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Bodo´s Power Systems®

Electronics in Motion and Conversion

August 2015

o-f.de

COMPARISONS

are always
interesting!

VARIS™ – the modular inverter system

Thanks to its modular and flexible design, VARIS™ offers compelling benefits. The desired power can be easily achieved via parallel connection of the modules. You are also free to choose your preferred cooling type. And the use of standard components makes VARIS™ both cost-efficient and sustainable. Talk to the House of Competence, because VARIS™ fears no comparison. Even with your current inverter systems, right?

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- **Parallel connection**
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- **Compatible rectifier VARIS™ R**
- **Compact and powerful with VARIS™ XT**

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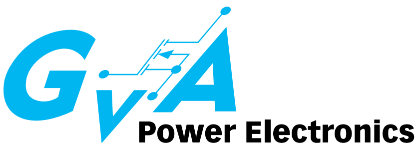

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www.electronicon.com

Your ideas – Our design

Large capacitors are often the most economical option for your high-power application. ELECTRONICON has over 75 years of experience in capacitor manufacturing and more than 70 years of experience in film metallization processes. This expertise puts us in an ideal position to service any capacitor requirements for applications up to 25kVDC/10kVAC and beyond:

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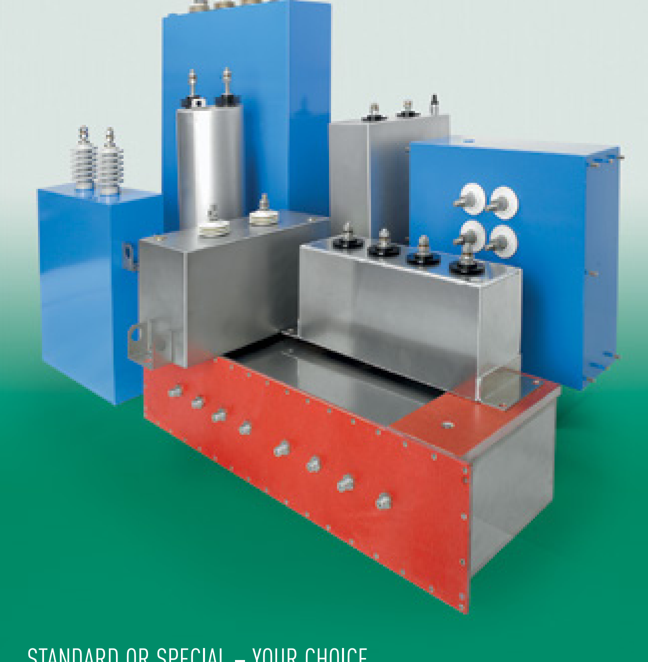

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The Gallery

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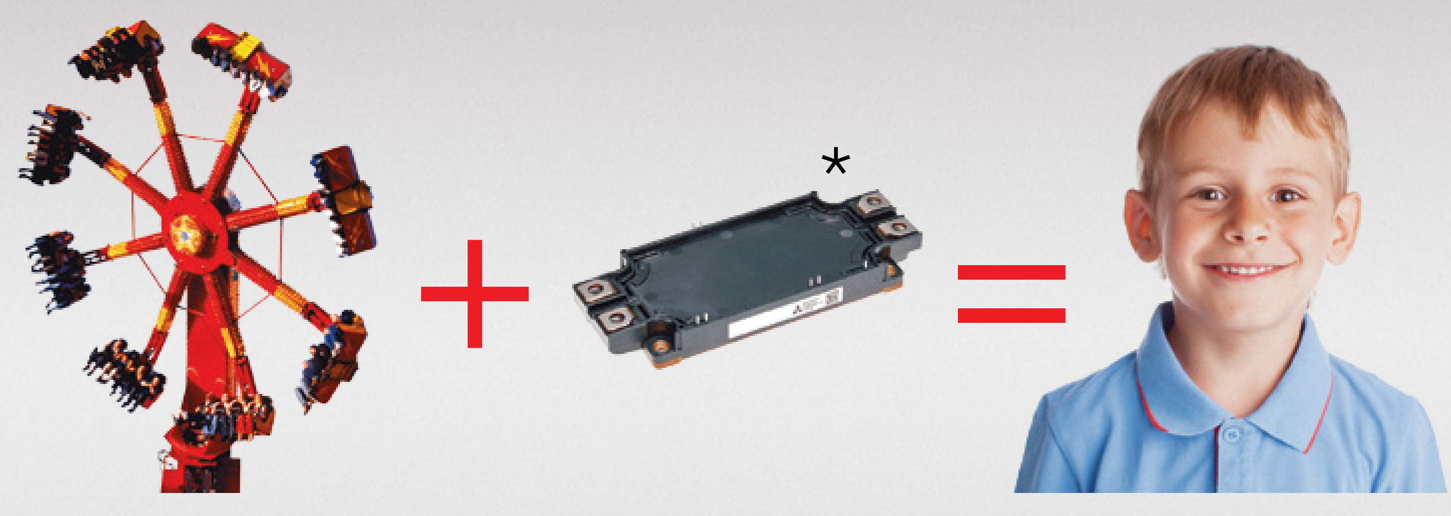

Always first-class results: Power Devices from Mitsubishi Electric.

Precise and efficient control of dynamic processes puts heavy demands on the components used. When it counts, power devices from Mitsubishi Electric are always first choice. Because, in addition to many innovations, they consistently provide added quality, performance and robustness – and therefore reliably ensure first-class results.

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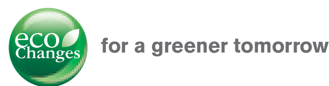
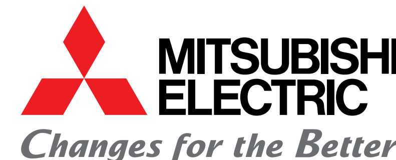


More information: semis.info@meg.mee.com / www.mitsubishichips.eu



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Events

Thermal Management,
Denver CO, August 5-6
http://www.thermalnews.com/conferences

EPE ECCE 2015,
Geneve, Switzerland, September 8-10
http://www.epe2015.com/

Electrical Fuses 2015
Dresden, Germany, September 14-16
http://www.icefa2015.com/

EU PVSEC 2015,
Hamburg, Germany, Sept. 14-18
http://www.photovoltaic-conference.com

HusumWind 2015,
Husum, Germany, September 15-18
http://www.husumwind.com

A World of Freedom and Peace

Is it a dream that never will be true? I was born during a time of peace and freedom in my small region. As a child I watched the results of the war, with Germany separated into two countries. And during my life I saw the re-unification of Germany.

Looking around the world we see a lot of conflicts. We hear of journalists who are abused and prevented from doing their work. It is not everywhere that subjects can be reported freely.

Freedom of publishing is essential everywhere in the world, a free press is the instrument of democracy, and journalists must be respected for their work. Even countries that seem to have freedoms, sometimes work against human rights. Freedom of expression, and for those who publish, insure that we are able to sustain basic human dignities. It is just not acceptable that journalists are punished for reporting the truth. History has shown that repression of the press marks the beginning of disastrous regimes. I wish that all my readers could support such freedoms and peace for all journalists - as befits their responsibility.

As engineers we can make progress in ways different than political. We can develop technology that generates better lives, while conserving our sources of energy. Semiconductors have been changing our world so significantly and so rapidly that we need to watch how sustainable these innovations are. I have a VW beetle, model 74, and it still runs well after 41 years. Most machinery is obsoleted well before this which can be a good thing, as my modern car in daily use does so much better in fuel consumption than my old beetle. This is a result of applying modern electronics which developed in the last several decades. Electrical and electronic components in a car have increased from 10 percent to more than 30 percent today. The full electric car, of course, surpasses this, but the trend continues for all types.

In the second half of the year we have important conferences and shows addressing the production of semiconductors - like SEMICRON and productronica. These conferences highlight the improvement in semiconductor manufacturing that we have come to rely upon.

We have delivered eight issues this year. All technical articles are archived on my website and are also retrievable at PowerGuru. Bodo's Power Systems reaches readers across the globe. If you speak the language, or just want to have a look, don't miss our Chinese version: www.bodoschina.com

My Green Power Tip for August:
Having a swim in the Baltic every morning can replace the mandatory shower. This reduces water demand and the energy to heat it up. While this works during our summer, I have seen pictures of people in Moscow doing it in winter. Brrr.

Regards

KEEP UP WITH THE TIMES

LF xx10

Current transducer range
Pushing Hall effect technology to new limits

To save energy, you first need to measure it! To maximise energy savings, you need to measure the current used accurately!
By using the most advanced materials available, LEM's new LF xx10 transducer range breaks new ground in accuracy for Closed Loop Hall effect transducer performance.
LEM ASIC technology brings Closed Loop Hall effect transducer performance to the level of Fluxgate transducers and provides better control and increased system efficiency, but at a significantly lower price.
Available in 5 different sizes to work with nominal currents from 100 A to 2000 A, the LF xx10 range provides up to 4 times better global accuracy over their operating temperature range compared to the previous generation of Closed Loop Hall effect current transducers.
Quite simply, the LF xx10 range goes beyond what were previously thought of as the limits of Hall effect technology.

- Overall accuracy over temperature range from 0.2 to 0.6 % of I_{PN}
- Exceptional offset drift of 0.1 % of I_{PN}
- Fast response time less than 0.5 µs
- Higher measuring range
- 5 compact sizes in a variety of mounting topologies (flat or vertical)
- Immunity from external fields for your compact design
- 100 % fully compatible vs LEM previous generation
- -40 to +85 °C operation

www.lem.com

At the heart of power electronics.

World's First Sintering Preforms Presented by Alpha at PCIM, Nuremberg

Alpha, the world leader in the production of electronic soldering materials, introduced its latest product offering for Die Attach applications, including a world first for Sintering at the PCIM show in Nuremberg, Germany, on the 19th-21st May. Alpha's new ALPHA® Argomax® 9000 Preforms are a world first for the Power Semiconductor Industry. These innovative preforms deliver superior thermal conductivity, ultra high reliability and excellent electrical conductivity. They have shown excellent performance in large area attachment and can help to simplify the manufacturing process.

Alpha's Global Product Manager for Sintered Materials, Julien Joguet attended PCIM for Alpha, "This year we launched one of our most innovative products at PCIM, the ALPHA® Argomax® 9000 preforms. Up until now ALPHA® Argomax® has only been available in both paste and film formats, but now we are the first to introduce a sintering product in a preform format to widen our product portfolio and extend the superior capabilities of Argomax®."

Alpha was also joined by representatives for Besi and Boschman on the stand which allowed for practical demonstrations of Alpha products on equipment such as pick and place machines.

For more information on Alpha and our Die Attach Products please visit our site or contact Julien Joguet at jjoguet@alent.com.

www.alpha.alent.com

Registration Opens for Microchip's European MASTERs

Microchip Technology announced that registration is open for its European MASTERs Conference at HTW - Berlin, Germany. 15th-17th September 2015 at HTW Berlin; Classes Available for All Experience Levels, From Beginner to Expert

The European MASTERs Conference is a valuable resource for designing with Microchip's products. It provides design engineers with an annual forum for sharing and exchanging technical information on the Company's 8-, 16- and 32-bit PIC® microcontrollers, high-performance analog and interface solutions, dsPIC® digital signal controllers, wireless and mTouch® sensing solutions, memory products, and MPLAB® development systems - including the industry's only singular IDE to support an entire 8-, 16- and 32-bit microcontroller portfolio.

This three day conference offers a selection of more than 50 classes that cover a broad range of topics, taught by Microchip's application and design engineers as well as selected industry experts. Learn from these experts and leave with everything needed to get up and running on new designs. Lectures, hands-on classes and unique Open Experts Lab sessions will cover a wide range of embedded control topics including new products and peripherals, C programming, firmware design, connectivity sessions on TCP/IP, USB, CAN and Bluetooth, graphics and capacitive-touch interface development, intelligent power supplies, motor control, selecting op-amps for sensor applications using an RTOS and low-power system design.

http://www.microchip.com/eumasters

Call for Papers: Your Chance to take Part in PEMD 2016 – Power Electronics, Machines and Drives

The IET is pleased to invite Bodo's Power Systems readers to take part in the programme of one of the world's most important power electronics conferences. With over 400 engineers expected to attend, PEMD 2016 is the ideal opportunity to showcase your latest research and results with power electronics, machines and drives specialists. Successful authors benefit from a slot in the conference programme, plus significant publication opportunities including indexing on IET Inspec and the IET Digital Library and submitted to IEEE Xplore. Make sure you don't miss out!

Key conference themes:

- Power electronics
- Machines and drives
- Transportation
- Renewable energy systems
- Generation, transmission and distribution
- Industrial processes and applications

See the full technical scope and submit your abstract online by 4 September 2015 at:
www.theiet.org/pemd
http://conferences.theiet.org/pemd/index.cfm?origin=bodos-power.

www.theiet.org/pemd

German Chancellor Angela Merkel visits state-of-the-art chip manufacturing plant of Infineon Dresden

German Chancellor Dr. Angela Merkel visited Infineon Technologies Dresden GmbH today as part of her tour through the Dresden microelectronics cluster. She was accompanied by the Federal Minister of Education and Research Prof. Dr. Johanna Wanka and the Prime Minister of Saxony Stanislaw Tillich. Together with Dr. Reinhard Ploss, CEO of Infineon Technologies AG, they discussed the political framework for a competitive development and production in Germany.
Reinhard Ploss stressed: “Our investments in research, development, and production guarantees our competitive position and, with that, our success for tomorrow. The constant innovation success and growth of Infineon’s Dresden site demonstrably proves it. The integration of Infineon into Silicon Saxony and the conducive political conditions here are very helpful,” said Ploss.
Infineon runs its largest and most modern manufacturing and technology development center in Dresden with roughly 2,000 employees. The Chancellor was given a view into a real up and running Industrial 4.0 production via a live broadcast into the factory. This allowed her to exchange ideas directly with the company’s employees. The visit was rounded off by a demonstration in the Analysis and Characterization Laboratory, in which the chip structures can be examined via transmission electron microscope down to the atomic layer level.
In the past five years, Infineon has invested around €600 million in Dresden. On the one hand, the funds were allocated to the manufacturing of 200mm silicon wafers. Today, that production is the most highly automated 200mm production anywhere in the world. And on the other, Infineon is currently building the world’s first high-volume production of power semiconductors on 300mm thin wafers in Dresden. The semiconductor manufacturer is also planning on investing several hundred million euros in the coming years.

www.infineon.com

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Transphorm Announces New $70 million Investment Led by KKR

Transphorm Inc, an early stage semiconductor company focused on redefining power conversion, announced a $70 million investment round led by global investment firm KKR. KKR's investment follows initial rounds of funding from funds affiliated with Kleiner Perkins Caufield and Byers, Foundation Capital, Google Ventures, Soros Quantum Strategic Partners, INCJ, Fujitsu. Transphorm will use this funding to support its growth, product innovation and expansion.
Dr. Umesh Mishra, Chairman of Transphorm Inc, stated: "Transphorm was launched to address the urgent and important problem of losses in power conversion, a process that converts electricity from the form it is delivered to the form that is ultimately used. We are delighted KKR has chosen to invest in Transphorm. By merging the technological leadership of Transphorm with the semiconductor business expertise of KKR, we are taking a major step forward in solving the global problem of energy wasted in power conversion."

Transphorm believes that there is a very large market for its products as its ultra-efficient power devices and modules can eliminate more than 40% of all electric conversion losses by using Gallium Nitride ("GaN"), a new semiconductor material that switches at far higher speeds than traditional components. GaN-based technology, known for its connection to the 2014 Nobel Prize in Physics, creates a brighter, more energy efficient light that today is the basis of the multi-billion dollar LED-based lighting industry. Similarly, when applied to power conversion, GaN components enable significantly more efficient, compact, and cost-effective products.

www.transphormusa.com

www.kkr.com

10th International Conference on Electric Fuses and their Applications

The International Conference on Electric Fuses and their Applications to be held in Dresden 14th -16th September 2015, is the 10th in a series of conferences which began in 1976. Electric fuses play a vital role in the protection of low, medium, and high-voltage power systems, power electronic systems, electric vehicles, renewable energy systems and many other areas. The ICEFA conference provides a platform for researchers, manufacturers, users, and those involved with safety standardisation to share and discuss the latest developments.
A part of this event will be:
Future autonomous distribution grids - Fuses in a new environment
The large scale integration of powerful and volatile energy sources but also applications into the distribution grid requests the transition from a static to a dynamic grid. Local autonomous congestion management is the key for the implementation of such a smart grid.
With limited information of voltage and current in the grid a smart decental controller, installed in the ring main unit, is able to detect all voltage band infringements and overcurrents. Autonomously, the controller is using suitable grid components but also specific demand and generation devices to bring the system back in the stable state. Compared to a conventional static grid the transport capacity is nearly doubled. Since two years, this smart grid solution is in operation in two low voltage grid areas in Frankfurt. Currently, the transformation of this principle into the medium voltage level is in preparation. More and more active grid components are integrated into the system.
The standardisation process is ongoing. Also, the interaction with the smart market is being analysed. Based on such an active system management scenario, the future roll of traditional fuses is analysed and recommendations for the further development of fuses are given.

http://www.icefa2015.com

PCIM Asia 2015 Favorable Participant Reviews

PCIM Asia, an international exhibition and conference for power electronics, intelligent motion, renewable energy and energy management wrapped up on 26 June at the Shanghai World Expo Center with great success. The three-day events, which ran from 24 – 26 June, welcomed 77 exhibitors while covering 5,300 sqm of exhibition space. The fair, held concurrently with the inaugural SPS Automation Shanghai, attracted a total of 4,911 visitors, representing 12% increase over 2014, from 27 countries and regions who were able to source items including the latest semiconductors, passive components as well as power and thermal management systems. Whether they were involved in distribution or were sourcing for upcoming projects, buyers were offered an impressive array of technologies and solutions to meet their needs.

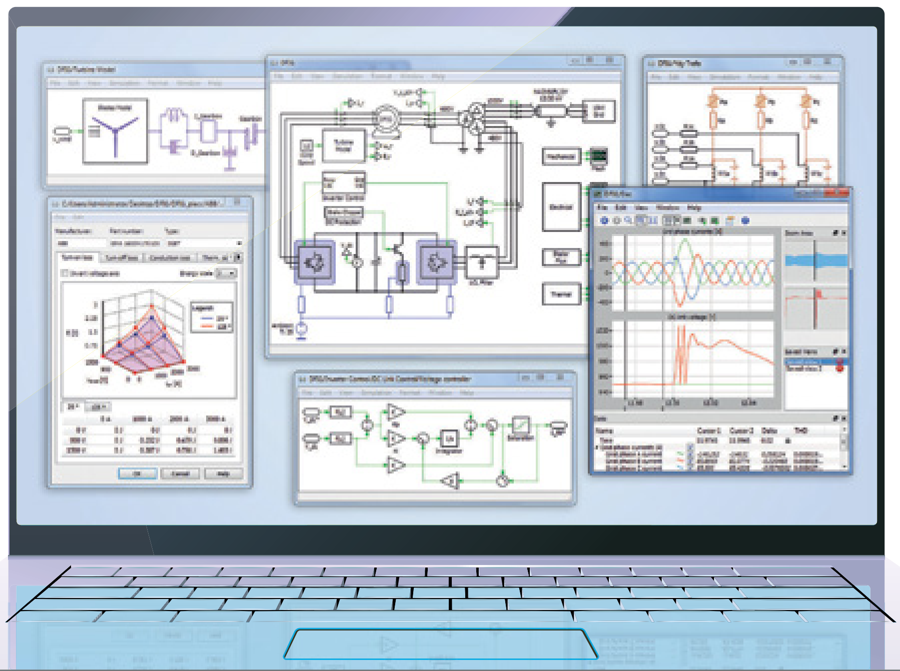
www.pcimasia-expo.com

LpS 2015 - Outstanding Conference Program Released

Luger Research, the organizer of the LED professional Symposium +Expo 2015 (LpS 2015), is proud to present a high-class, future-oriented conference with 60 technical presentations and 7 workshops. The annual Symposium and Exhibition is a well-known international hub for innovation and developments in the fields of LED & OLED lighting technologies. This year marks the fifth anniversary of the event. It will take place from September 22nd to 24th.
Even though there have been many cutting edge inventions during the past few years, developments in the fields of Human Centric Lighting and Internet of Things keep the fundamental change process in the lighting industry going. Lighting systems, and therefore components and modules, need to be more efficient for less cost. Controls have to be smarter and systems need to be connected and more intelligent. "We believe that lighting technologies will drive innovations and therefore a highly-focused technology event is required to understand and forecast next generation lighting systems", said Siegfried Luger, Event Director and Program Manager of the LpS 2015.

www.led-professional.com

THE SIMULATION SOFTWARE PREFERRED
BY POWER ELECTRONICS ENGINEERS



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Monolithic Power Systems Signs Digi-Key to Expand Globally

Monolithic Power Systems announced that MPS has signed a distribution agreement with Digi-Key Electronics, a leading, global, full-service provider of electronic components, for the promotion and sale of MPS products worldwide. MPS' mission is to reduce total energy consumption in its customers' systems with green, practical, compact solutions.

"We are very excited to partner with Digi-Key. I believe that MPS delivers best-in-class products and partnering with Digi-Key allows us to utilize their extensive engineering network and world class distribution capabilities to accelerate our customer acquisition," says Maurice Sciammas, EVP WW Sales. "I am confident that this new alliance will help expand MPS' customer base globally."

"MPS manufactures a broad range of high-performance power solutions that have the potential to be designed into many new applications," said David Stein, Digi-Key Vice President of Global Semiconductors. "Digi-Key strives to offer design engineers every option available for their design, so we are excited to carry MPS' power solutions that have many uses found in industrial applications, telecom infrastructures, cloud computing, automotive, and consumer applications."

www.monolithicpower.com

www.digikey.com

Smart Systems Integration Call for Papers 2016

The event, which will take place in Munich, Germany from 9 – 10 March 2016, will be once again the key platform for the Smart Systems Integration industry to meet and discuss current issues. Deadline to submit abstracts is 5 October 2015.

The conference committee, led by Prof. Dr. Thomas Gessner, Fraunhofer Institute of Electronic Nanosystems (ENAS), Chemnitz, Germany, looks forward to receiving submissions in English.

The conference addresses innovative smart systems, their manufacturing technologies as well as the international research work on smart technologies and materials. Special attention is paid to integration issues in order to guarantee reliability, safety and security of the systems.

Within the keynote sessions special focus is set on the two main topics "Hardware for the Internet of Things" and "Printed / stretchable and flexible electronics".

The Best Paper and Best Poster Award will be also awarded in 2016, each doped with a prize of 500 Euro.

The Call for Papers submission requirements and further information are available online at:

www.smartsystemsintegration.com/callforpapers

productronica Celebrates its 40th Anniversary

Smartphones, tablets, laptops: It's difficult to imagine life without these devices. productronica, the world's leading trade fair for electronics production, has contributed to the fact that these products exist today. After all, producing electronic devices that are this complex is only possible thanks to the constant ongoing development of production equipment and, with it, the electronics-manufacturing sector. productronica is celebrating its 40th anniversary in November. The secret to its success: Together with the industry, it has been setting new standards to promote future innovations time and again since 1975.

You may find high-resolution photo materials here. Additional information about productronica 2015 is available online at

www.productronica.de

Dave Freeman Passed Away in Early July

David Freeman has been a Texas Instruments Fellow and CTO for TI's high-voltage power business. His 40-year career has always focused on energy sources and energy management. He helped start Benchmarq Microelectronics and served as director of systems and applications. Benchmarq was noted for their battery management semiconductor products. In 1998, Unitrode Corporation, a leader in power management, acquired Benchmarq, and David became the systems and application director for the combined company. In 1999, Texas Instruments acquired Unitrode and David became the applications manager for TI power products.

David was a popular expert in his field who has presented at many conferences around the world, including in the U.S., Europe, China and Japan. He has written multiple technical papers and a monthly column in a publication targeted to electrical engineers. Many patents in battery technology and power management have been credited to David's efforts.

In order to focus more on advanced power technology development, David helped establish TI's Power and Energy Systems Lab inside of TI's Kilby Research Laboratories. He has currently transitioned to help start TI's High Voltage Power Solutions business as CTO.

David has a BS degree in physics from Midwestern University.

www.ti.com

Capacitors for Power Electronics

IGBT Snubbers
RF Mica Capacitors
DC Link Capacitors
-High Current, High Voltage Film
-High Capacitance Aluminum Electrolytic
AC Output Harmonic Filter Capacitors

www.cde.com

First Current-Sense Amplifier with Integrated High-Precision, Low-Drift Shunt Resistor

Device reduces calibration effort, system cost, and footprint for test and measurement, communications load monitoring, and power supplies

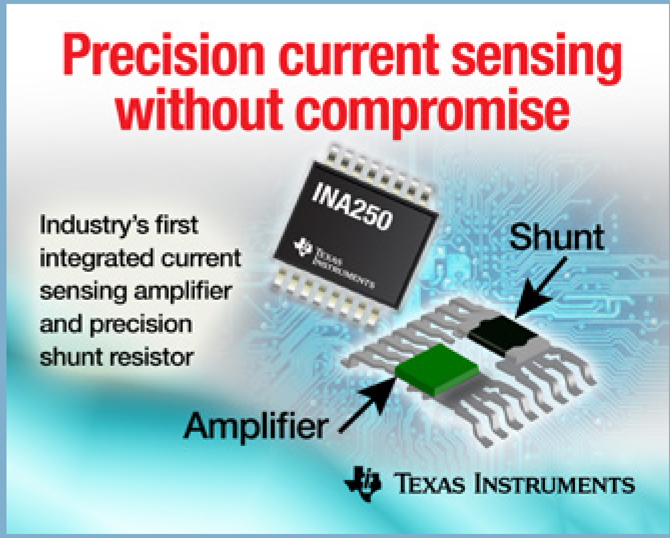
Texas Instruments introduced the industry's first current-sense amplifier to integrate a high-precision, low-drift shunt resistor, which can deliver highly accurate measurements over a wide temperature range. TI's INA250 integrates the shunt resistor with a bi-directional, zero-drift current-sense amplifier to support both low-side and high-side implementations. Its accuracy and low drift reduce or may eliminate designers' calibration effort for many systems. This integration also enables lower system cost and a smaller board footprint compared to competitive solutions. For more information about the INA250 current-sense amplifier, see www.ti.com/ina250-pr-eu.

By enabling high-accuracy measurement along with low system cost and a small board footprint, the INA250 current-sense amplifier delivers higher performance to applications such as test and measurement, communications load monitoring, and power supplies. Test and measurement designers can achieve required performance levels and potentially eliminate calibration while reducing cost up to 76 percent. High-performance enterprise and telecom equipment designers can achieve distributed measurement to maximize system efficiency and enhance system management.

Key features and benefits of the INA250 current-sense amplifier

- Industry's most accurate integrated solution:
- The integrated 2-milliohm shunt resistor offers 0.1 percent tolerance as well as low drift of 15 pmm/°C from -40oC to 125oC, enabling higher performance of the end equipment.
- The amplifier offers offset current of 12.5 mA with temperature drift of 250 µA/oC and gain drift of 30 ppm/°C.
- The integrated packaging technology ensures an optimized Kelvin connection between the IC and the resistor.
- The amplifier enables a maximum error of 0.75 percent over the temperature range of -40°C to +125°C.
- Reduces system cost up to 76 percent and the board footprint up to 66 percent compared to competitive solutions by integrating the shunt resistor.
- Low power consumption: Maximum power consumption of 300 µA minimizes the load that the measurement methodology adds to the system.

Tools and support to speed design
The INA250 evaluation module (EVM) enables designers to quickly and easily evaluate the device's accuracy. The INA250EVM is available from the TI store and authorized distributors for US$49. INA250 TINA-TI and TINA-TI Spice models are available for download.



Support is available in the TI E2E™ Community Current Shunt Monitors Forum, where engineers can search for solutions, get help, share knowledge and solve problems with fellow engineers and TI experts.

Package, availability and pricing
The INA250 current-sense amplifier comes in a 5-mm-by-6.4-mm thin-shrink small outline package (TSSOP). It is available now, priced at US$1.40 in 1,000-unit quantities. Three other gain options will be available in 4Q15, allowing designers to optimize full-scale output voltage based on the target current range.

The INA250 is the latest addition to TI's growing portfolio of innovative current-sense amplifiers that offers a leading combination of power, size and accuracy. See TI's entire current-sense amplifier portfolio.

Learn more about TI's current-sense amplifiers

Read blog posts about designing with current-sense amplifiers.

Watch training videos about the INA250 current-sense amplifiers.

Learn about TI's innovative sensing portfolio.

www.ti.com

Silicon Carbide:
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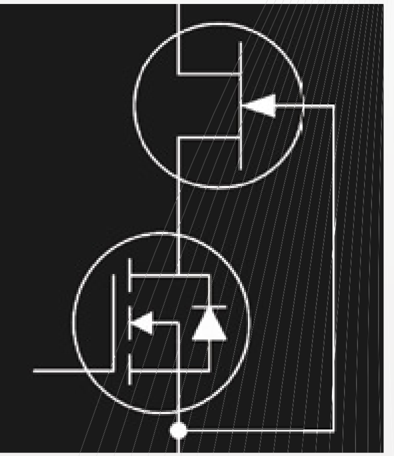

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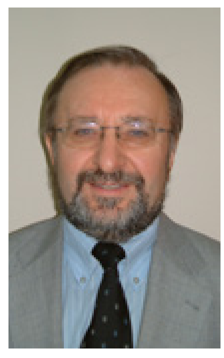
China - a Challenging but Important Market Place for Power Electronics

By Prof. Dr. Leo Lorenz, ECPE



Also there is a slowdown in same market segments this year China remains the most dynamic, extremely competitive but also challenging marketplace for all power semiconductor devices and power electronic products in the world. The new Government is almost two years in office and there are clear signs that they focus very strong on Energy related topics e.g. wind power, solar power, energy transmission lines and storage units, extending the network of High Speed Trains and pushing for E-vehicles in the big Cities.

With the merger of CSR (China South Railway Coorp.) and CNR (China North Railway Coorp.) China will became an extremely strong and very competitive player for offering High Speed Rail Systems on the world market. To satisfy the fast growing economy the increasing demand of electrical energy to a great extend is coming by new build nuclear station. This enables China to develop advanced technologies in this field and hence elevate to a leading nation exporting nuclear power plants to the world market.
In several fields of applications covering power electronics such as High Speed Trains, Renewable Energy Technologies, Motor Control and Power Quality Control units as well as Power Supplies in all telecom and consumer equipment China elevated within one decade only to an extremely attractive country to become a key technology player around the world. Now this is attracting many SME's and big companies from Europe, USA and Japan to provide their services and technologies with localized production capabilities.

However there are still some key technologies lacking to satisfy the value added chain for all power electronics converter e.g. power semiconductor technologies. This was recognized by the NDRC (National Development and Reform Commission) Ministry about 10 years and triggered a huge funding program by MOST (Ministry for Research) and MIIT (Ministry for Industry and Information Technology) to motivate Research Organizations (Universities & Research Centers) and Industries to direct research, developments in power devices (mainly IGBT's) and build up appropriate production capabilities. Within the last 5 to 8 years this happened to a great extent that today there are several players on the market producing IGBT power modules and manufacture standard Si-IGBT Chips. Along with this activity CSR took over Dynex Cooperation UK- a leading UK company for high power IGBT dies - and established a high tech 8 inch production line for IGBT chips. This production facility is equipped with the newest processing equipment enabling CSR to produce state- of the Art IGBT chips and high power packages.

Due to the cooperation and technology transfers with leading players in USA , Europe and Japan, in many aspects, within 15 years only, China picked up to the top nations in some important technologies, e.g. Transportations Systems, Energy- , Communication- , and Consumer Technologies but also in Education e.g. Elite- Universities with excellent Infrastructure and dedicated Research Centers. While 15 years ago only 15% of the students had a reasonable skill the English language today, this is more than 80%.

However some cultural related issues are still very different between China and the western countries. Just to mention a very few: the decision making process, the problem handling capability, the people management hierarchical structure, logistic management and how to serve the customer are very different between these nations. For this reason still both mentalities have to learn a lot from each other to minimize the misunderstandings. But on the other side I hope this remains different to keep the attractivity of the individual cultures.

In 2015 the PCIM Asia took place from June 24th to 26th in Shanghai and attracted experts from Industry and Academia in the 14th year for a dedicated and highly recognized conference and exhibition in the field of Power Electronics. The PCIM in China is having a continuous, robust growth rate and in the meantime it belongs to the most important technical platforms for researchers, product development engineers as well as decision makers and marketing specialists to detect new business opportunities. This exhibition and conference has had an excellent developed over the years to become a prestigious forum to exchange information and create new business opportunities along the main stream of power electronic system development. The conference itself is supported by a dedicated Advisory Board Members consisting of distinguished Professors from Universities and Industries from China, Japan, Korea and Europe.

The PCIM Asia this year addressed key development trends in advanced power converters, future power semiconductor devices, renewable energy technologies and E-Mobility. The 2 keynote presentations are "SiC Power Semiconductor Devices for environmental friendly E-Vehicles" by Dr. Kimimori Hamada (Toyota Motor- Cooperation, Japan) and "Driving Transport Electrification" by Prof. Chris Gerad (Univ. of Nottingham, UK) highlighted important future direction for improving our environment. A special industrial session on Power Devices for Transportation systems and Renewable Energy Technologies attracted many participants from Industries, Universities and Research Centers.
The recipients for the Best Paper Award this year where Keiichi Higuchi from Fuji Electric Japan on a "New Type of Power Module for E-Vehicle" (Sponsored by Mitsubishi) and Mukai Hao from China Electric Power Research Institute on "Electric Energy storage in Wave Power Integration" (Sponsored by Semikron), the Young Engineer Award was devoted to Dr. Hong Yao Long from University of Sheffield UK on "New Generation of Clustered IGBT with High Ruggedness" (Sponsored by LEM).

The PCIM Asia with 14 years history in China is a brilliant example of how to outperform in this high competitive Chinas Market. The PCIM 2016 is now open for setting up a comprehensive technical program for attracting experts from industry and academia around the globe. Try and come, you will benefit.

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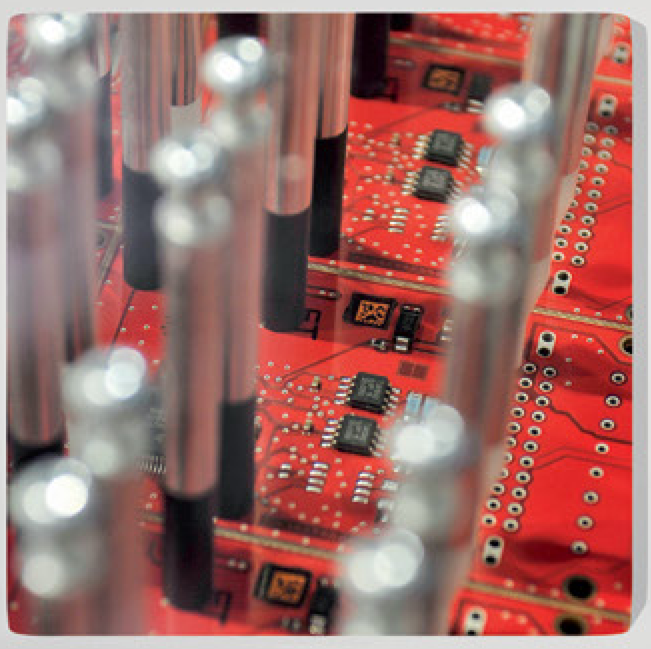

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Electronics Industry Digest

By Aubrey Dunford, Europartners

SEMICONDUCTORS
Cypress Semiconductor and Uphill Investment continue to evolve their respective offers to acquire Integrated Silicon Solutions (ISSI). As a result of the last amendment, the merger consideration with Uphill was further increased to $ 22.00 per share in cash. ISSI and Uphill amended the Uphill agreement after Cypress announced that it had submitted a revised offer of $21.25 per share.

Acsiel, the French components association, reports that Q1 2015 semiconductor sales in France were up 21 percent on a euro basis compared to Q114 and up 15.5 percent sequentially, at € 531.6 M. Sales to the OEMs were up 14 percent, representing 72.5 percent of the total. Sales to distribution were up 19 percent, at € 146.2 M.

The European Commission is launching three new research projects aimed at making electromobility cheaper, more efficient and more reliable in order to facilitate more environmentally-friendly vehicles on Europe's roads. Europe will be the site for the continued development and production of electric vehicles under these projects, which will run until 2018 and are headed by Infineon Technologies.
70 partners with a total of 120 researchers from 15 countries, and representatives of ECSEL Joint Undertaking, the European Union, the European Commission and the German Federal Ministry of Education and Research will participate to the three research initiatives, with total funding of about € 67 M. The entire automotive value chain is contributing to this effort, from chip producers to car manufacturers. In electric vehicles, on average about 50 percent more electronic components and semiconductors are installed compared to vehicles featuring combustion engines.

Intel CEO Brian Krzanich confirmed recent reports of layoffs in a company-wide email sent out last week, The Oregonian reported. "Yes, we are implementing headcount reductions," he wrote in the internal memo. Krzanich didn't specify the exact number of layoffs.

Crocus Technology, a French supplier of magnetic sensors and embedded memory solutions designed with Magnetic Logic Unit (MLU) technology, a disruptive CMOS-based rugged magnetic technology, has secured € 19 M in funding.

Worldwide semiconductor manufacturing equipment billings reached $ 9.52 billion in the first quarter of 2015, so SEMI. The billings figure is 7 percent higher than the fourth quarter of 2014 and 6 percent lower than the same quarter a year ago.

OPTOELECTRONICS
Aledia, a French developer and manufacturer of next generation 3D LEDs based on its Gallium-Nitride-on-Silicon platform, announced the closing of its Series B financing round and the execution of development and supply contracts with major LED buyers. The round, totalling up to € 28.4 M, includes new investments from Valeo, the world's second-largest supplier of car lighting systems and IKEA. Based in Grenoble, Aledia is a pioneering developer of next-generation LEDs based on its disruptive WireLED nanowire technology, which allows manufacturing of 3D LEDs on 200mm or larger wafers in existing CMOS foundries, and their straightforward integration with electronics.

Samsung Display unveiled the industry's first mirror and transparent OLED display panels. Samsung Display's advanced OLED display panels will open up new possibilities for optimizing the potential for visually interactive computing technology.

PASSIVE COMPONENTS
Emilio Ghilardi will join Kemet as Executive Vice President of Global Sales and Marketing, effective July 1st, reporting to Per Loof, Chief Executive Officer. He will be based in Silicon Valley.

German PCB manufacturers' revenues for April were up by 1.2 percent year-on-year, so the Zvei. Total revenues for the first four months of the year were down by 1 percent compared to the same period last year. While medium sized companies fared well during the period, smaller manufacturers had to cope with single-digit percentage declines. New orders in April were 3.1 percent higher than last year.

OTHER COMPONENTS
Keysight Technologies announced a recommended cash acquisition of Anite, a U.K.-based supplier of test and measurement solutions to the international wireless market. At 126 pence per share, the acquisition values Anite at approximately £ 388 M ($ 606 M). This cash acquisition has been unanimously recommended by the board of directors of Anite.

Synopsys, a global supplier in electronic design automation (EDA), semiconductor IP and in software quality and security testing, has signed a definitive agreement to acquire Atrenta, a provider of SoC realization solutions for the semiconductor and consumer electronics industries. By integrating Atrenta's complementary static verification and implementation technology with its verification and design platforms, Synopsys can offer a more comprehensive, robust portfolio of silicon to software solutions for today's complex electronic systems. The terms of the deal are not being disclosed.

DISTRIBUTION
Mouser Electronics has received more than 20 Top Performance Awards from its manufacturer partners for 2014.

Digi-Key Electronics announced a global distribution agreement with FLIR Systems.

3ctest, a Chinese supplier in EMC instrumentation, appointed AR Europe as their exclusive distribution partner in Europe for their pulsed EMI products.

This is the comprehensive power related extract from the «Electronics Industry Digest», the successor of The Lennox Report. For a full subscription of the report contact:
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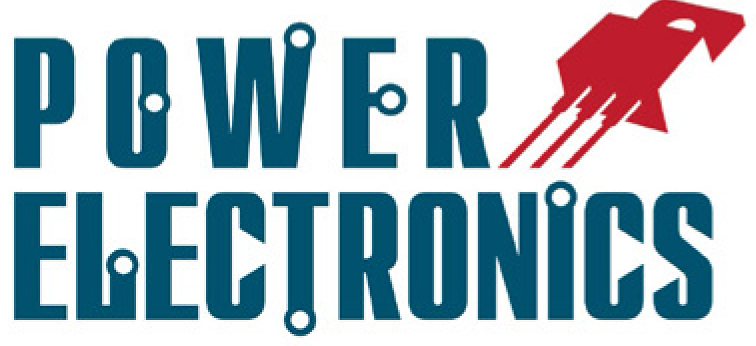

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Let’s Get Social in China

By Gavin Hsu, i2i Group China / Bodo’s Power Systems China

When you think of social media, what comes to mind? Facebook? Twitter? Instagram? Of course, these social media platforms are being used by people to socialize, but increasingly these platforms are being used for business development and promotional purposes. This is happening every day, in every country and in almost any industry and of course including the power electronics industry.

As a new media format, social media is increasingly complementing traditional media and other marketing. Combining online and off-line to your marketing plan increases your sales leads and brand awareness.

The China market differs from the world in many ways. Most of the world’s most popular social media platforms are blocked and are not accessible in China. The leading social media platforms in China are WeChat, Weibo and QQ Zone. I bet you’ve never heard of any of them.

WeChat or WeiXin as it is known in China, was introduced in 2011 by Tencent Technology and has now become the number one social media platform in China. As of the first quarter of 2015, 90% of Chinese smart phone users have downloaded and activated their WeChat platform. Over 549 million users are active on the WeChat platform every month. The average WeChat user uses the platform more than 40 times each day. Even though WeChat is produced by a Chinese company, they have members in over 200 countries around the world. The App is available in more than 20 different languages.

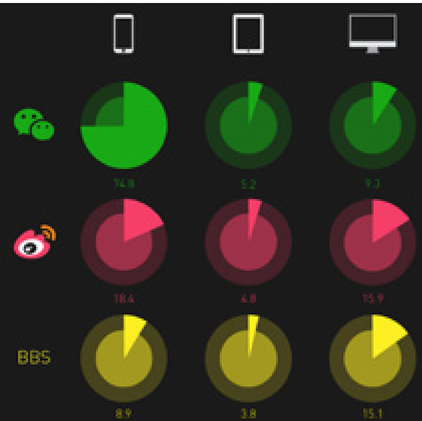

Figure 1: Device penetration for social media users (%)

Different from Facebook, Twitter or Instagram, WeChat offers a comprehensive universe, basically an intranet on the internet, including message pushing, sharing, video, photo, online shopping, a mini-website, user survey, payment process, membership programs and customer service embedding etc. You can think about Facebook or Twitter as being one room in the house and WeChat being the whole house.

Infineon: Infineon China launched its WeChat corporate account in June 2014. During the past year, its WeChat platform has become the primary interaction point for the company to communicate with its clients and product users. Infineon use the platform to introduce the latest product technology, invitations to events, recruitment and product information and data.

Figure 2: WeChat replaces QQ zone, Weibo experienced a significant drop

Since WeChat has really taken off in China, companies are increasingly using this powerful tool for marketing and promotion. Here are some examples of what power electronics companies in China are already doing with WeChat:

Mitsubishi: Mitsubishi Semiconductor China launched its WeChat corporate account in 2014. Providing product information, invitations to events, interactivity with product users, Mitsubishi also launched its “Cute” social media spokesperson, in Chinese named

Figure 3: Rogers video at Bodo’s China WeChat account

Figure 4: PCIM Europe message pushing at Bodo’s China WeChat account

Figure 5: IGBT video message pushing at Bodo’s China WeChat account

"Xia Ling Jiao", translated literally meaning little water chestnut shape. Cute is available online to inform customers about Mitsubishi's corporate concept and history.

ICkey: as a local Chinese online distributor, ICkey uses it's WeChat account to better service clients. Products can be ordered online through the WeChat platform. Customers can also track their order process, make payments with WeChat Wallet, interact with customer service and connect with other customers, all through the WeChat platform.

Last year, Bodo's Power China launched its own WeChat account. As of June 15, 2015, nearly 1200 power electronics engineers are presently using the account on a weekly basis.

The platform is used to connect advertisers with your readers. On May 29, we produced a message push and video for Rodgers Power Electronics, seen by 949 of the 1135 registered users, a nearly 85% response rate.
On May 20, we sent out a show report about PCIM Europe, receiving 580 reads from the 1097 users, more than 50% response rate.
On May 15th, we offered a IGBT push promotion for CSR company, achieving a 45% response rate.

WeChat is a power tool for connection, business, sales, and promotion and is going global. Bodo's Power China is at the forefronts of this new revolution. If you would like to learn about WeChat function and how it works, Bodo's Power China can provide consultancy services to you as well.

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Driving a Single-Phase BLDC Motor

How to use a low-cost microcontroller as a driver for a single-winding, single-phase brushless DC motor

In a low-power motor application, where cost is more important than complexity and torque requirements are reduced, a single-phase brushless DC (BLDC) motor is a good alternative to a three-phase motor.

By Mike Gomez, Application Engineer and Mark Pallones, Team Lead, Microchip Technology

This type of motor is low cost because of its simple construction, which is easier to fabricate. Also, it only requires a single-position sensor and a few driver switches to control and energise the motor winding. Therefore, the trade-off between motor and control electronics can work out favourably.

To maintain the cost effectiveness, a low-cost motor driver is needed. The driver circuit described here can exploit two feedback loops. The first, the inner loop, is responsible for commutation control, while the second, the outer loop, handles speed control. The speed of the motor is referenced to an external analogue voltage and fault detection can be sensed during over-current and over-temperature conditions.

Fig. 1 shows the single-phase driver based on Microchip's PIC16F1613 8bit microcontroller, chosen because of its low pin count and on-chip peripherals that can control the driver switches, measure the motor speed, predict the rotor position and implement fault detection. This application uses the following peripherals: complementary waveform generator (CWG); signal measurement timer (SMT); analogue-to-digital converter (ADC); digital-to-analogue converter (DAC); capture compare PWM (CCP); fixed voltage reference (FVR): timer; comparator; and temperature indicator. These peripherals are internally connected by firmware, which reduces the number of external pins required.

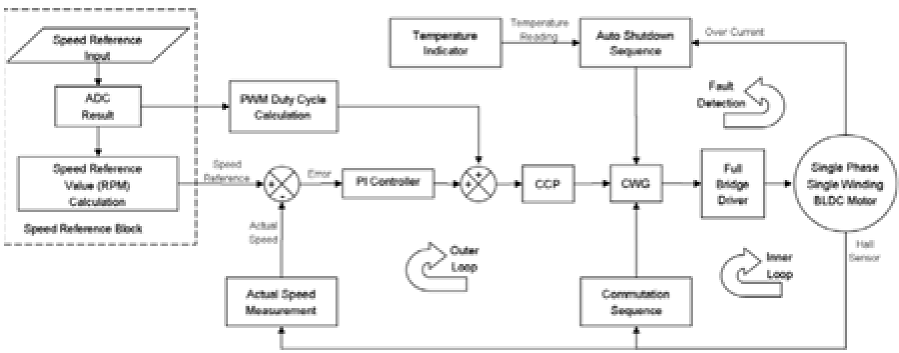

Figure 2: Control diagram of motor driver

The full-bridge circuit, which energises the motor winding, is controlled by the CWG output. A Hall sensor is used to determine the rotor position. Current that passes through the motor winding is translated into a voltage through the sense resistor Rshunt for over-current protection. The speed can be referenced in an external analogue input. Fig. 2 shows the control diagram of the motor driver; for this application, the rated motor voltage is 5V and rated speed 2400rev/min. The motor driver supply voltage is 9V. The speed reference can be any analogue input. The microcontroller's ADC module has 10bit resolution and up to eight channels, making its suitable for different kinds of analogue input. This is being used to derive the speed reference and the initial PWM duty cycle, used to initialise the speed of the motor based on the source of the speed reference.

The initial duty cycle can be increased or reduced by the result of the proportional-integral (PI) controller and the new duty cycle value loaded in the CCP, the PWM output of which is used as the initial source of the CWG to control the modulation of the lower side switches of the full-bridge driver and, hence, the speed of the motor.

Figure 1: Block diagram of single-phase BLDC driver

Inner loop

The inner feedback loop is responsible for commutation control. The CWG output, which controls the excitation of the stator winding, depends on the state of the Hall sensor output, which is compared with an FVR by the comparator. The comparator hysteresis is enabled to disregard the noise in the sensor output.

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The output of the comparator toggles between forward and reverse full bridge mode to produce clockwise or anti-clockwise rotation. The CWG output is fed to the switches' input of the full bridge circuit.
To produce one electrical cycle, a forward-reverse combination must be executed. One mechanical revolution of the motor requires two electrical cycles, therefore two forward-reverse combinations must be executed to complete a single clockwise rotation of the motor.

Full-bridge circuit

The full-bridge circuit in Fig. 3 is primarily composed of two p-channel MOSFETs as high-side switches and two n-channel MOSFETs as low-side switches. The main advantage of the p-channel transistor is the simplicity of the gate-driving technique in the high-side switch position, thus reducing the cost of the high-side gate-driving circuit.
Even though the high- and low-side switches can be switched on at the same time – cross conduction – this kind of switching should be avoided otherwise it will create a current shoot-through that might damage the driver's components. To avoid this, a dead-band delay can be implemented using the CWG's counter registers. This provides non-overlapping output signals that stop the high- and low-side conducting at the same time.
Ideally, the n- and p-channel MOSFETs should have the same on resistance (RDSon) and total gate charge QG to obtain the optimal switching performance. Therefore, while it would be good to choose a complementary pair of MOSFETs to match these parameters, in reality this is impossible due to their different construction; the chip size of the p-channel device must be two to three times that of the n-channel to match the RDSon performance. But the larger the chip size, the larger the effect of QG. Thus, when selecting the MOSFETs, it is important to decide whether RDSon or QG will have the biggest impact on switching performance and choose accordingly.

Fault detection

Exceeding the motor's maximum allowable torque loading can cause the motor to stall and the winding to take the full current. Thus, to protect the motor, fault detection for over current and stalling must be implemented.
To implement over-current detection, Rshunt is added to the drive circuitry, which gives a voltage corresponding to the current flowing in the motor winding. The voltage drop across the resistor varies linearly with respect to the motor current. This voltage is fed to the inverting input of the comparator and compared with a reference voltage based on the product of Rshunt resistance and the maximum allowable stall current of the motor.
The reference voltage can be provided by the FVR and can be narrowed down further by the DAC. This allows a very small reference voltage to be used, which lets the resistance be kept low thus reducing power dissipation from Rshunt. If the Rshunt voltage exceeds the reference, the comparator output triggers the auto-shutdown feature of the CWG, the output of which will remain inactive as long as the fault exists.
Over temperature can be detected using the device's on-chip temperature indicator, which can measure temperatures between -40 and +85˚C. The indicator's internal circuit produces a variable voltage relative to temperature and this voltage is converted to digital by the ADC. For a more accurate temperature indicator, a single-point calibration can be implemented.

Outer loop

The outer loop shown in Fig. 2 controls the motor's speed under varying conditions such as changes in load demand, disturbances and temperature drift. The speed is measured by the SMT, which is a 24bit counter-timer with clock and gating logic that can be configured for measuring various digital signal parameters such as pulse width, frequency, duty cycle and the time difference between edges on two input signals.
Measuring the motor's output frequency can be done through the SMT's period and duty cycle acquisition mode. In this mode, either the duty cycle or period of the SMT signal can be acquired relative to the SMT clock. The SMT counts the number of SMT clocks present in a single period of motor rotation and stores the result in the captured period register. Using this register allows the actual frequency of the motor to be obtained.
When the speed reference is compared with the actual speed, it will yield a positive or negative error depending on whether the actual speed is higher or lower than the set reference. This error is fed to the PI controller, which is a firmware algorithm that calculates a value that compensates for the variation in speed. This compensating value will add to or subtract from the initial PWM duty cycle to produce a new value.

Conclusion

In cost-sensitive motor control applications, an efficient and flexible microcontroller can have significant impact. Device efficiency can be measured against the level of integrated peripherals to optimise the control task along with the number of pins and memory and the size of the package. Additionally, ease of use and time to market are important especially if variants of the design are required.

This article has shown how a low-cost microcontroller can meet these requirements and let the driver set the desired speed reference, predict the rotor position, implement a control algorithm, measure the actual speed of the motor and impose fault detection.

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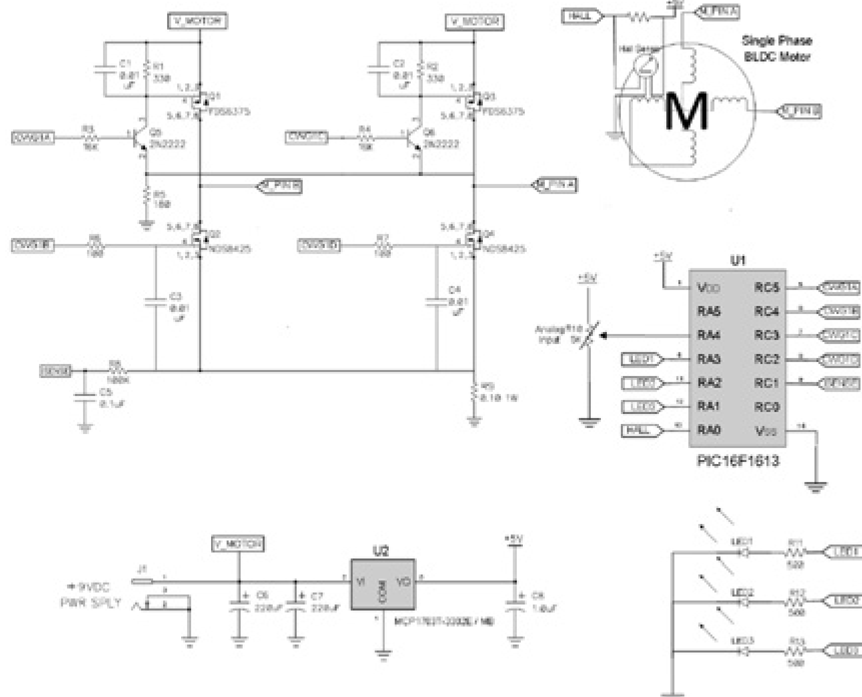

Figure 3: Single-phase BLDC motor driver schematic diagram

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More Power and Higher Reliability by 7th Gen. IGBT Module with New SLC-Technology

The main requirements of power electronics system are high efficiency, high power density and high reliability. To achieve the high efficiency Mitsubishi Electric developed the 7th Gen. IGBT chipset. To additionally fulfill the requirements of high reliability and high power density, the newly developed SLC package technology is combined with the 7th Gen Chip in the NX-type IGBT Modules Series.

By Thomas Radke, Mitsubishi Electric Europe B.V., Koichi Masuda, Mitsubishi Electric Corp., Japan

Industrial IGBT Modules are used in various fields of applications. All those applications require compact power modules with high power density, high reliability and high efficiency with reasonable cost.
To fulfill all these requirements, the 7th Gen. NX-type IGBT Modules based on SLC-Technology have been developed. The 7th Gen. IGBT, which is based on CSTBT^{TM} concept, provides high efficiency by the reduction of dynamic and static losses [2]. The loss reduction is the first step to realize a high power density module. In a second step the thermal resistance R_{th} must be improved in order to increase the power capability at a given operation temperature and to reduce the temperature swings. By combining improved temperature and power cycling capability, high reliability and compact power modules can be realized. The newly developed SLC-package technology provides low thermal resistance and high power and thermal cycling capability.

SLC-Technology
SLC (SoLid Cover) -Technology is a newly developed package technology for realizing high reliability and high thermal conductivity [3]. The comparison of the new package structure with a conventional structure is shown in Figure 1.

Metallized ceramic substrates are conventionally used to realize the electrical insulation between the electrical circuit with semiconductor chips and the module's base plate. Those substrates are joint to the copper base plate by a solder layer. The drawback of this material combination is the mismatch of CTE (Coefficient of Thermal Expansion) between ceramics, solder and copper. This mismatch causes solder cracks by temperature swings and limits the life time of power modules. The module's withstand capability against this stress is known as temperature cycling capability.

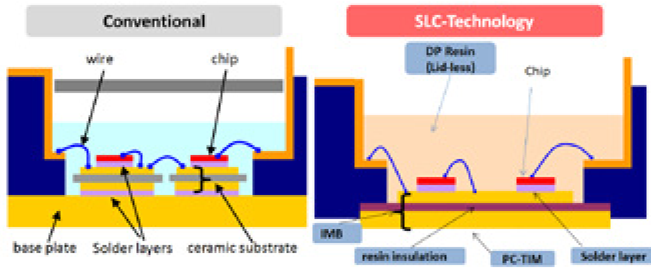

Figure 1: Comparison of SLC and conventional package structures

In the SLC-Technology the insulation is realized by a resin material which has a similar CTE value as copper. The base plate and the solder layer are eliminated because the top and bottom side copper layers can be directly bonded to the insulating resin layer. By this IMB (Insulated Metal Baseplate) the thermal cycling capability is essentially improved. Current status of the ongoing temperature cycle test is shown in Figure 2. Currently it has reached 40k cycles at 80K temperature swings. This result is about 7 times higher than the conventional capability, and this test is still ongoing without failure. Furthermore, as shown in the right side of Figure 2, after 40k cycles no delamination at all could be observed so far. Therefore even higher thermal cycling capability is expected.

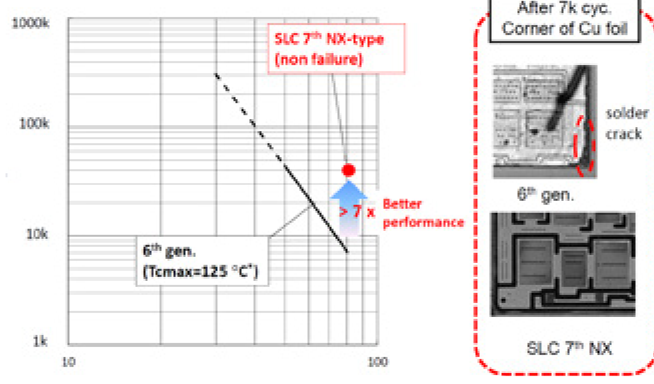

Figure 2: Thermal cycle test status

In conventional modules the maximum size of those ceramic substrates is limited by the thermal cycling capability because the mechanical stress applied to the solder layer caused by temperature swings is increasing with larger substrate size. Therefore in conventional IGBT Modules with a base plate size of 122mm x 62mm usually two or three ceramic substrates are used as shown in Figure 3. On the other hand the new SLC-technology consists of one common IMB owing to elimination of solder layer between substrate and baseplate. By this common substrate approach the effective area available for mounting power chips in the module is expanded and wire bond connections between the substrates are eliminated, thus reducing the internal parasitic package inductance and also the lead resistance. Hence the common IMB is one key element of the SLC-technology to achieve compact power modules with high power density.

Besides the thermal cycling capability also the power cycling capability must be considered to develop a high reliability power module. Main root cause of the power cycling failure mode is the degradation of the bonded wires joint. Continuously current flow and the related junction temperature swings cause strain at wire bonds. In the new SLC-technology the bondwires are covered by hard direct potting resin instead of soft silicone gel. By this hard DP-Resin, the mechanical stress of the wire bond is spread homogeneously to the whole surface of the wire as shown in Figure 4. In a conventional power module the mechanical stress of the wire is not absorbed so much by the soft silicone gel and that stress is concentrated to the base of the bonding wire. The 6th Gen. IGBT modules apply already an optimized and improved wire bonding technology to achieve the high power cycling life time with aluminum wires and soft silicone gel coat. Moreover by combination of this wire bonding technology and the SLC-technology the power cycling capability is essentially improved by keeping the well approved Aluminum wire bonds with their known cost advantages compared to expensive technologies like copper wire bonding. The comparison between the target power cycling capability of the SLC-technology and the 6th Gen. modules is shown in Figure 5.

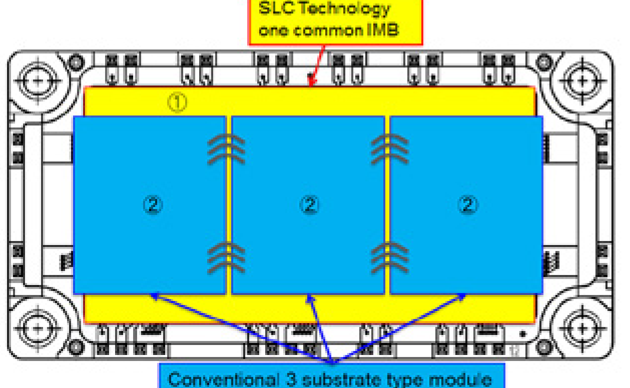

Figure 3: NX-type package with: 1 IMB and 2. Conventional ceramic substrate

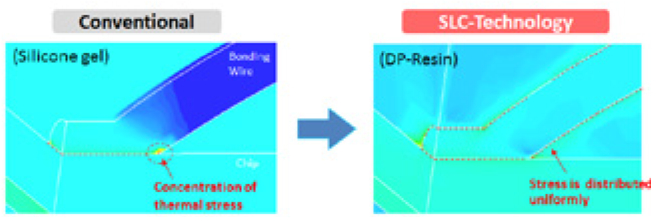

Figure 4: Stress concentration to the wire bond with Conventional and SLC-Technology

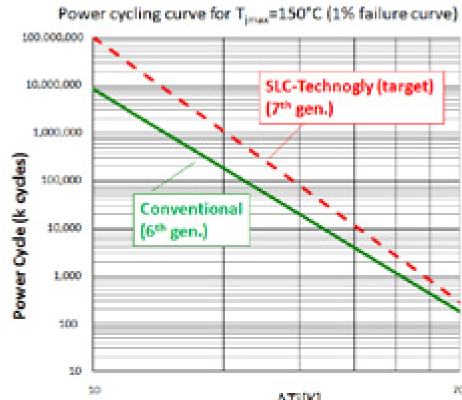

Figure 5: Power cycling capability of Conventional and SLC-Technology

To have a further improvement of the power cycling life time the junction temperature swing should be reduced. This can be achieved by improving the thermal resistance of the power module. Applications with constant load are usually thermally limited by the maximum junction temperature specification.

To cover also these requirements the SLC-technology has improved thermal resistances. SLC-technology applies the IMB, therefore the solder layer which has low thermal conductivity between substrate and baseplate is eliminated. The insulation material and the thickness of the insulation layer of the IMB are selected to achieve the best trade-off of insulation capability, reliability and low thermal resistance. By this optimization it is possible to achieve a reduction of the thermal resistance from junction to the case Rth(j-c) by approximately 30% compared to conventional modules where aluminum oxide (Al_2O_3) is widely used as ceramic material.

In conventional modules with copper baseplate and ceramics substrate, a warping of the baseplate also has to be considered during temperature cycles due to the unmatched CTEs and the resulting "bi-metal effect". This warping limits the possibility to improve the thermal contact resistance between baseplate and heat sink Rth(c-s). With the new SLC-technology which has the matched CTEs, this warping can be virtually eliminated and the thermal interface between baseplate and heat sink can be further improved by using an optimized pre applied phase change thermal interface material (PC-TIM). The total thermal resistance from junction to heat sink of a conventional module technology is about 43% higher than SLC-technology at same chip sizes. This outstanding thermal performance is also one of the essential features to fulfill the market requirements for high power density and high reliability.

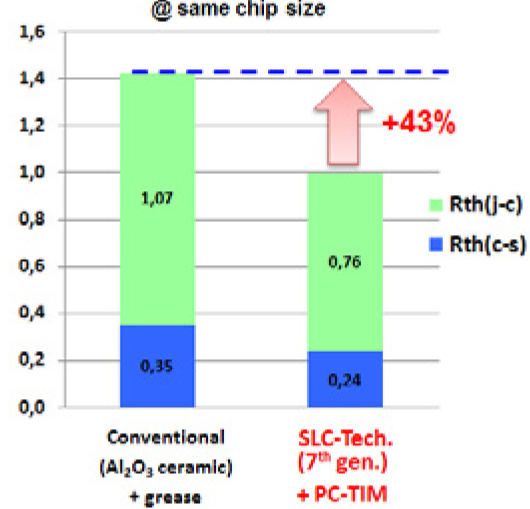

Figure 6: Comparison of thermal resistances at same chip size

7th Gen NX-type IGBT Modules

The new SLC-technology together with the 7th Gen IGBT chipset is introduced in the NX-type Modules Series of Mitsubishi Electric.

Figure 7: 7th gen NX-type 2in1 IGBT Module

The 7th Gen IGBT chip has an improved trade-off of collector emitter saturation voltage and turn-off switching losses. The cell design is optimized to have an improved controllability of the dv/dt by the gate resistor. By using the RFC structure (Relaxed Field of Cathode) for the freewheeling diode it is possible to improve also the trade-off of recovery losses and forward voltage drop by keeping the soft recovery behavior [2].

The characteristics of the new chip set was evaluated and used for the simulation of losses with the Mitsubishi simulation software called MELCOSIM [1]. The result is that the 1200V class 7th Gen IGBT can save about 15% of total losses compared to the 6th Gen IGBT under typical motor control inverter application conditions. To support the inverter assembly process on customer side, all 7th Gen. NX-type Modules will be available with the optimized PC-TIM and PressFit Pin terminals. Figure 8 shows that this NX-type 7th Gen IGBT Modules with SLC technology is underdevelopment with a comprehensive line-up to support wide range of applications with these new technologies.

Circuit	Package Size [mm²]	I_C [A]		
		650V	1200V	1700V
2in1	62x152		225	225
		300	300	300
		450	450	450
		600	600	600
	114x110		1000	
6in1	62x122	100	100	100
		150	150	150
		200	200	
7in1	77x137	150	100	
		200	150	

Figure 8: Line-up plan of 7th Gen NX-Type Modules with PC-TIM and PressFit options

System performance of 7th Gen Chipset and SLC-Technology
The features of 7th Gen Chipset from IGBT module point of view are explained. But to understand the impact on the inverter system these features have to be evaluated by a mission profile which is representative for typical inverter mode operation. For many applications load cycles have to be considered for the mission profile. By a loss simulation with the IGBT and diode chip characteristics this load profile can be transferred into a loss profile. From this loss profile with the thermal impedance the temperature profile can be calculated. Finally the lifetime can be predicted with the temperature profile in combination with the cycling capability curves from the modules [4].

In Figure 9, an example with normalized values is shown. From loss simulation by MELCOSIM it is noted that the total losses of 7th Gen. Chipset can be reduced by 15% compared to previous generation. It means the loss profile is reduced to 85%. As considering this 15% loss reduction and the approx. 30% improvement of the thermal resistance the junction Tj swings can be reduced to 60% compared to conventional module with aluminum oxide ceramics substrate and copper baseplate. In case of applying same loss that Tj swings of conventional module is 50K, Tj swings of SLC-Technology with 7th Gen. chipset would be 30K. So the result of target power cycling curves with the reduced Tj swings is that more than 10 times higher lifetime compared to conventional module can be reached by using the SLC-Technology with combination of 7th Gen IGBT. Or in case of the same life time the Tj swings with SLC-technology can be increased to about 57K which is equivalent to increased output power by more than 50%.

Summary
A new series of Mitsubishi IGBT modules for 600V and 1200V rated voltage has been developed covering a wide current range based on the well-established NX-package style. The new IGBT module series combines the latest 7th generation IGBT- and FWDi-chips with an innovative packaging technology, called SLC-technology.
The new IGBT module series is enabling inverter designs with higher output currents, higher power density and improved reliability (increased power cycling life and increased temperature cycling life). It's an excellent answer to the complex needs of state of the art inverter designs.

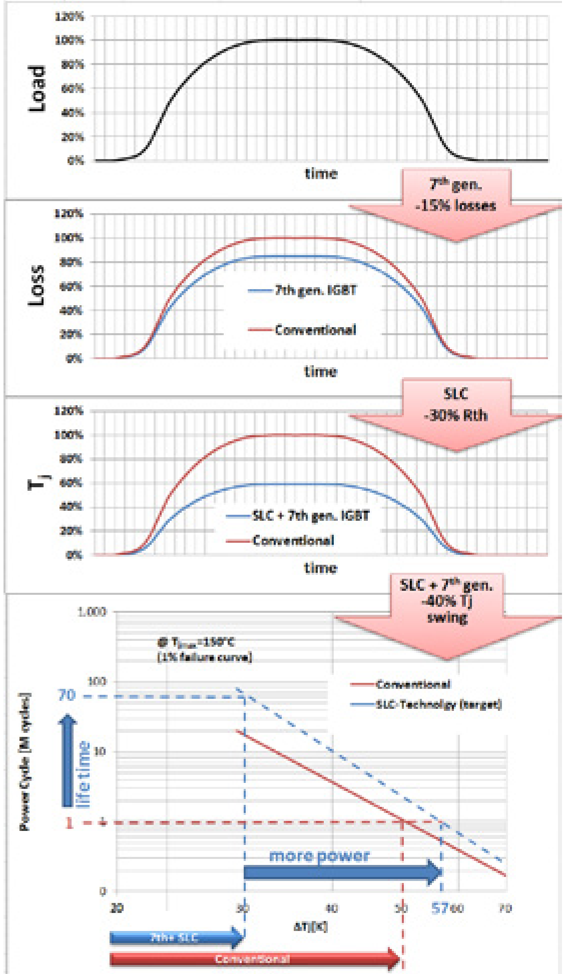

Figure 9: Normalized load cycle example with comparison of SLC-technology with 7Gen. IGBT and Conventional Module

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New Ways to Produce Fast Power Thyristors

The article covers new methods utilized at manufacturing of fast power thyristors by means of low-temperature junction of silicon chips with molybdenum discs by sintering of silver paste. This approach unites all advantages of free floating silicon and siluminium soldering technologies. This method makes it possible to produce fast thyristors with semiconductor chip diameter of 100mm and more. Moreover, devices have improved thermal cycling capacity, lower thermal resistance and advanced recovery characteristics.

By Dmitri Titushkin, Alexey Surma and Anatoly Chernikov, PROTON-ELECTROTEX, Russia and Sergei Matyukhin, State Scientific Production University, Russia

Introduction

Traditional technologies of silicon wafer-thermal compensator junction do not comply with requirements for next-generation power semiconductors. Nowadays, low temperature baking (sintering) technology is spreading widely in semiconductor production. This technology is actual for junction of semiconductor chip with molybdenum discs for power and high power thyristors and diodes, designed for switching currents in the range from thousands to hundreds of thousands amps, and having the silicon chip diameter of 50 – 150 mm [1, 5].

Our experience with use of sintering at manufacturing of single-crystal power thyristors and diodes proves other advantages of this technology, including thermal cycling capacity improvement [3, 4], thermal resistance decrease [2, 3, 4], and surge current value increase [1].

Currently PROTON-ELECTROTEX masters manufacturing of power semiconductor devices by means of sintering. The article describes how characteristic of fast thyristors and diodes can be improved thanks to this technology.

Technological options of silicon chip-molybdenum disc junction

At present, there are two technologies utilized in manufacturing of power thyristors: alloying and free floating silicon technology.

Alloying technology joins silicon chip with molybdenum thermal compensator by use of vacuum soldering with aluminum-silicon alloys. This method provides firm silicon chip-molybdenum disc junction with good cycling capacity and quite low thermal resistance. External installation force from the cathode side is required to secure thermal contact.

However, since alloying is a high-temperature process (about 700C), thermomechanical stresses occur in Si-Mo packet because of different thermal expansion coefficients of silicon and molybdenum. This issue becomes even more significant for joined discs of bigger linear dimensions (diameters).

Another problem with alloying technology is active dissolving of surface layers of silicon chip. This issue is topical at manufacturing of fast-recovery devices as it is necessary to decrease the thickness of silicon chip and generated anode emitter in order to secure the required performance characteristics. Thickness decrease and fusion penetrations lead to dispersion of emitter layer injection rate resulting in uneven spread of anode current.

Free floating silicon technology puts a semiconductor wafer with cathode and anode metallization between cathode and anode thermal compensator of semiconductor device. Thanks to absence of soldered joint, there are only pressure thermal and electrical contacts between molybdenum thermal compensator and silicon wafer.

Pressure contact design's advantage is absence of deformations and residual voltages that occur during soldering of silicon wafer with thermal compensator due to difference between linear expansion coefficients. This feature is extremely important for manufacturing of semiconductor elements with diameter of more than 80mm. Another important advantage of free floating silicon technology is that surface layers of silicon do not dissolve.

The disadvantage of this method compared to soldered contact technology is higher thermal resistance from anode side.

Also, in order to avoid shorting of control area and cathode, mounting force is not to be applied to control area of thyristor. So this force does not spread on the same area from the anode side of the element.

As a result this may lead to issues with switching of high di/dt current pulse rise. This may also cause problems with low anode current operation of thyristors with auxiliary thyristor element securing control current of distributed control electrode (distributed gate) of main structure.

Non-soldering technology disadvantage described above is topical for power thyristors with semiconductor element of 80mm and more, as they need to have large and complex distribution area in order to provide required characteristics.

Growing demand for thyristors with higher power density and longer lifetime is a market trend, especially for high-frequency applications requiring fast thyristors.

That's why the goal in manufacturing of fast power thyristors is to use the technology uniting advantages of soldered and free floating silicon approaches and narrowing down their disadvantages. This new technology needs to comply with following requirements:

- it needs to be applicable for large area elements;
- it needs to have low temperature of treatment process;
- it needs to have high electrical and thermal conductivities;
- its thermal cycling stability must be high.

Low temperature baking silver fine-dispersed layer technology (sintering) meets all these requirements.

On one hand, sintering technology provides firm junction with molybdenum disc and secures the element from partial dissolving of surface silicon layers. (Figure 1).

On the other hand, sintering technology decreases residual thermomechanical voltages and deformation profile on the semiconductor

element. Experiments proved for sintered semiconductor elements to have 2 times lower bending of semiconductor elements compared to parts produced with soldering technology.

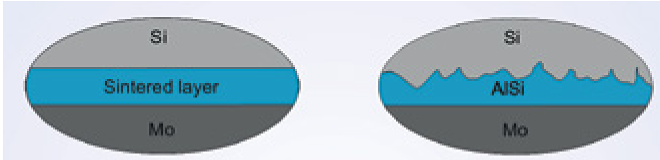

Figure 1: No partial dissolving of silicon surface layers on the anode side

Improvement of fast high voltage thyristors' characteristics

Improvement of fast high voltage thyristors' characteristics is shown by the example of TFI393-2500-28 thyristors (average current of 2500A, repetitive forward and reverse voltages of 2800V). These parts have 100mm semiconductor element diameter. They were manufactured of silicon wafers of 120Ω*cm resistivity and 580µm thickness. Two batches of TFI393-2500-28 thyristors were manufactured using different technologies of silicon chip-molybdenum thermal compensator joining.

Relations of main characteristics (on-state voltage drop VTM, turn-off time tq, reverse recovery charge Qrr,) are shown on figures 2 and 3.

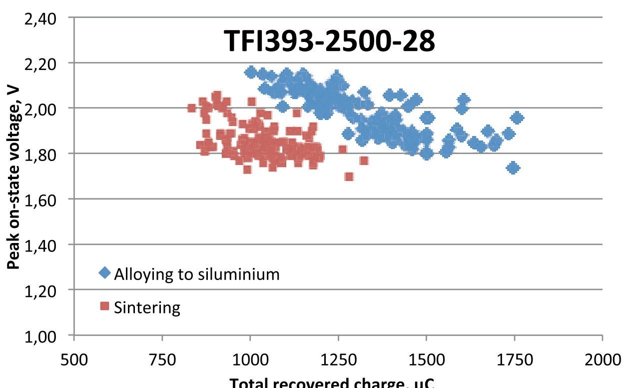

Figure 2: VTM - Qrr relation of TFI393-2500-28 thyristors

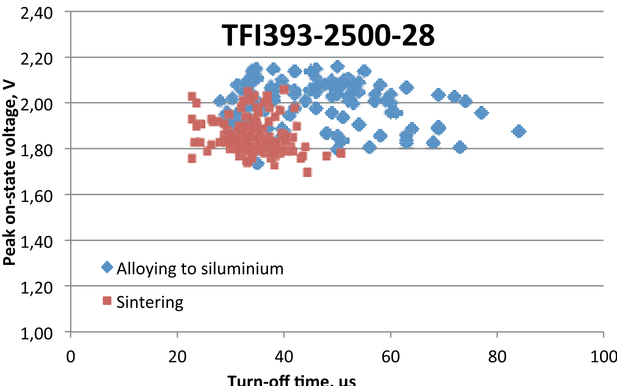

Figure 3: VTM - tq relation of TFI393-2500-28 thyristors

Figures 2 and 3 showing that thyristors produced with sintering technology have better VTM – tq, Qrr ratios. Absence of anode emitter melting positively affects distribution of characteristics across thyristor element area.

Thus sintering technology helps making fast power thyristors with improved characteristics. (Figure 4).

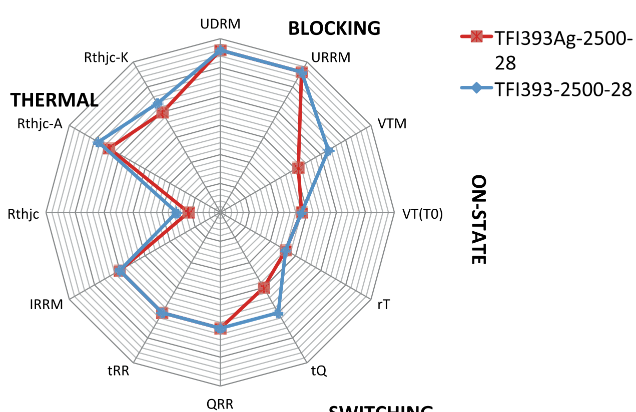

Figure 4: Relation of TFI393-2500-28 thyristor's main characteristics

Conclusion

Our experience with manufacturing of power single-crystal semiconductor devices using low temperature sintering of silver paste proves that this technology can improve characteristics of fast diodes and thyristors. This technology decreases thermal resistance, turn-off time and reverse recovery charge of fast thyristors with 100mm semiconductor element diameter, decreasing on-state voltage drop and increasing root-mean-square current and on-state surge current in the same time.

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Passive Embedding for Performance and Reliability

Thanks to new materials and integration technologies the embedding and integration of passive components is making great advances. New miniaturized components designed specifically for embedding enable even more compact and reliable systems.

By David Connett, Director Reference Design, TDK

The dimensions of passive components and their ruggedness for further processing often determine whether they are suitable for specific embedding and integration technologies. TDK has developed innovative capacitors and thermistors and employs state-of-the-art integration technologies that enable superior passive embedding solutions.

Embedding capacitors in IGBT modules

Traditionally, IGBT modules in the mid power range and based on Si and SiC technologies employ external snubber capacitors. Until now, it was not possible to embed these components and thus shorten the long leads that are afflicted with parasitic inductances. Irrespective of their dimensions, conventional capacitors are insufficiently resistant to the heat involved in the direct assembly of the IGBT module. In addition, some have only a low capacitance per volume and suffer considerable loss of capacitance at high rated voltages.

Now, with the CeraLink™, a completely new kind of capacitor has been developed that suffers none of these drawbacks. CeraLink technology is based on the ceramic material PLZT (lead lanthanum zirconate titanate). In contrast to conventional ceramic capacitors, CeraLink has its maximum capacitance at the application voltage, and this even increases proportionately to the share of the ripple voltage (Figure 1).

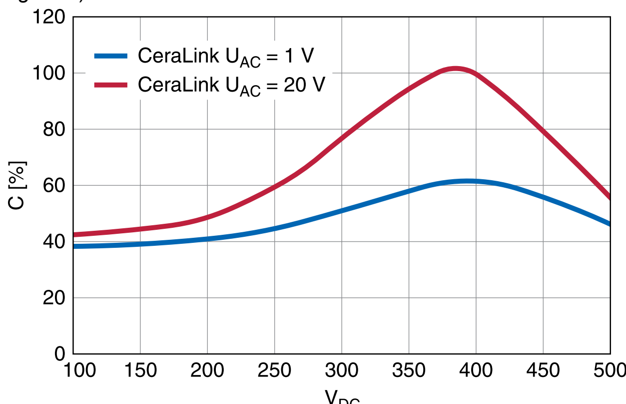
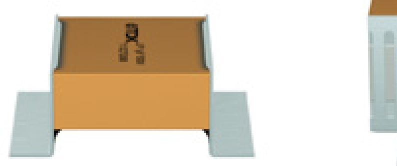


Figure 1: Capacitance of the CeraLink as a function of voltage
In contrast to other capacitor technologies, the effective capacitance of the CeraLink rises with increasing voltage. The impact of the ripple voltage amplifies this effect additionally.

Another advantage is its high insulation resistance. The RC time constant t is 70 000 ΩF at 25 °C and this value drops only slightly even at 150 °C. As a result, this prevents the feared uncontrolled thermal runaway from occurring. Its parasitic effects are also very low: ESR is only 50 mΩ at 100 kHz and drops to only 10 mΩ at 1 MHz, resulting in very low losses. The ESR declines even further as the temperature rises: at 85 °C it is already less than 20 percent of its original value at 25 °C. This results in charge and discharge times of between 25 ns and 30 ns. The ESL of CeraLink capacitors is below 5 nH, making this technology particularly suitable for fast-switching inverters.

All these advantages make CeraLink technology predestined to be embedded in IGBT modules as snubber capacitors. Two SMD types with rated voltages of 500 V DC are available for this purpose (Figure 2). The low-profile 1 µF variant with dimensions of only 4.35 mm × 7.85 mm × 10.84 mm and the 5 µF type with dimensions of 13.25 mm × 14.26 mm × 9.35 mm are particularly compact and may be placed very close to the semiconductor with negligible ESL.



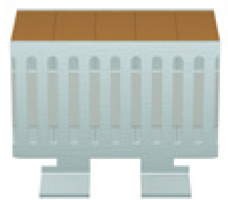


Figure 2: SMD CeraLink for integration in IGBT modules
The CeraLink low-profile 1 µF variant (left) and the 5 µF type (right) are designed for embedding in IGBT modules. They feature compact dimensions and can withstand high temperatures of up to 150 °C.

Embedding temperature protection in IGBT modules

IGBT modules in inverters achieve the highest possible efficiency when they are operated at their upper temperature limit. Thus, exact monitoring of the operating temperature is required in order to prevent damage to the semiconductors. The suitability of standard SMD NTC thermistors used for this purpose up until now, however, is rather limited because they are not compatible with all semiconductor assembly processes. In particular, these include high-temperature soldering and silver sintering under pressure.

In order to solve this problem, a wafer-based manufacturing process for EPCOS chip NTC thermistors was developed (Figure 3). The new components are now able to withstand the thermal and mechanical stresses encountered during assembly. Moreover, they save space because they need no special pads for soldering to the semiconductor substrate.

A key advantage of the NTC thermistors manufactured from wafers is the configuration of their electrical contacts. In this case, they are located on the top and bottom surfaces of the chip. This allows the lower terminal to be contacted directly and with complete surface contact onto the semiconductor substrate using conventional semiconductor processes. The upper terminal is contacted via conventional wire bonding, as is usual for IGBT modules. The contact surfaces are

optionally available in gold or silver plating in order to achieve the best possible bonding results.

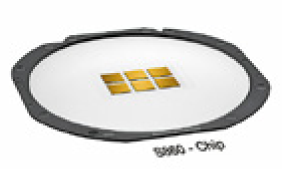


Figure 3: Wafer and EPCOS NTC thermistor with contacts on the top and bottom surfaces
Complete EPCOS NTC wafer with carrier (left) and an individual NTC chip (right). The flat contact areas are on the top and bottom surfaces, rather than on the sides, which is more usual.

Among the other advantages of these chip NTC thermistors are their minimal electrical and thermal tolerances. This precision is achieved by means of a special process technology: Before separating the individual elements from the wafer, the total resistance of the wafer is measured with respect to a rated temperature of 100 °C. The size of the thermistors to be separated is then determined based on this. This ensures that the tolerances of the separate components is much smaller than those of standard NTC thermistors rated at 25 °C, as is shown in Figure 4.

Because EPCOS chip NTC thermistors have a narrow tolerance of only ±1.5 K at 100 °C, IGBT modules can then be operated without premature derating at temperatures very close to their maximum permissible values and thus be utilized more efficiently. This solution is also suitable for new power semiconductor generations such as those based on SiC.

3D integration with LTCC and SESUB

As smartphones and other portable electronic devices are designed to support more bands and offer greater functionality, a maximum level of integration that goes beyond the miniaturization of the single components is required in order to keep these devices compact. LTCC technology (low temperature co-fired ceramic) is an established technology that enables the functions of passive components such as inductors, capacitors and resistors to be embedded within the thin ceramic layers. Depending on the level of integration, LTTC technology, which is used mainly to manufacture RF modules for smartphones, can save up 80 percent space compared with discrete solutions.

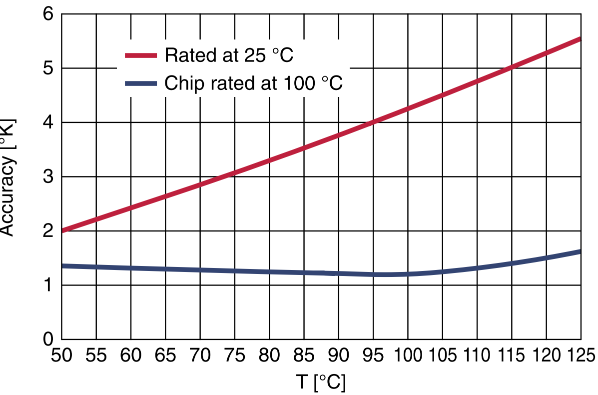


Figure 4: Comparing the precision of NTC technologies
In the temperature range of around 120 °C, which is critical for semiconductors, the chip NTC thermistor has a high measurement accuracy of ±1.5 K. In contrast, the standard type rated at 25 °C exhibits a relatively large tolerance of >±5 K

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However, because the LTTC sintering process takes place at temperatures higher than 500 °C, heat-sensitive components such as semiconductors must be mounted in piggyback mode on the upper side of the modules after sintering. By actually embedding the ICs in the substrate, TDK's SESUB technology (semiconductor embedded in substrate) represents a new approach to integration. Even including the embedded ICs, the overall thickness of the SESUB substrate is only 300 µm, (Figure 5).

Figure 5: Cross-section through a TDK SESUB substrate
The four micro-structured substrate layers are only 300 µm thick – including of all connections and vias. Even ICs with numerous fine-pitch I/Os can be embedded into the TDK SESUB substrate. The discrete passive components required can be placed on the surface of the substrate.

The discrete passive components required can be placed on the surface of the substrate. In order to increase the integration density even further, thin passive components will also be embedded in the substrate in a next step. Because SESUB modules make use of the third dimension, their area is 50 to 60 percent smaller than conventional discrete solutions, depending on the design.

The shorter line connections within the substrate layers of the modules lead to improved parasitics and thus support better system performance. EMC performance is also improved due to the shielding effect of the metal layers inside the SESUB substrate. In addition, SESUB delivers excellent thermal attributes due to the fact that the IC is completely embedded. All surfaces of the chip are in full contact with the laminate, which optimizes the heat transfer from the semiconductor into the substrate layers. These layers themselves contain the copper micro-interconnection grids, which provide for a very homogenous and efficient heat dissipation. In particular, their superior thermal performance is important for applications in the area of power management, transceivers, processors, and the power amplifier – or all the main components of a smartphone. In addition to miniaturization, a key criteria for the use of both LTCC and SESUB technologies are their high reliability and significantly reduced logistics outlay.

Figure 6: Space-saving TDK SESUB module
Left: The TDK Bluetooth low energy module worldwide, developed for the Bluetooth 4.0 low-energy unit with dimensions of only 4.6 mm x 5.6 mm. The complete power management of a smartphone is integrated in the TDK power management unit (right).

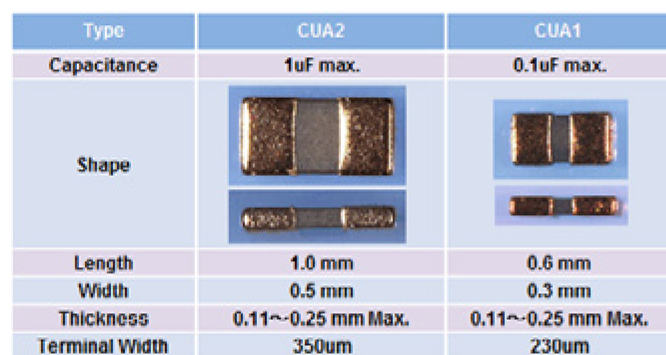
A typical example of a SESUB design is the extremely compact TDK Bluetooth 4.0 low energy module, developed for the Bluetooth 4.0 low energy (LE) specification, which is being marketed as Bluetooth Smart (Figure 6 left). With a footprint of only 4.6 × 5.6 mm2 and a low insertion height of 1 mm, the new SESUB-PAN-T2541 Bluetooth 4.0 LE module sets the industry benchmark for Bluetooth Smart modules. The module is also very well suited for use in wearable devices thanks to its compact size.

SESUB is also highly suitable for handling the power management in smartphones. In the TDK power management unit (PMU) module (Figure 6 right), the IC for managing the power supply was embedded directly into the substrate for the first time. This innovative step allows manufacturers of end equipment to reduce their development costs and times still further. In combination with newly developed capacitors and power inductors in SMD versions, the module dimensions are only 11.0 mm x 11.0 mm x 1.6 mm. They also contain a highly efficient power supply for the buck converter in a 5-channel configuration with an output current of up to 2.6 A as well as low-noise, high PSRR (power supply rejection ratio) low dropout regulators for up to 23 channels and an extremely efficient charge circuit for lithium-ion rechargeable batteries.

Utilizing the integration potentials of PC boards

Multilayer PC boards have long ceased to be merely carriers of components. In order to utilize their integration potentials more efficiently, TDK is working jointly with industry partners on the further development of technologies for embedding active and passive electronic components. Among other things, the standardization of the integration technologies, which play a critical role in the implementation of highly miniaturized modules, is to be driven forward.

Especially the MLCCs that are needed in nearly every circuit for buffering and noise suppression offer significant potential for integration and thus miniaturization. TDK has developed the MLCC-CU series, which can be embedded in PCBs. Unlike conventional MLCCs, their electrodes are not tin-plated, but rather made of copper and inserted directly into the laminate layers of the PC boards. These MLCCs are distinguished by their very low insertion heights, which, depending on the type, are between 0.11 mm and 0.25 mm (Table 1).



Type	CUA2	CUA1
Capacitance	1uF max.	0.1uF max.
Shape		
Length	1.0 mm	0.6 mm
Width	0.5 mm	0.3 mm
Thickness	0.11~0.25 mm Max.	0.11~0.25 mm Max.
Terminal Width	350um	230um

Table 1: TDK MLCC-CU series for embedding in PCBs

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- Motion control: technologies, methodologies, platforms and application proposals;
- Passive and power: magnetic supercapacitors and capacitors;
- Power management: analog & digital solutions;
- Power supplies;
- Energy efficiency;
- Systems for energy storage

TARGET

Manufacturers, suppliers, customers, engineers, designers and buyers

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Increased Power Density and Performance with 3D Embedded Substrate Technologies

A Special Project of the PSMA Packaging Committee March 2015

By Brian Narveson and Ernie Parker Co-chairman, PSMA Packaging Committee

Market Drivers
Power source suppliers are continually being asked to deliver more power in the same footprint. This challenge has hit a fever pitch as digital semiconductor packaging technology has increased performance with wafer stacking through the use of wafer thinning and through-silicon-via (TSV) technology. In addition the introduction of 2.5D and 3D integration, has facilitated heterogeneous ("More than Moore") integration. Use of this technology is increasing as conventional die shrinking has hit a "cost barrier" brought about when advanced deep-submicron semiconductor technology could no longer reduce cost with the addition of more functions to the semiconductor die. Digital 3D packaging and integration allows the power requirements of the digital load to increase two to five times, within the same footprint, in a single generation. Now the power industry is tasked with finding new ways to package power sources that will meet this demand, but without increasing footprint.

In parallel, power semiconductor technology is facing a "construction barrier" that prevents the realization of the significant benefits new technology can offer in terms of increased power efficiency and higher power density. These new technologies, including gallium-nitride (GaN), silicon-carbide (SiC), and gallium-arsenic (GaAs) power semiconductor devices, all require operation in a package that is free of bond wires and that minimizes parasitic interconnect elements. Both of these challenges can be addressed with power packaging utilizing embedded substrate technologies.

Investigation of Solutions
To investigate this technology the Power Sources Manufacturing Association (PSMA) commissioned a report "Current Developments in 3D Packaging with Focus on Embedded Substrate Technologies". The 340 page report, prepared under contract by LTEC Corporation with subcontract to Anagenesis, Inc. and Fraunhofer-Institute was published in March 2015. It is based on the extensive research of over 750 articles and papers and by conducting 30 industry expert interviews.

For the purpose of this article the following definitions apply: Embedded substrate technology is defined as the inclusion of at least one active or passive electrical component within the top and bottom conductive layers of a substrate, with a substrate defined as a planar structure having multiple conductive and insulating layers. Fig. 1 provides an example of this technology illustrating a Sarda Technologies 12 V input, 16 A output, 5 MHz heterogeneously integrated power stage using 3D packaging with embedded substrate technology.

As part of the project 30 companies were surveyed to determine why they were actively producing or developing power sources utilizing embedded technology and at what power level they were considering for this technology. The survey found the overriding reasons for using the technology was to reduce size (increase power density) and improve performance. It also found development activity at power levels up to and exceeding 1000 Watts.

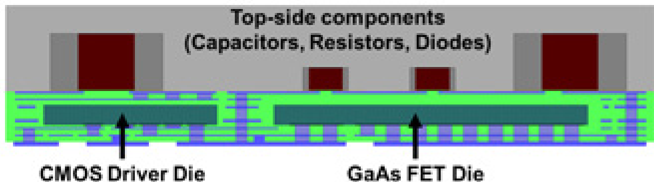

Figure 1: PCB-embedded two-phase power stage with GaAs FET quad (Courtesy of Sarda Technologies Inc.)

Core Technology
The core technology required for embedding is a PCB or Inorganic Substrate. Europe is leading in high volume, commercially viable embedded substrate manufacturing technology. This success was enabled by research projects funded by the European Union's sixth and seventh framework programs (FP6, FP7). The first, "HIDING DIES" (FP6), developed the fundamental technology for chip-in-polymer packaging based on embedding thinned silicon in resin coated copper (RCC) dielectric followed by laser drilling of via holes to the chip contacts and to the substrate and finally metallization of vias and conductor lines. A follow-on project "HERMES", under FP7, focused on bringing the technologies into real manufacturing PCB production. AT&S leveraged its involvement with these programs to develop their large panel-based PCB process known as Embedded Component Packaging (ECP^{TM}). The AT&S ECP™ process is depicted in Fig. 2. AT&S manufactures on 18 in. x 24 in. panels, has shipped over 100-million units, and claims > 99% yield. Their process is used by GaN Systems and Texas Instruments for embedding of their semiconductor devices.

An overview of several of the processes available for making embedded substrate power assemblies are listed below. Details and additional processes can be found in the report.

TDK-EPC Corporation has developed its own process named Semiconductor Embedded in Substrate (SESUB™). Their embedded process is suitable for high density power supply modules or subsystems, either as substrates or interposers, with or without overmolding. A benefit of SESUB™ is the ability to have complete metal shielding of the package, an attractive feature for EMI reduction.

General Electric has been a pioneer in recognizing the benefits of component embedding and in technology development, beginning with technology for chip embedding in the 1990's. GE's Power Overlay Technology (POL), is backed by a strong portfolio of over 300 patents. GE is actively engaged in licensing its technology.

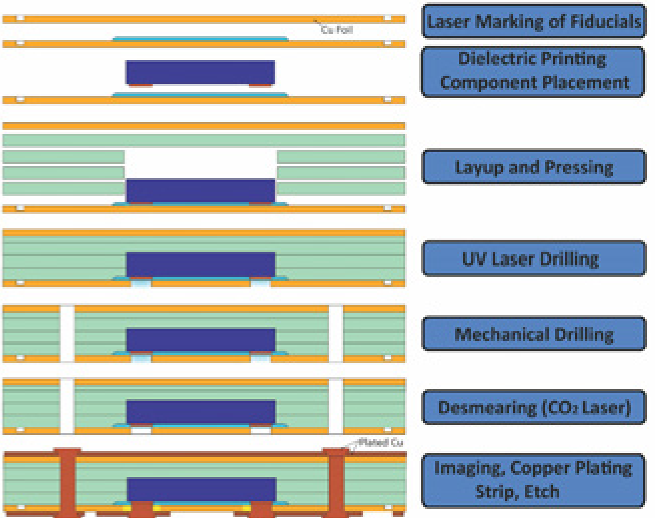

Figure 2: AT&S Embedded Component Packaging (ECP™) Process Flow

Infineon developed a variant of the AT&S process that is similar to TDK-EPC's SESUB™ and have used that in their Dr. Blade™ product family

Schweizer AG's P2-PAK process, shown in figure 3, was an early entrant with embedding developed as an alternative to expensive direct-bond-copper (DBC) for high current inverters, converters, industrial motor drives, and automotive applications.

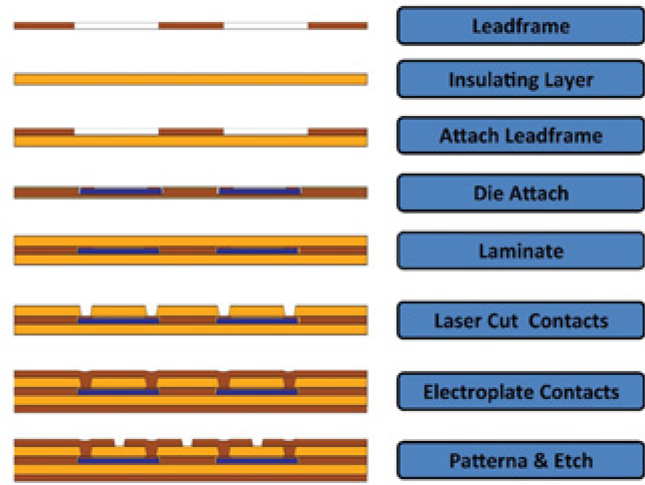

Figure 3: Schweizer P2-PAK Process

Additional processes from Fujikara, Shinko, Wurth Electronik, and Semikron are covered in the technology report. Japan and Korea tend to have a leadership position in fine pitch high density low power technologies, while European companies have leadership position in embedding power electronic components.

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Component Technology
The second key technology for embedding is the availability of components. There are two classes of embedded components. First, there is the discrete device, termed the "inserted" component. In this case, the surface mount passive device, R L or C, is manufactured prior to assembly in the printed circuit board. Usually these are mounted in laser machined cavities within the printed circuit board. Semiconductor devices are also inserted and connected to the substrate using a variety technics.

Secondly there is the "formed" component that is manufactured as element(s) within the printed circuit board. All three types of passives (Resistors, Capacitors and Inductors) can be formed in an imbedded substrate. Fig. 4 illustrates the various types of embedded components and Fig. 5 shows how they can implemented is a PCB substrate.

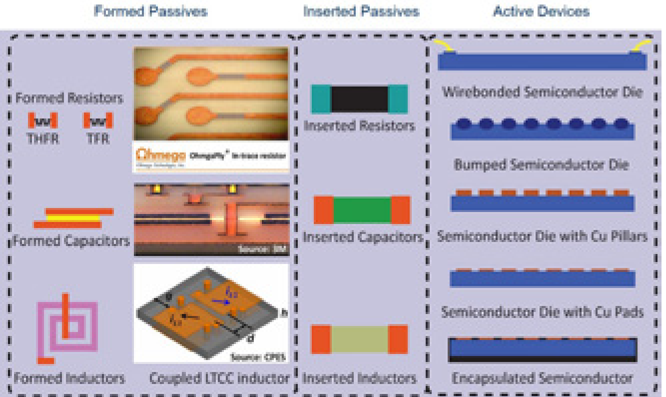

Figure 4: Embedded Components

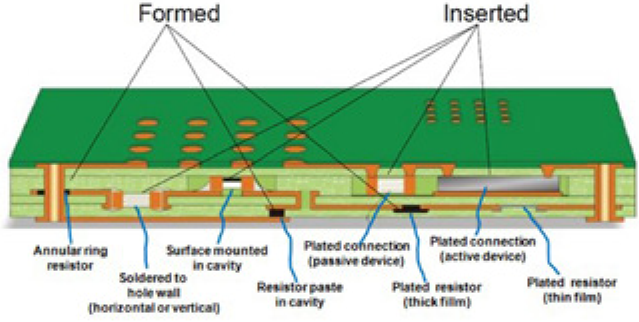

Figure 5: Example of an embedded assembly

The ability to execute an embedded power design is very dependent on the availability of insertable passive components, optimized for PCB embedding purposes. The report devotes individual chapters to resistors, capacitors and inductors. Availability of power devices is still somewhat limited in terms of form factor and terminal metallurgy but the number of sources is expanding rapidly. The report also provides lists of vendors with production parts available now.

Successful transition to full volume manufacturing depends on advances in supply chain and technology for compatible passive component technologies. While this article focused on embedded substrate component technology, the 3D Embedded Substrate Technology report also covers the current state of the art as well as challenges and constraints in semiconductors, passive components, high temperature die-attach, interposers, thermal management, packaging technologies, additive manufacturing and laser fabrication, all of which will play a role in the success and timing of a transition to 3D power packaging.

Standards
Another sign of the maturing of embedded substrate technology is the number of standards completed and being written. IPC has published embedded standards for, resistors (IPC-4811), capacitors (IPC-4821), printed circuit board design (IPC-2316) and materials (IPC-4101) plus one being written on design and assembly processes (IPC-7092). Substrates, components and manufacturing processes are available and being developed to meet these standards. There is more elaboration on standards in the report.

Summary
There has been substantial progress and excellent opportunities lie ahead for the power electronics and semiconductor industries and the entire manufacturing ecosystem to embrace PCB embedding and 3D packaging technologies for power electronic applications. The intersection of these technologies with the emerging wide-bandgap power semiconductor technology creates truly exciting possibilities. These technologies, combined with wide-bandgap semiconductor devices will literally re-vitalize the entire power electronic infrastructure for the twenty-first century.

The PSMA reports on 3D packaging are provided free of charge to PSMA members. Others interested in the reports may order a copy from PSMA at

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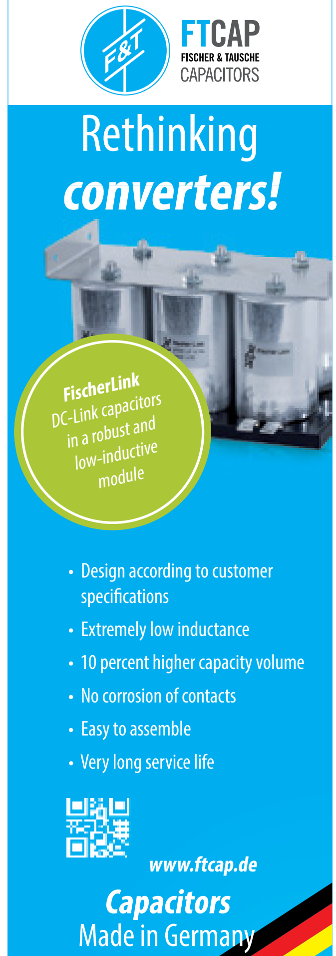

Numerical Modelling in Design for Reliability of Power Modules

This article deals with today's reliability issues of power modules. It sums up relevant failure modes as well as their causes and explains how numerical modelling can support design processes in different phases of development. As an example, a lifetime modelling technique for aluminum thick bond wires in power modules is described in more detail.

By Arian Grams, Martin Schneider-Ramelow, Olaf Wittler and Felix Wüst, Fraunhofer IZM, Berlin, Germany

Power electronics remains a fast growing field and also a changing one. Amongst the main driving business sectors for trends in power electronics are power generation and the automotive industry. New applications demand higher power and power densities as well as higher efficiency and miniaturization. Also, the places of installation accumulate and bring with them harsher environmental conditions. For example mounting places close to the engine in hybrid cars experience high temperatures combined with vibrational loads and offer few space. To fulfill the growing demands, the use of new assembly and packaging technologies as well as new materials are necessary. Thus a need for expertise in reliability arises when designing and manufacturing power modules.
The reliability of power electronics can be addressed and improved already in early design phases by modelling techniques. In that way, the effort for prototyping and testing can be reduced and the whole design process can be improved and shortened. In order to be able to correlate package design with reliability measures, an understanding needs to be based on the underlying physical and chemical relationships as far as it is useful for solving the design question. This article gives an example on the package-oriented Physics of Failure (PoF) approach.

The main failure modes for classical interconnects in power electronics are bond wire lift-off, bond wire heel crack, die attach degradation, DBC delamination and DBC attach degradation. Figure 1 gives an overview.

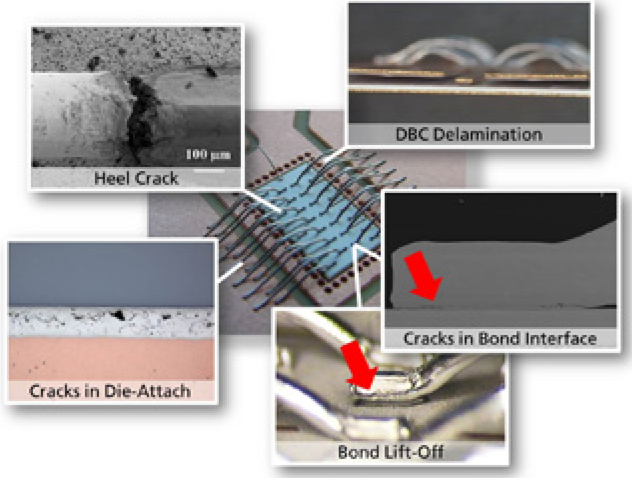

Figure 1: Failure modes in a power electronic module

They are caused by the difference of the coefficients of thermal expansion (CTE) of the adjoining materials. When a power electronic chip is heated up, the different components expand at different ratios. This leads to mechanical stresses within interconnections and interfaces.
A silicon chip has a CTE of about 2.5 ppm/K, copper of about 17 ppm/K. When heated up (or cooled down) this leads to mechanical tension in the solder or sintering layer. If repeated temperature swings are applied, a crack will be initiated and continue to grow until the thermal path is degraded. As a result the chip will eventually overheat and fail.
An aluminum bond wire has a CTE of about 23 ppm/K. Due to the local mismatch to the CTE of the semiconductor, temperature cycles will lead to degradation of the interface with crack growth and finally bond wire lift-off. The relative movement of the two bond sites of a wire bond caused by bending of the substrate (global CTE mismatch) exerts stresses on the bond wire, which can cause heel cracks. DBC delamination results from the mechanical tension in the bonding interface between ceramics. It is also driven by the differences in CTE of both adjoining materials and strongly depends on the amplitude of the temperature swing.

A newly developed method to calculate the lifetime of wire bonds subjected to active power cycling will now be explained in more detail. The failure mode addressed is the propagation of cracks in the interface or close to the interface of wire bond and chip. As mentioned above, it is caused mainly by the local CTE mismatch between the chip and wire material. This interface crack is roughly oval or circular and reduces the effective bond area until finally the bond lifts off from the substrate. The method has been applied to aluminum thick wire bonds of 300 µm and 400 µm thickness that are commonly used in power modules.

Amongst Physics-of-Failure models, the most commonly used model for fatigue of metals is the Coffin-Manson approach.

$$N_f = C_1\left(\Delta\varepsilon_{pl}\right)$$

Thus, a lifetime N_f for a specific load scenario can be predicted from a damage parameter Δ_ε, which can be obtained from numerical simulations. Alternatively to Coffin-Manson, a modified Paris approach can be used to calculate not only the time to failure, but the actual current crack area at any time:

$$\frac{dA}{dN} = C_1(\Delta\varepsilon_{pl})^{C_2}$$

Herein, dA/dN describes the increase of crack area per load cycle. This gives a couple of advantages:
- The crack growth parameters are not strictly limited to a single geometry, so the effect of different bond tools or bond parameters on lifetime resulting in different initial interface areas or different wedge geometries can be investigated.
- The decrease of thermal and electrical performance due to the deterioration of the interface can be considered as well as the interaction with other failure mechanisms.
- Crack growth is determined gradually, so that no assumptions like miners rule are necessary to consider damage accumulation for complex load conditions
- Different failure criteria can be defined: As an example the effect of the potting material properties on lifetime can be investigated. When the interface is sufficiently deteriorated, the bond will be lifted off the chip by the expansion of the potting when applying a thermal load.

To calibrate a crack growth model for Al thick wire bonds, Fraunhofer IZM has performed active power cycling tests to compile the necessary experimental data. Therefore, a special test setup was developed, that allows to performing active power cycling at defined temperature swings. The test stand comprises MOSFETs in linear operation mode at currents of 5-7 A sintered on DBC. For each bond that has been tested, the temperature swing was known and the crack propagation during cycling was monitored by shear tests and optic evaluation of the shear sockets. In this way 300 µm and 400 µm wires have been tested at the temperature swings 75 K, 85 K, 95 K and 105 K (cooler reference temperature was 20 °C for all cases).

To obtain the damage parameter for the crack propagation equation, a numerical simulation model has been set up. It consists of a wire bond wedge, chip and chip metallization. The crack is included with parametrical size, so that the damage parameter can easily be calculated for different crack states. As damage parameter the plastic strains $\Delta\varepsilon pl$ accumulated from one cycle to the next are considered and averaged in an area near the crack front. An example strain distribution can be seen in Figure 2.

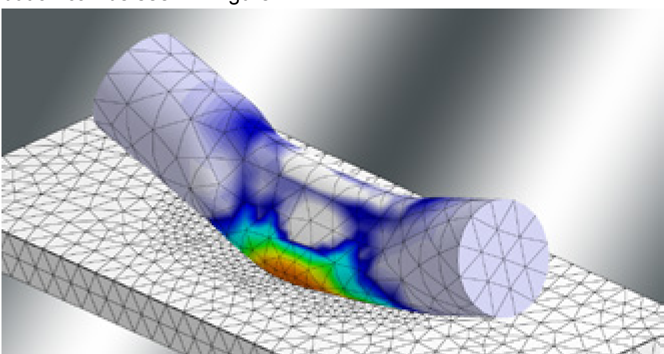

Figure 2: Finite element simulation submodel of wire bond wedge on semiconductor. The colors depict the strain distribution due to active power cycling.

The simulation results are sensitive to the material data used. Whereas silicon is well known and defined, the aluminum properties change with the wire material and microstructure of the bond and thus have to be characterized individually – by tensile tests or nanoindentation. Figure 3 shows temperature-dependent stress-strain curves of an Al-H11 wire.

With the experimental power cycling data and the damage parameters calculated by the simulation models, a crack propagation law in the form of a modified Paris approach has been calibrated. This kind of model enables to predict crack propagation after any number of cycles for different load conditions. An example is given in Figure 4. There, failure is assumed when the remaining interface becomes smaller than the cross-sectional area of the wire.

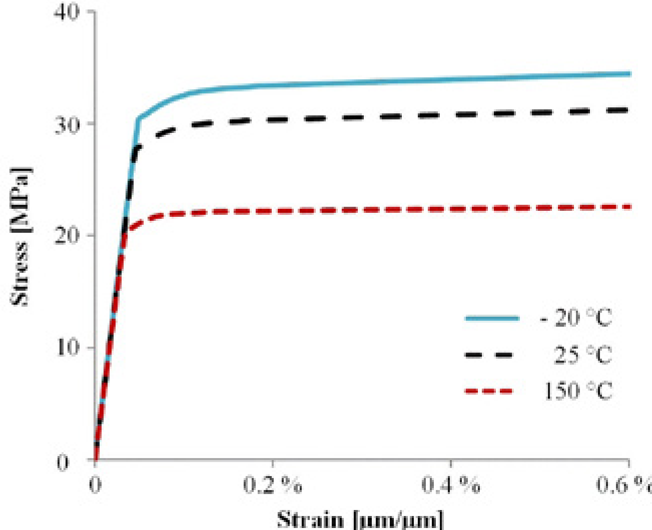

Figure 3: Temperature-dependent stress-strain curves of Al-H11 wire obtained from tensile test

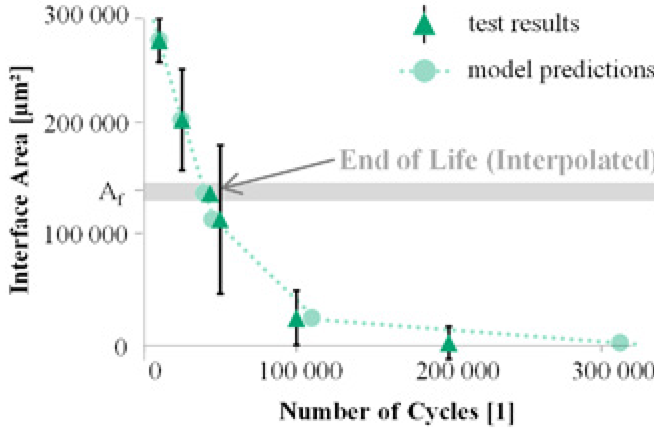

Figure 4: Crack growth prediction and test results for a bond interface subjected to active power cycling (400 µm wire, 85 K temperature swing)

In the development process of a power module modelling helps in that way to optimize design and create reliable products. Different design options can be compared and evaluated quantitatively without the need for expensive assemblies and testing. For a detailed overview of reliability for power electronics join our upcoming workshop on September 4, 2015. It will also cover the main range of failure mechanisms regarding classical and new technological trends. For further information, please visit our web page.

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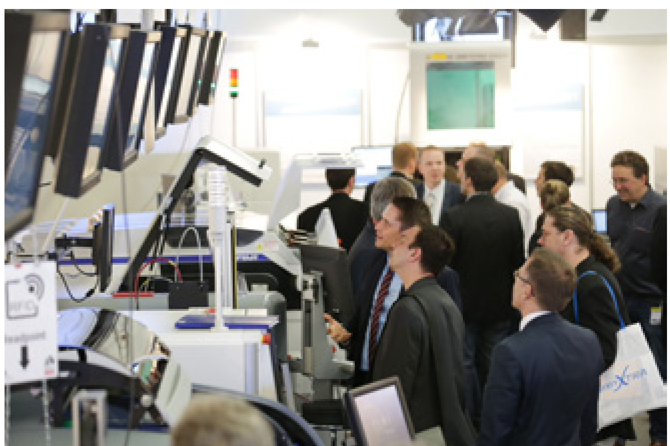
SMT Hybrid Packaging 2015: How to Package Future Power Components?

SMT Hybrid Packaging is the exhibition which informs its visitors about newest trends in semiconductor, PCB and systems manufacturing technologies. This year´s main topic was packaging technologies for smart systems at wafer and panel level which creates impact on power components, too.

By Wolfgang Patelay, Freelance Journalist, Bodo´s Power Systems

New at SMT Hybrid Packaging 2015 was the "High Tech PCB Area" in which companies presented their products and services regarding the PCB topic. The integrated forum and the catering area enabled discussions about developments and trends. "Man – Machine – Collaboration - Technology produces emotions, emotions control Technology" was the topic of the production line 2015. Initiated by Fraunhofer IZM Berlin, exhibitors at the "Optics meets Electronics" joint stand were showed the effects of the introduction of optical technologies in electronics and available solutions. At the joint stand of the 3-D MID network, 16 companies and institutes from all areas of interdisciplinary MID technology informed about the current status of technology and new serial applications. The formal presentation of the MID Industry Award 2015 took place on the MID forum.



Klaus-Dieter Lang, chairman of the SMT Hybrid Packaging committee defined in his presentation „Packaging Technologies for Smart Systems at Wafer and Panel Level", customer requirements for smart systems. Smart systems are one of the actual mega-trend in the electronics industry because there is no doubt that our world becomes smarter and smarter. Examples are Smart Cities, Smart Homes, Smart Healthcare, Smart Cars, Smart Watches, and even Smart Clothes and all of them need power supplies. Therefore these smart systems have to be connected, operate autonomously and safe, and be miniaturized. This creates impact on system integration and assembly. The robust, modular, and standardized systems must be produced at very low cost and energy-efficient with improved materials and advanced technologies for different application environments. They must transmit high volumes of data or pre-assessment of data with large bandwidth in real time over long ranges via high performance wired or wireless technologies. They require also the analysis of very large amounts of data, so called Big Data, as well as an extremely high level of data security which includes high reliability of data identification and no chance for manipulation. These systems should also include navigation capability and an intuitive human-machine interface for ease of use.

These customer requirements lead to the following driving forces for system packaging. There is increased functional integration in the minimized systems what means passive components are integrated in RDL and systems-in-package (SiP) as well as 3D capabilities are used to create the smallest possible dimensions. Future systems have to have the thinnest packages with minimum lateral area. But theses systems need to have also the maximum electrical performance e.g. minimum interconnect line length and reduced number of interconnects, multilayer RDL, and increased operating speeds. Hence the power consumption of theses dense packages is increasing what results in challenges for the thermal performance of the small chips with a high number of I/O and small pitches. Therefore the system requires improved chip to board coupling to overcome the thermal issues. And last but not least the entire production costs (batch processing, packaging, test) of the systems must be at minimum. The solution for all of these challenges is wafer level packaging. Beside the increasing density of the chip packages via 3D technologies there is also the trend to embed PCB technologies to create a so called PLP (panel level package). This requires advanced PCB processes and materials ready for PLP as well as improved resolution and accuracy for next generation PLP. 2015 is - according to Yole Development - the starting point for the general use of real 3D chips with TSV (through silicon via) and 3D FOWLP (fan-out wafer level package). In its new report "Fan-Out and Embedded Die: Technologies and Market" Yole analysts mentioned that the FOWLP market reaches almost 200 Million Dollar and is expected to grow with 30% GAGR. After describing in detail the various methods of wafer level integration, silicon-interposer roadmap, the embedding process for PLP, panel level molding including PCB embedding substrates, IC substrate technologies, and the market for 3D components, Lang concludes that the production of embedded packages is ramping up fast. The market volume in 2013 was according to Yole 340 million dollars and is forecasted to reach 1700 million dollar in 2016. Driving forces for this growth are smart phones and computers. In smart phones DC/DC converters, power management units, and connectivity modules

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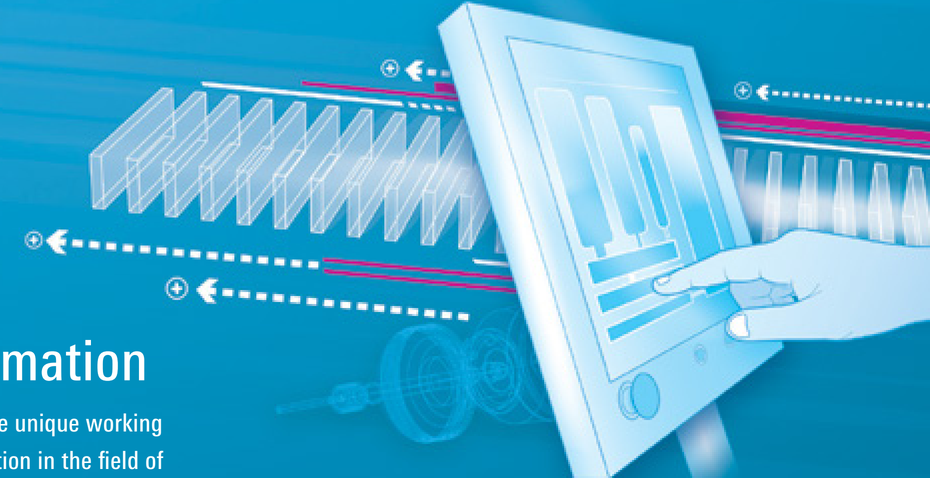

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will be produced with embedded package technology in future. MOSFET packages and driver MOS SiPs are the main applications in the computer market. PCB embedding technology is already implemented at PCB manufacturers, semiconductor manufacturers, and OSATs (outsourced semiconductor and test) or will come soon. To embed active components like integrated power management devices in laminate packages, power devices like voltage regulators, automotive modules including embedded IGBTs, RF modules, FOWLP, and PoP (package on package) with embedded application processor opens great market opportunities. The market volume for these embedded power modules was - according to TechSearch International - 727.5 Million Dollar in 2012 and will grow to 2,444.8 million dollar in 2017.

How to produce smart systems with these future devices was demonstrated at the joint booth Future Packaging by 36 electronic production companies. The sample board featured Flip-Chip components, SiP-om Board, 008004 components, SMD crimp connectors, tiny micro push button, Al bonds, and flex-rigid printed board to create a folded cube. This board was manufactured several times during the exhibition with commentary in English.

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Smart LED DC Module 20W, an Efficient Compact LED Solution

By Valentin Kulikov, fulit

A DC fed LED module combines the most recent LED technology with a smart DC driver, offering a ready-made solution for fixture producers, researchers, and hobbyists. The module is populated on a metal core PCB, implementing both the LEDs and high efficiency driver, incorporating both thermal fold-back and dimming. Thermal fold-back and active control of the maximum temperature of the module provides a great advantage. While the driver is small, it operates at high efficiency, above 94%, and accepts input voltages up to 60 VDC (as shown in Figure 1). In the event of a failed (shorted) LED, its efficiency is still high enough to keep the remaining LEDs operating correctly. If even more lighting reliability is desired, the module (upon request) can be provided with LED shunts, thus solving open LED failures.

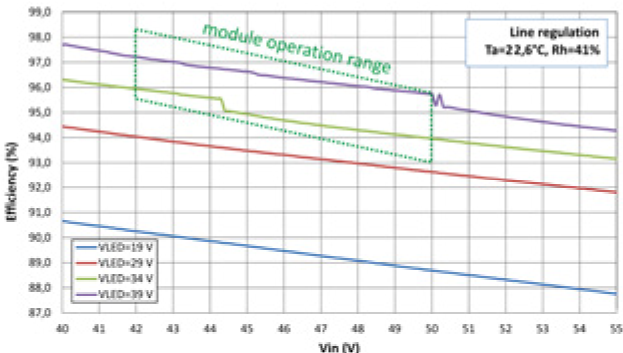


Figure 1: Smart LED module efficiency characteristics

Several modules can be paralleled and connected to central or individual constant voltage 48 VDC power supplies, thus forming lighting fixtures or a system according to specific needs. The module is used conveniently with control accessories from FuturoLighting [1]. Because of the integral thermal fold back, the module itself will never get overheated, therefore its lifetime is not affected by inappropriate installation and inappropriate environments, i.e., it is thermally safe even without a heat sink. If the module temperature should become higher than a set temperature, the driver decreases current flowing to the LED's, reducing power consumption and keeping the temperature constant. This is shown in Figure 2. This current change is continual and does not disturb visual perception.

Lamp intensity, flux, as well as module consumption can be controlled by dimming signals, either a fast PWM (0-5 V, from an MCU) or an Analog signal (regular dimmers 1-10 V, isolated). On request, there are several other control options available, including protected PWM input and different analogue signal levelling.

The smart LED module is assembled with Cree XT-E, with output flux > 2300 lm (LED hot efficiency >110 lm/W) @ Tsp = 70°C, CCT = 4000K, CRI >70. Based on customer needs we are able to populate modules with different LED brands including white, colour, IR and UV LEDs.

The Module dimensions are 145x43 mm, with a total height only 4.1 mm, so as to fit into thin street optics 2x6 (shown in Figure 3.).

The module is compatible with optics from Ledil, Carclo, and other manufacturers, and it can be customized on request, according to your needs, including dimensions and LED positioning.

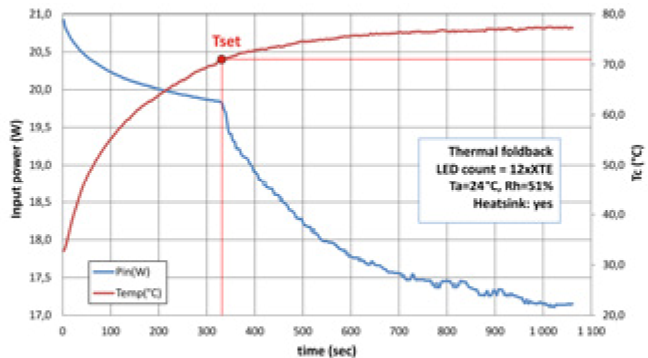


Figure 2: Smart LED module thermal foldback (used inappropriate sized heatsink

Fields of application

The module will find applications in Low Bay, High Bay, Street Lighting, wall washers, plant growing, UV curing, IR security vision and in other special purposes. The LED module is customizable and customers can select a specific LED brand, light colour (R, G, B, IR, UV, and their combination, for instance, for research and other scientific purposes), CCT, CRI, flux bin, and also drawing current (example, see Figure 5). Simply add a central or individual 48 VDC power supply and connect as many modules as needed to create a lighting system. The required power source should be sized to provide 22W to each, for example 4 Smart LED modules will need a minimum 90 W power supply.

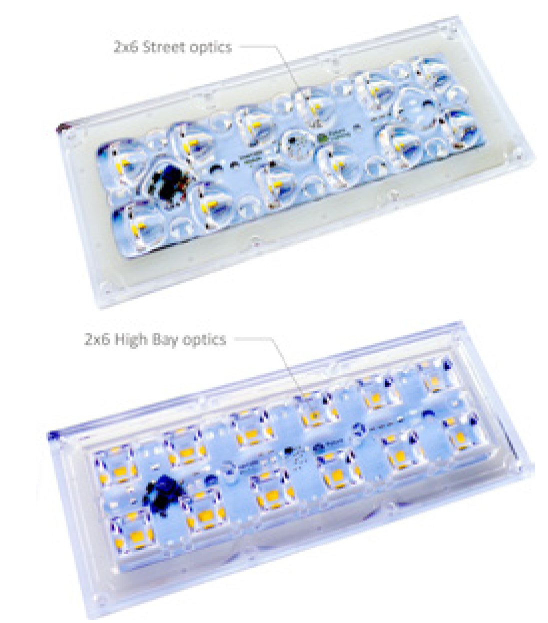


Figure 3: Smart LED module fitted into 2x6 street optics (top), high bay optics (bottom)

Low voltage smart grid

These LED modules are suitable to form low voltage (48 VDC) grids involving dimming control, occupancy detection and other smart functionality. For example, a central SMPS of 480W can supply around 20 LED modules, providing above 46k lumen flux (from modules at Tsp = 70°C). Figure 4, shows a connection example using PWM signal across modules.

Conclusion

These modules are a ready-made solution for everyone designing lighting fixtures and systems. The Smart DC LED module can be easily used to form low power up to high power fixtures for general lighting, plant growing, Sea life aquariums and many others. It is only required to connect an appropriate number of modules together and power them from a constant voltage power supply. Additionally, these modules control the maximum temperature, extending module life and minimizing temperature degradation and failures. Even a missing heat sink will not lead to a module overheating. Smart LED modules have dimming input that can be either PWM or Analog controlled. Additionally, proximity sensors can be connected to the DIMM input for presence detection and light switching. But the easiest way method of brightness control is to use a potentiometer and few low cost components to make provide dimming. More information can be found in the product Leaf letter [2ddsxxxxxx].

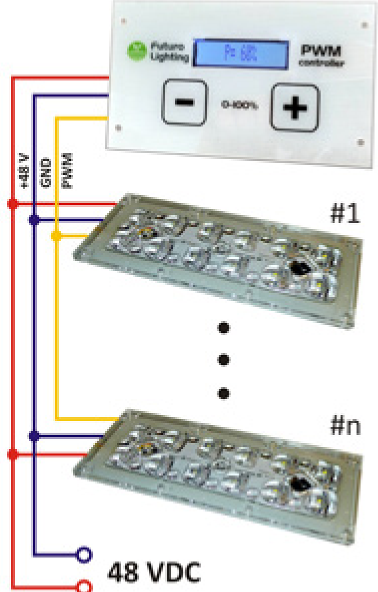


Figure 4: Low voltage grid with PWM dimming

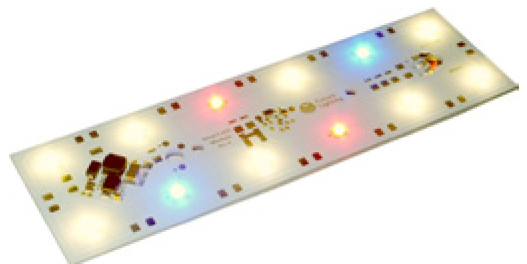


Figure 5: Customized LED module for sea life aquariums

Literature

[1] Available controls: http://www.fulit.eu/controls.html

[2] Smart DC LED module Leaf letter: http://www.fulit.eu/docs/smartdc20_lft.pdf

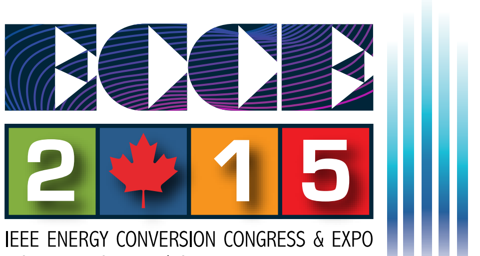
www.fulit.eu

Important Author Dates

January 15th, 2015: Digest submitted via the website
May 1st, 2015: Notification of acceptance or rejection
July 1st, 2015: Final papers with IEEE copyright forms

Other Important Dates

February 16th, 2015 : Submission of Tutorial proposals
March 31, 2015: Submission of Special Session proposals



The Seventh Annual IEEE Energy Conversion Congress and Exposition (ECCE 2015) will be held in Montreal, Canada, on September 20 - 24, 2015. ECCE 2015 is the pivotal international conference and exposition event on electrical and electromechanical energy conversion. To be held for the first time outside USA, ECCE 2015, in Montreal, Canada, will feature both industry-driven and application-oriented technical sessions, as well as industry expositions and seminars. ECCE 2015 will bring together practicing engineers, researchers and other professionals for interactive and multidisciplinary discussions on the latest advances in various areas related to energy conversion.
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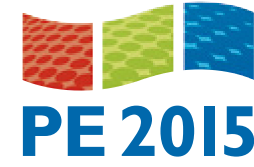

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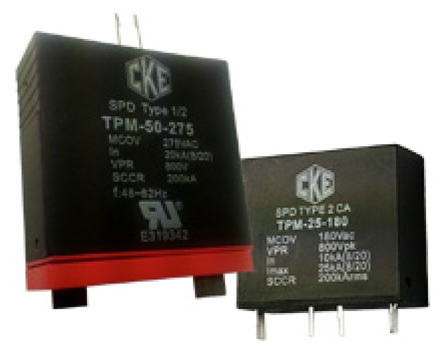
Thermally Protected MOVs – TPM Series

Dean Technology, Inc. today announced the newest edition to its CKE suppression products, the TPM series. These thermally protected MOV suppressors have a high surge current capability, meet UL 1449 3rd edition, and provide floating remote signaling contacts for fault indication.



The TPM Series suppressors integrate a thermal disconnect apparatus in series with the MOV disc;
ensuring that if the unit overheats it is disconnected from the circuit. This helps to eliminate common
failure modes that have historically occurred in the field with MOV components in uses including lightning protection, and inductive or capacitive load switching. The fail-safe nature of the CKE TPM Series offers extra assurance against any risk of fire or similar negative event.

"The TPM Series is a great example of how Dean Technology is working tirelessly to keep pace with the ever evolving standards for electrical components," said Larry Cagle, Dean Technology's director of technology development. "We want to ensure we have the most modern products available in our particular markets, while continuing our mission to provide a full range that covers any new or historic
need. These TPM devices hold true to that, and also our commitment to offer products at the best possible value."

www.deantechnology.com

The Engion Sentry 6.8 kW Solar Energy Storage System

The VARTA Micro Group announced that its subsidiary VARTA Storage GmbH has expanded its compact and powerful engion product line of energy storage systems to include engion sentry automatic backup power battery storage system, which features 6.8 kW output power. The engion sentry will be exhibited at Intersolar North America, July 14 through 16, 2015 in San Francisco, CA. Additionally on display will be VARTA's engion flex power and engion element battery storage systems designed for commercial and residential applications, respectively.

All members of the engion product line can be remotely monitored from a smartphone or the Internet.

Housed in a sleek, tasteful and lockable cabinet, engion features state-of-the-industry lithium-ion (Li-ion) and lead acid battery technology to allow residential and commercial property owners and managers greater independence from public utilities by storing energy generated by new or existing photovoltaic (PV) systems. The engion sentry backup power system combines German engineering with solid American manufacturing. It assures that power is available in the event of a power grid fault and is an extremely safe and robust alternative to backup generators. The engion sentry eliminates noise emission and the increasingly common occurrences of carbon monoxide poisoning.

Due to the modular configuration of the battery modules, engion sentry is offered with usable battery capacities up to 18 kWh. The engion also boasts redundant mechanical and electrical functions, along with flame-retardant housing and automatic overvoltage cutoff. The system is engineered specifically to allow existing battery modules to be combined with future battery technologies.

http://www.varta-microbattery.com/en.html

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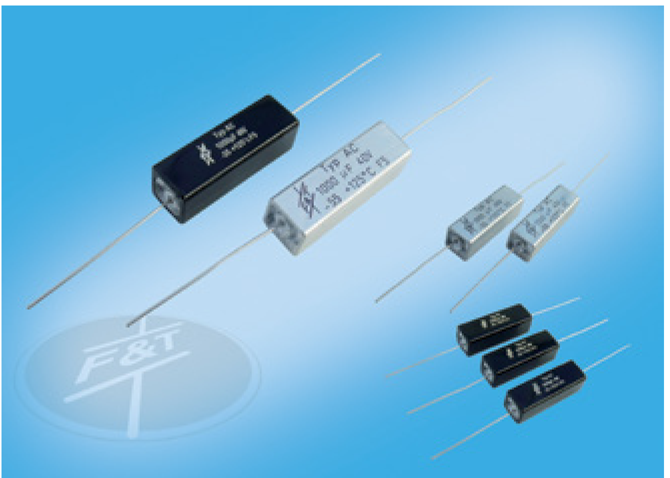
Cubic Design for Axial Electrolytic Capacitors

The Husum-based capacitor expert FTCAP demonstrates, however, that this does not necessarily have to be the case: the new cubic design offers significant advantages especially with respect to cooling.



"In some applications, the capacitors are in contact with the cooling modules. The larger the contact surface, the more effective the cooling," explains Dr. Thomas Ebel, Managing Director of FTCAP. "Compared to conventional capacitors, those with the new design have a 28 % larger surface." This larger contact surface allows better connection of the cube-shaped capacitors to the cooling systems, which results in improved cooling capacity. That, in turn, results in significantly better current-carrying capacity – this design allows it to be duplicated. The hermetic laser sealing of the cover also makes it possible to double the service life.
Another advantage of the cubic design is the high degree of space utilisation: the capacitors are designed for flat mounting and can even be stacked. Dimensions between 10x10x20 mm and 18x18x49 mm and voltages of 25 to 100 Volts make them ideal for use in the automotive industry.
The capacitors are designed for combination in a modular system and the capacities can be adjusted individually. The innovative components feature internal multiple contacts with up to four lugs.

www.ftcap.de

Hall-Effect Angle Sensor ICs for Motor Position Applications:

The A1331 and A1334 from Allegro MicroSystems Europe are a family of contactless, Hall-effect based magnetic sensor ICs for high-speed motor position sensing in safety-critical automotive applications.
Allegro's dual-die A1331 and A1334 angle sensor ICs are based on vertical Hall-effect technology with system-on-chip architecture that provides fast output refresh rates and low signal path latency.
Each device is offered in a TSSOP-24 package that contains two individually sawn, electrically isolated silicon ICs. The dual-die feature makes them suitable for use in safety-critical applications that require the use of redundant sensor ICs, especially in ASIL compliant automotive systems. The A1334 is also offered in a single die configuration in the TSSOP-14 package for applications that do not require redundancy.

Typical applications include electronic power steering or power braking motor position sensing, transmission actuator position sensing, throttle/pedal position detection, and other systems that require accurate measurement of angular or rotary position.
The A1331 and A1334, with their onboard digital signal processing functions and EEPROM for factory and customer programmability, are designed specifically for on-axis/end-of-shaft angle sensing applications that require ultra-fast output refresh rates and low signal path latency.
These sensor ICs include a 4-wire 10 MHz SPI interface with a 25 µs output refresh rate and a nominal signal path latency of only 60 µs. In addition, the ICs can operate directly off a vehicle battery, supporting a wide 4.5-14.5 V supply voltage range while consuming just 10 mA (maximum) of supply current per silicon die. They also include signal path and I/O diagnostics designed to meet the stringent needs of ASIL safety requirements.

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		900A		P		
250 × 89	2-Pack	1000A			E E+	P
		1400A	E	P	E	P
	Chopper	1000A			E	
		1400A		P	E	
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E : E-type (low switching losses) E+ : E-type with large Free Wheeling Diode P : P-type (low $V_{CE,sat}$ & soft turn-off)

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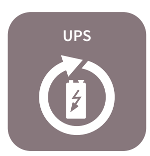

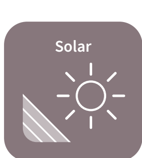

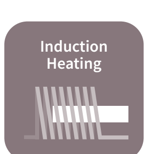

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