heat sinks and fans, and even in some cases using liquid cooling. And the FR-4 system internal to these modules just didn't cut it. So it was a great opportunity, a great opening for the IMS, an acronym standing for insulated metal substrate materials. So what these designers did is they mounted their heat-generating components directly to the IMS material.

And then they left all the logic and non-heat generating components on a multilayer FR-4 module, and then they connected the two using surface mount pins or PEM nuts. And it's been a wonderful fix for dealing with the heat generated as these designs increase in wattage. So today that's migrated into still using IMS in these brick modules, but we see applications in battery charging, we see applications in LED lighting, for example. Several customers replacing high wattage bulbs are using a copper base IMS with thermal dielectric and traces on both sides, mounting of LEDs on both sides so that they simulate light output that's 360 degrees, much like a conventional light bulb. So as we migrate forward, the pressure on designers in power is intense. It's always, "Increase the output, increase the performance of these modules." However, you must remain with the same footprint and size, and that's quite a challenge. That being said, it's a great fit for our IMS materials.

Shaughnessy: Denis, tell us a little bit more about this. What exactly do you all mean by multilayer IMS? What's the construction like?

Denis McCarthy: In all fairness, we tend to lump things together, and IMS is insulated metal substrate. When you get to a multilayer, you're more along the lines of a thermal management package. So in that regards, a multilayer IMS board can be typically two, three or four layers bonded to a piece of aluminum or a piece of copper to provide that heat sink package. But in today's market, we're also going after multilayer, pure multilayer packages without an IMS or a metal substrate or a metal plate based on our A series materials, which are glass reinforced materials that tend to allow PC shops and OEMs to build a standard 10-, 12-layer panel and place that thermal management material in an opening or in the entire panel, wherever they would like to place it. For instance, they could put it on an outer layer for a video card and perhaps drop one of the heat sinks or one of the fans to use the material to spread the heat across the panel.

Shaughnessy: This is for either one of you. What are your customers asking for as far as the IMS laminates go?

McCarthy: I've been working with several OEMs the last couple of months, and currently they're looking for a higher layer counts, laser drillable materials, higher thermal performance. So I'm working with some, again some very large OEMs they're dealing with eight-, 10-, 12-layer panels that are going into some very high-end control modules that have laser drilling, blind vias. And then we have some fairly simple people that are just looking for two-layer boards to be bonded to a piece of aluminum for high-end LEDs with the controller. Instead of having FR-4 driver board, they're actually adding all of that, the electronics, the driver part of it to the actual two-layer IMS panel.

Shaughnessy: Rax, from the fabricator's standpoint, tell us a little bit about processing the IMS materials.

Rax Ribadia: Well, you have to pay special attention in drilling. We have to use special bits and have to calibrate our feeds and speeds in order to drill the material. And also in routing, you used to have to use a diamond-coded bits or specialized tools in order to cut the material. When it comes to the multilayer 5A2, a similar process, basically making sure that your drilling and routing is very fine-tuned so the customer gets the best quality. Other than that, it normally runs just like any other FR4 or polyamide material throughout our shop.

Shaughnessy: Do you have to invest in any new equipment?

Ribadia: No, you don't have to invest in new equipment. You just have to do a little bit of homework, as far as getting the right tools in order to process the material.

McCarthy: Basically, the biggest changes, again, are in the tooling and then the actual press cycle. So to laminate that material takes a slightly higher pressure, but it all runs into the same type of equipment that a standard FR-4 or as Rax pointed out and polyamide and material would run.

Pete Starkey: Can I ask Chris, in the first instance, why is a two-layer multilayer IMS system required?

Hanson: It's really required because similar to my discussion about the DC-to-DC break exercise or product, these designers of modules that use or generate heat, whether it's an LED applications or power applications, or even underhood applications, they're still confined in space, and by space, I mean, area footprint. It's pretty rare that in a vehicle these days that an automotive engineer is allowed to actually increase the size of a module. Without that capability, but yet he or she is expected to increase the perfor-

mance of that module. So to do that and have enough capacity to connect components through circuit traces, they have to increase the number of layers. And traditional IMS, even going back I mentioned that started in the early '90s, but even today, I would still say the total market is probably 70-80% single layer usage. Moving into this multiple layer technology with thermal materials is still a relatively uncharted territory, but designers are forced to increase performance of their product without the capability of increasing space.

And even though that's a frustration for them, for us at Ventec it's an absolute welcomed situation because we provide not only the thermal materials, but Denis is working on multiple applications that in some cases use three different Ventec materials, meaning our Ventec single-layer IMS, Ventec thermal prepregs and then a Ventec a high-TG for stackup. So the beauty for customers today with respect to Ventec is the fact that we saw this market coming and we have products in multiple divisions that can suit these designs. And it's essentially a one-stop shop for these customers. They don't have to buy FR-4 from one supplier. They don't have to buy IMS from a second supplier and then get some prepregs from a third supplier. The beauty of Ventec is they get it all from one customer, one supplier, Ventec. In the event there are some issues, questions, problems, it's one phone call. It's not multiple phone calls to multiple suppliers. And it just really makes the designing of a multiple layer system using Ventec very easy.

Starkey: Thanks for that, Chris. You've already mentioned a few, but what sort of applications are you using these multilayer systems in?

Hanson: So with respect to power, we're seeing it in DC-to-DC applications. We see it in AC to DC applications. As we move into the world of non-gasoline engines, AKA hybrids and electric vehicles, we're seeing the requirements for these types of stackups in battery charging, battery management. And then if you look into aerospace applications, military where Rax and his team specialize, we see a lot of requests for some really creative stackups in that space. So power supplies for radar systems or infotainment systems or the kind of materials that have to withstand heat well beyond the normal, maybe 120, 130 at the normal range today. We're seeing requests for products that are exposed to incredible heat environments.

Starkey: Denis, can I ask you what sort of IMS materials are used in a multilayer stackup?

McCarthy: Most of the time, we're going to try to guide the designer or the OEM and the PCB shop to use one of the A series of materials, these are 4A2

or the 5A2 materials. And this is basically because it's glass reinforced, and the glass reinforcement will allow for registration layer to layer where the B-series material is not supported with glass. It's just a resin with thermal fillers in it. It will tend to shrink or move much more than something that's supported with glass. So we tend to try to design them and try to point the OEM and designer towards the glass reinforced materials so that they can get a good, solid registration through their stack, especially when they're talking about eight-, 10-, 12-layer boards.

Starkey: Yeah. And I presume that the designers engage with you at a very early stage of the design to get your application support.

McCarthy: We absolutely try to do that for the most part, but we do still, we do tend to see some odd requests come across someone's desk, and then we get a call for help, and we have to try to guide them down the correct path.

Starkey: I understand I've been there. Denis, do the multilayer IMS systems use a metal base plate?

McCarthy: Not all of them. There are some that certainly, we have people that are bonding two, three, four-layer boards to a metal base plate. Typically though, Pete, when we're talking about multilayer, most people are trying to use a standalone solution without a metal base plate. And we also have the 4A2 to which you can actually take and use that to bond a heat sink to a multilayer board. So in the past, for instance, a GTE would be bonded to an aluminum heat sink with a piece of no flow prepreg. Today we have applications where people are requesting thermal prepregs for that bonding. And they're able to use the 4A2 to bond a standard eight-layer FR4 board to the aluminum heat sink.

Starkey: So that the prepreg itself becomes part of the heat transfer system.

McCarthy: Absolutely.

Starkey: Which leads me to the next question, really. I'm talking directly to Chris, how is heat transferred in a multilayer IMS system?

Hanson: Very good question. So we started with a thermal prepreg that is loaded with thermal fillers. So there's already a decent thermal conductivity value within the prepreg itself, that'll pull heat directly from the copper traces above. But, generally speaking, in most of these multilayer applications, the requirement of thermal vias, copper plated, or completely copper plugged or filled vias are almost exclusively required to really get the heat out of the copper trays, right below the power component and then

down to an alternative metal piece of equipment, whether it's the base plate or potentially a casting or a heat sink itself.

Starkey: Thanks. If I can come back to you again, you've already partly answered this one I think, but what comment can you make on the design challenges that engineers face with multilayer IMS systems?

Hanson: Pete, they're going to face the same challenges they face with FR4 basically, or any other standard material. Whether they have impedance, you have to have the right Dk/Df, but for the most part, we haven't experienced anything that we can't overcome with the use of certain glass styles or certain copper weights. We can do thermal vias, very small vias, laser holes. So there's nothing we haven't been able to accomplish yet with the standard 5A2 and 4A2 materials. So in today's market or today's applications, we don't see any hurdles that we have not been able to overcome as of yet.

Starkey: As a PCB fabricator, Rax, what technical support does Ventec offer you?

Ribadia: Ventec's been great. We get a request from various different industries and a lot of different clients asking for stackups or coming to us as a solutions provider to say, to give you an example, we had a tier one supplier who was using a different material, but they were really looking for thermal conductivity and they were guided by whoever to say, "Hey, use this material," but it was not really going to work. It was an eight-layer board with four-ounce copper. And so when I reached out to them, we made the board for the customer, but it wasn't really working to what their intentional use was. So when they reached out to say, "This is not working." I said, "Well, what is the real purpose? Why did you use this particular material?" And they had mentioned that they were looking for thermal conductivity.

So I reached out to Denis and within half an hour we were able to come up with the stackup. And we went back to the customer, shared the data sheet, "Hey, this is really going to work for your application that you're looking for." They were thrilled about it, and we were able to give them samples within two weeks with the support from Denis getting the materials. And then again, within three weeks, they were able to test their product and it worked beautifully. So now we are in a phase of where they're making all the drawing changes and issuing all the ECOs to use the Ventec 5A2 material. And now they're going to production relatively soon. So, a lot of times customers don't know exactly what they're looking for.

They're either using a material where they have a longer lead time, but they really want the product right away. And we basically kind of find a substitute within the IMS material. Ventec goes all the way up to seven watts per meter Kelvin. So we're able to kind of give them a range of solutions that customers are able to use and Ventec's been great, they're about a phone call away. Within hours, we were able to come up with the right solution for what customers are looking for.

Starkey: It certainly is great to hear that you've got that sort of positive working relationship with your material supplier. You're part of the same team rather than just a customer and a supplier.

Ribabia: Absolutely.

Starkey: Chris, I'll come back to you. I know there are several of them, but do all IMS suppliers offer multilayered systems?

Hanson: That's a really good question, Pete. I will say the simple answer is no. We have some wonderful IMS competitors out there that do provide materials that can be used in multilayer systems, but some don't, some IMS suppliers just stick to single-layer stackup. There are a few out there that that actually can make a two-layer system in-house, but they wouldn't support moving those types of materials or selling those types of materials to a company like Excello.

So, as I mentioned before, we at Ventec looked into the future and realized there's going to be a big market for these types of materials, so with the support of our R&D team, and a lot of input from Denis' side, Ventec has prepregs that are coated in fiberglass. We've got some dielectrics that are unreinforced, coded to liner that for the right application, we sell to customers. We can put dielectric on copper foil and sell that to a customer like Rax. And for many of these applications, we would make a copper core in house, meaning we would take two sheets of the copper foil, laminate those together with an excellent thermal material and sell that as a stack to the board shop, and then in addition, sell the prepregs and the aluminum.

So it's not common in the industry for all IMS suppliers to have multiple layers systems that they can sell. And certainly, I'm obviously biased, but I would say Ventec stands alone on top of the hill when it comes to the multitude of products we offer that can be used in multilayer stackup, as I said before, I really consider Ventec in this arena, a one-stop shop.

Starkey: You've made that clear Chris, but again, I get the impression that you've got a very broad product offering, not just in IMS materials, because

you can offer all of the other complementary materials, which make up the total construction. And you also seem to have a very flexible approach in that you prefer to look at the customer's challenges, the OEM's challenges, and if need be formulate a particular material to resolve a particular problem.

Hanson: You're absolutely dead on and straight with your comment, Pete. If you know Rax or Denis, these are the kind of guys who love these really creative unfounded, sometimes almost unrealistic applications. These guys love to roll up their sleeves, dig in, and then eventually, in almost all cases, come back to a customer and say, "We can manage that. And here's how." Sometimes, maybe not, and it requires communications back and forth with the engineering team at the OEM. But I say more times than not, we can come up with a beautiful stackup that provides the heat dissipation these engineers require.

Ribadia: One of the great things is not just that you can make a board, but you want to be able to help a customer go into production. It's not just making five or 10 prototype pieces where they'll be successful. But when they're talking about going into a thousand pieces or hundreds of units, we need to make sure that design is manufacturable, and there'll be able to go to various different vendors if I'm able to support them for capacity issues. So I think that's where Ventec excels compared to the other competitors, because we are making solutions where we know that once we build a prototype for them this is going to go into production. They will not have any issues moving forward. So I think that's the great support we get from Ventec. That's really excellent.

Starkey: Thanks, Rax. Chris, if I could come back to you again, give me a sort of ballpark cost comparison between a multilayered system and a single layer IMS. I mean, knowing which one must be more expensive.

Hanson: To be honest, obviously, a multilayer system, especially if it includes a metal base plate is going to be more in cost than a single-layer system.

Starkey: Oh clearly, but what sort of proportion?

Hanson: If we're talking about a two-layer system that is just adding another layer of dielectric and another layer of copper to a conventional single layer, IMS is probably in the neighborhood of maybe a 50% price increase. However, Denis touched on several applications he's pursuing that essentially really don't use a metal base plate. And in those applications, we can be very competitive in price compared to conventional IMS. So, IMS

materials, unlike FR-4 use metal, they use a lot of copper. They use a lot of aluminum and pricing for those materials on the market today, continue to increase. In fact, there's a lot of talk right now about copper foil, really starting to escalate in price worldwide.

So we're at the mercy of the metal markets to some extent. And we're also at the mercy of the designs from the customer. So, I can give a good price difference, apples to apples. But if we go from a single layer IMS stackup using one-ounce or two-ounce copper foil to a multilayer that uses four-ounce copper, like Rax mentioned, in six or eight layers, it's is really hard to give a cost comparison for that kind of application.

Starkey: I apologize for putting you on the spot on that one. But I believe it was a reasonable question to ask.

Hanson: And to be honest, Pete, it's a good thing you asked that question, because if we were to spend a half-hour talking about these types of applications and people join or watch and then walk away, that's the first question they're going to say to themselves is, what's the cost difference?

Starkey: At the end of the day, it's really down to when you look at the finished product, what's the total cost of ownership, and really the costs are having overcome the challenges that were involved in designing and fabricating that product in the first place.

Hanson: Exactly. So I can say this in many applications, whether it's for power or LEDs, those customers that move to a really solid thermal dissipation stackup in their design, oftentimes see such improvement that they can reduce the number of power components, D-squared packs or LEDs in a lighting application. So if you take a look at a complete bill of material or system costs, sometimes using an IMS stackup that dissipates heat actually produces a lower system cost or lower bill of materials. So if you just look board to board price, sure, the IMS multilayer stackup is going to be more, but if you're able to reduce the number of power components or LEDs, oftentimes the total system cost is lower.

Starkey: Final question, which possibly is another cheeky question. How does Ventec sell their multilayer products to PCB shops?

Hanson: That's also a good question. So I guess my answer would be just about any conventional concept that the customer desires, meaning we sell prepregs. We sell, as I mentioned, we can sell our high-performance dialectics on liner for special applications. We sell copper cores, which are the copper foil sandwich together with a dielectric in the middle. And in

some cases, customers buy aluminum base plates with dielectric on the aluminum base plate, either in B-stage or fully cure. So the simple word that comes to mind with respect to our offerings is flexible. We really enjoy getting an email or a phone call from guys like Rax that say, "Hey, this customer is in need of dissipating some heat, here's today's stackup. Where do we go?" And then a guy like Denis with 35 years of experience in the circuit board industry, he rolls up his sleeves and comes back with, in most cases, a complete stackup that provides a great solution for the customer. So the sky's the limit, really.

And one beautiful thing about Ventec is, if for some reason we don't have a product that is available as a standard today, we generally, for the right piece of business, don't have any hesitation or hold back to go pursue that product for our customer.

Starkey: No, I think this sort of roundtable has made it clear that you don't need to do a lot of selling. The essence of it is in the technical engineering support, the getting involved with the designer, getting involved with the fabrication. At the end of the day, the OEM and the customer see what they can rely on from Ventec in terms of the support and the involvement. And they just choose whatever product is the appropriate product for that design and instruct the purchasing department to buy it. That's a sort of naïve way of looking at it for my point of view. It's more about the technical service and the technical support. And at the end of the day, the actual selling operation, you don't need to do the selling, the engineering, the technical support do the selling for you.

Hanson: It's a very true statement. I don't know how much we want to publicize that because I'm instructed to sell, so we made it too easy. My phone call will ring from my management saying, "You're not so necessarily needed anymore." You're very right. This isn't a cost per cost type of sale. It's a very heavy engineering specific type of sale. So it requires people like Rax and Denis who have 20, 30 years of experience. So you're absolutely right. It's pretty difficult to look at a design guide or a couple of technical data sheets and come up with a stackup. It does really require some engineering support on our side, our tech support from both the PCB shop and Ventec itself.

Starkey: Thanks, Chris. I say once more, I apologize for asking the awkward questions. You've given some very realistic answers. I'm very grateful.

Shaughnessy: Do any of you have anything else that you want to add? This has been really great.

McCarthy: I wanted to add that Ventec is looking out to the future, and our 5A2 material is actually familied by UL with our VT 47 materials. From a PCB standpoint, the fabricator shop, and from the OEM standpoint, they can easily exchange a standard FR-4 design that they're having problems with and add some 5A2 to the certain parts of that design or to the entire design and end up with something that they can run through UL without any problem. It's just a matter of adding a letter. I just thought that would be something that I should add to let everybody know Ventec is trying to streamline processes, especially at the PC shop and the OEM.

Hanson: Very good point, Denis. And really from my standpoint, I feel like we've covered everything that I desire to cover it. The takeaway is Ventec has a full product offering, not just within thermal materials, but there's rarely an application out there that we can't cover with 100% Ventec products, all the way through. And so that we're flexible, we're creative. And we just want to share the word with the electronics industry that, achieving your thermal needs is very feasible these days. I thank you guys at I-Connect007 for allowing us to join. Andy, Pete, it's good to see you both.

Starkey: Thank you for being so open in a discussion. It is really appreciated. And maybe we can meet in person in the new year.

Shaughnessy: All right, thank you all for joining us!


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