Improve New Product Positioning, Reduce Time to Market, Protect Your IP Through Benchmarking and Deep Analysis

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LTEC Corporation

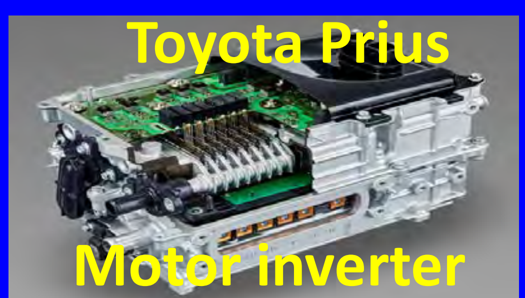
member

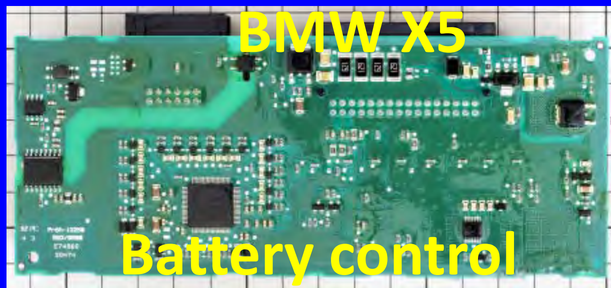
Introduction

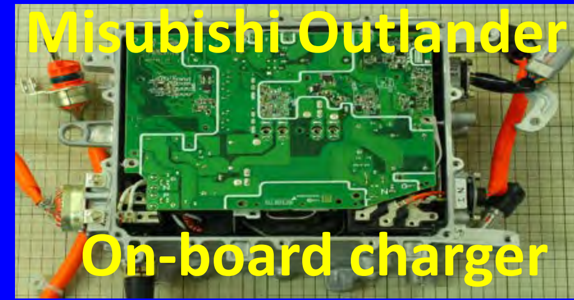
- About LTEC corporation
- Definition of terms:
  - Technical Analysis (Hardware, IP)
  - Reverse Engineering (RE)
- Re-inventing RE: Harvesting the synergies between product development and learning through RE:
  - Collaborative RE (CRE)
  - Collaborative Outsourced RE (CORE)
- Practical (real life) examples
- Summary

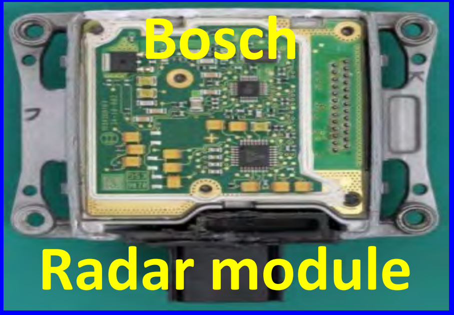
About LTEC Corporation

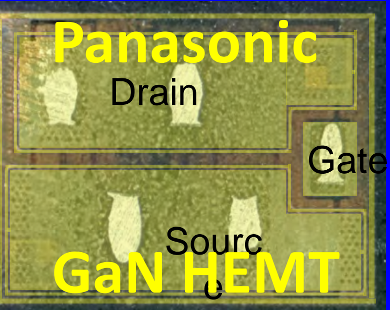
- LTEC is Japan's dominant provider of intellectual property services. We provide
  - Technical analysis of products released to market
  - Intellectual property (patents) analysis
  - Technology analysis

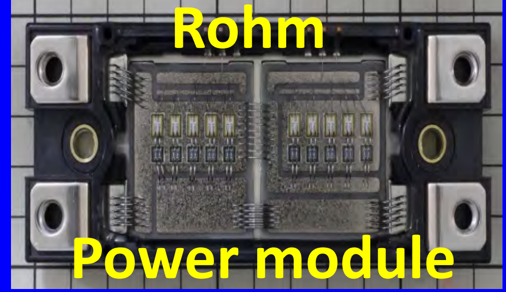


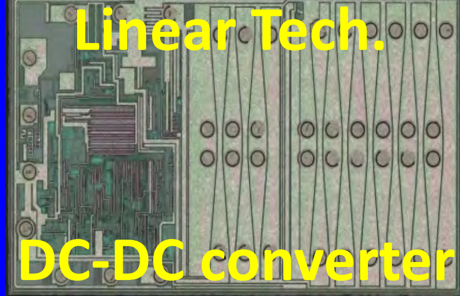












We focus on power electronics

LTEC Corporation and Its Client Base

Region	Companies
Japanese Electrical manufacturers Semiconductor/Component manufacturers	Panasonic, Toshiba, SONY, NEC, Hitachi, Mitsubishi, Murata, Taiyo Yuden, Rohm, Renesas, TDK, Sharp (Foxconn), Yamaha
Japanese Automotive manufacturers	Toyota, Mitsubishi motors, Mazuda, Denso, Aishin, Hitachi automotive, Yazaki, Calsonickansei, Yamaha
USA Semiconductor manufacturer	Qualcomm, On-Semiconductor, IDT, Maxim, Intel (Altera),
Korean Automotive manufacturer	Hyundai automotive, LGE
Korean Electrical manufacturer	Samsung, LGE
Taiwanese Semiconductor manufacturer	MediaTek, TSMC

Definition of Terms

Technical Analysis - Definition

- Focused secondary research involving
  - Intellectual property (IP), patents
  - Technology
  - Hardware: Reverse Engineering (RE)
  - Software (RE)

Technical

TECHNOLOGY

RE

IP

Analysis

Technical Analysis is secondary research involving IP (patents,) technology, hardware/software RE

Reverse Engineering (RE) - Definition

- RE is process to extract knowledge or design blueprints from anything man made.
- RE is about learning about new technologies, know-how not yet available from textbooks, patents and other publications just yet; about latest technologies.
- RE teaches you things not readily available.
- RE helps your company to remain competitive.

I have a lot more to say about this!
Come to Booth 1339

!RE is about learning!

Example

Example: Learning through RE

- **Example:** RE performed on latest generation SiC MOSFETs.

How is Tj=200°C operation achieved by new package EMC?

SCT30N120

Silicon carbide Power MOSFET 1200 V, 45 A, 90 mΩ (typ., T_J = 150 °C) in an HiP247™ package

Datasheet - production data

HiP247

Features

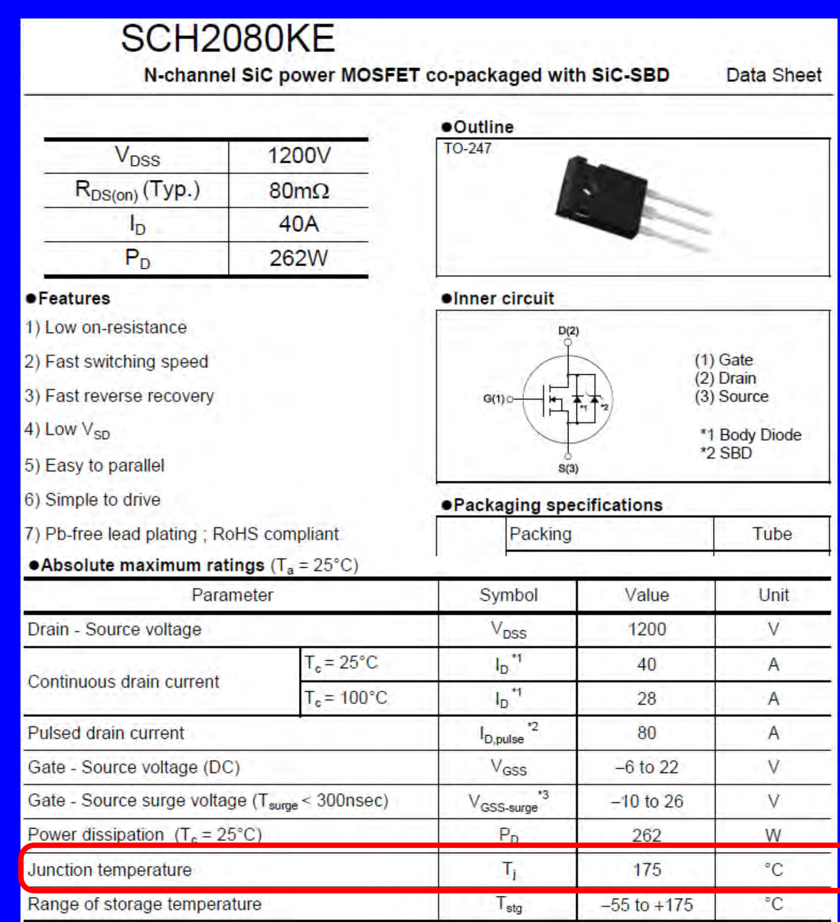
- Very tight variation of on-resistance vs. temperature
- Very high operating temperature capability (T_J = 200 °C)
- Very fast and robust intrinsic body diode
- Low capacitance

Applications

- Solar inverters, UPS
- Motor drives
- High voltage DC-DC converters

Table 2: Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{DS}	Drain-source voltage	1200	V
V_{GS}	Gate-source voltage	-10 to 25	V
I_D	Drain current (continuous) at T_C = 25 °C (limited by die)	45	A
I_D	Drain current (continuous) at T_C = 25 °C (limited by package)	40	A
I_D	Drain current (continuous) at T_C = 100 °C	34	A
I_{DM} (1)	Drain current (pulsed)	90	A
P_{TOT}	Total dissipation at T_C = 25 °C	270	W
T_{stg}	Storage temperature range	-55 to 200	°C
T_j	Operating junction temperature range		°C



SCH2080KE

N-channel SiC power MOSFET co-packaged with SiC-SBD — Data Sheet

V_{DSS}	1200V
$R_{DS(on)}$ (Typ.)	80mΩ
I_D	40A
P_D	262W

●Outline

TO-247

●Inner circuit

●Features

1) Low on-resistance
2) Fast switching speed
3) Fast reverse recovery
4) Low V_{SD}
5) Easy to parallel
6) Simple to drive
7) Pb-free lead plating ; RoHS compliant

●Packaging specifications

Packing	Tube

●Absolute maximum ratings (T_a = 25°C)

Parameter		Symbol	Value	Unit
Drain - Source voltage		V_{DSS}	1200	V
Continuous drain current	T_c = 25°C	I_D *1	40	A
	T_c = 100°C	I_D *1	28	A
Pulsed drain current		$I_{D,pulse}$ *2	80	A
Gate - Source voltage (DC)		V_{GSS}	−6 to 22	V
Gate - Source surge voltage (T_{surge} < 300nsec)		$V_{GSS-surge}$ *3	−10 to 26	V
Power dissipation (T_c = 25°C)		P_D	262	W
Junction temperature		T_j	175	°C
Range of storage temperature		T_{stg}	−55 to +175	°C

RE reveals undisclosed features

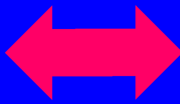
Learning through RE

- Example: We performed RE on latest generation SiC MOSFETs.

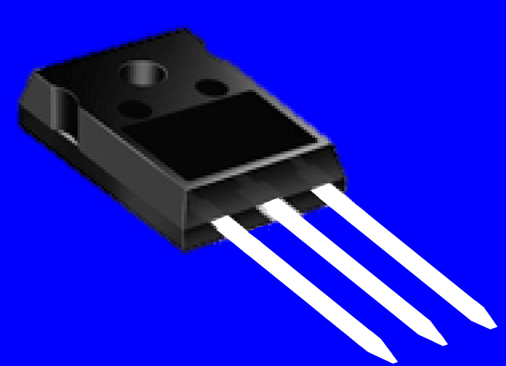
How is Tj=200°C operation achieved by new package EMC?

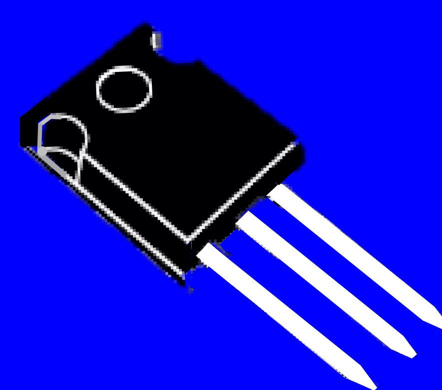
T_j=200Cº Continuous

$T_{storage}$=200Cº



Tj=150Cº Abs. Max.





➡ **What are the key enablers?**

Enabling Continuous 200ºC Operation

- Evidence:

a)

PIQ 4.94um Source 3.60um Gate

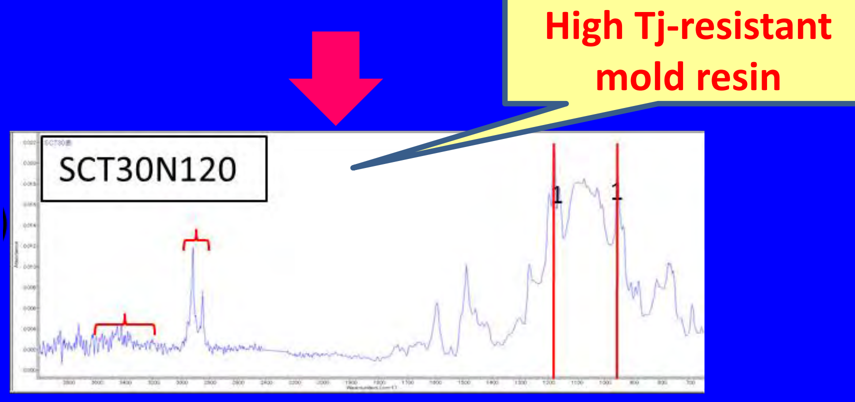
PIQ 6.14um Source 4.70um Gate Necking

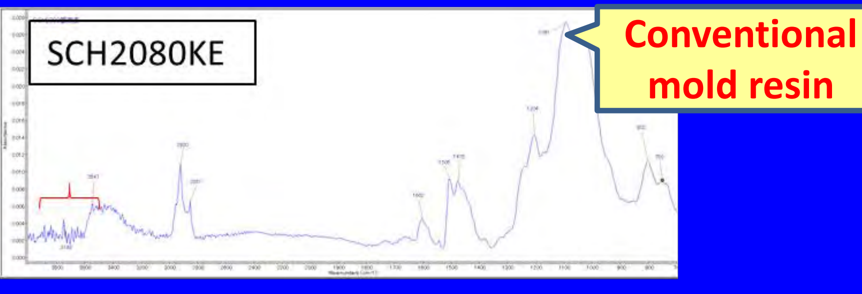
b)

Al Ti NiSi SiC SCT30N120

Al Ti Gate SiC ※Pb(debris) SCH2080KE

SEM cross-section observation of evaluated SiC devices. (a) Transistor structure. (b) Detail of the top metal (source) electrode.





Measured package resin FTIR spectrum of samples (a) SCT30N120 (SiC Tjmax = 200℃), and b) the SCH2080KE (SiC Tjmax = 175℃). Strong peaks (around 980 cm^{-1} and 1200 cm^{-1}) in the SCT30N120 SiC device package are observed.

RE quickly identifies key enablers

RE vs. IP Analysis: Different Objectives, Identical Methodology

R&D AND PRODUCT DEVELOPMENT DEPARTMENTS

IP (PATENT) DEPARTMENTS AND LAW FIRMS

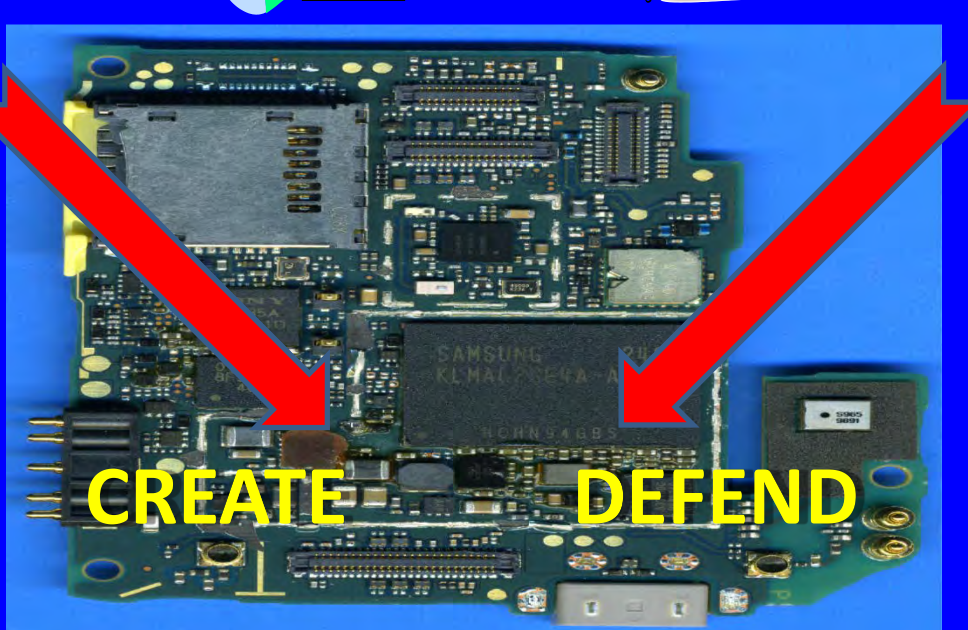
WANTS TO KNOW:
COMPETITORS' PRODUCTS AND TECHNOLOGIES

WANTS TO KNOW:
COMPETITORS' IP AND TECHNOLOGIES

ANALYZE

LEARN

UNDERSTAND



ANALYZE

LEARN

UNDERSTAND

RE has much to offer to both branches

Our Unique Approach to RE

Re-inventing RE

- About LTEC corporation
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A Unique Approach to Technical Analysis

Collaborative Reverse Engineering (CRE)

Collaborative Outsourced Reverse Engineering (CORE)

- Provides dynamically targeted RE by working collaboratively and interactively with
  - Product development teams
  - IP analysis and protection teams
- Facilitates fast learning through RE in a way that
  - Enhances new product positioning
  - Accelerates the pace of product development

RE in Product Development

IP	RE	Design	IP+RE
PAT LANDSCAPE	**Level 1 RE (Overview)** **Level 2 RE** • Structure Analysis • Material Analysis **Level 3 RE** • Circuit Analysis • System Analysis **Level 4 RE** • Related Patent Analysis		PATENTS File, De-fend

Product Development Flow

Recognize: RE is a natural starting point to develop creative new ideas

CORE Provides Active Support in Product Development

Product Development		CRE/CORE
Market Research		
Preliminary Product Definition		◆ Competitor products analysis ● Product Benchmarking ● Technology Benchmarking
Product Definition	Patent Strategy	◆ Patent, IP landscape Analysis
Development Design	Design Environment	◆ RE for Physical Modelling: ● Electrical models (SPICE) ● Thermal models
Prototyping	Supply-Chain Development	◆ Supply-chain: ● Outsourced components QA assessment by RE
Reliability Test, Q/A		
Release to market		

We are engaged in the background as needed

Why "Collaborative" RE?

- ❑ Manpower/resource utilization
  - ❑ Enhanced productivity ➡ faster time to market
  - ❑ Parallel vs. serial process ➡ faster time to market
  - ❑ Unique know-how
  - ❑ Cost of labor
- ❑ Delivers deep understanding of your competitors' strengths and weaknesses prior to product definition
  ➡ more competitive product
  - ❑ Uncovers hidden features, materials, trends
  - ❑ Helps avoid re-inventing the wheel
- ❑ Mitigates risks

Why "Outsourced"?

- You can
  - free up designers to focus on product development
    ➡ faster time to market!
  - build a solid foundation for design activity by benefiting from our
    - broad knowledge gained from analyzing similar products
    - knowledge of the latest technology
    - proprietary tools and methodologies

Examples

Example: Why "Outsource"?

- Understand your competition (hardware, software, and patents, technology) prior to product definition/design

Model 1
Model 2
Model 3
Model 4
Model 5
Model 6

?

Performance?

Reparability?

Features?

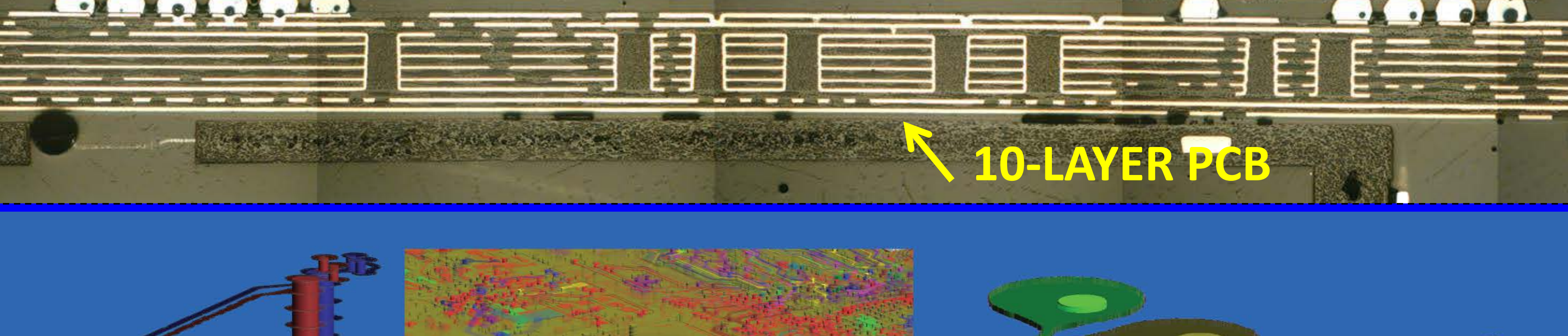
Design improvements?

Learn from the past, learn from the best, apply to the future

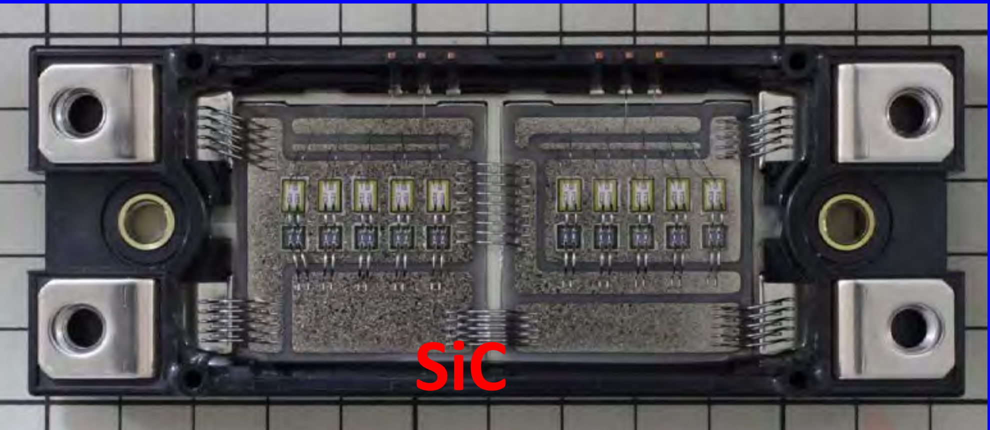
Rely on broad knowledge of the competitive landscape

Example: Collaboration with Design Teams

- Is manpower available to do the work in-house?
  - RE is labor intensive!
  - Parallel RE and design vs. serial? Faster time to market!



Example: Understand Latest Technology



D

S/SS

IC

TH

Thermal Pad

GaN

Early detection of technology trends

Example: Understand Latest Technology

AMD (RadeonR9 Fury X)

Interconnect Technology in 3D packaging is a major challenge!

TSV

Top HBM Memory die

HBM Memory die

HBM Base die

Silicon interposer

100.0µm

Stacked High Band Memory (HBM)

Processor(CPU,GPU)

Silicon interposer

Package substrate

PCB

1000µm

Early detection of technology trends

Example: Understand Latest Technology

Apple (A10)

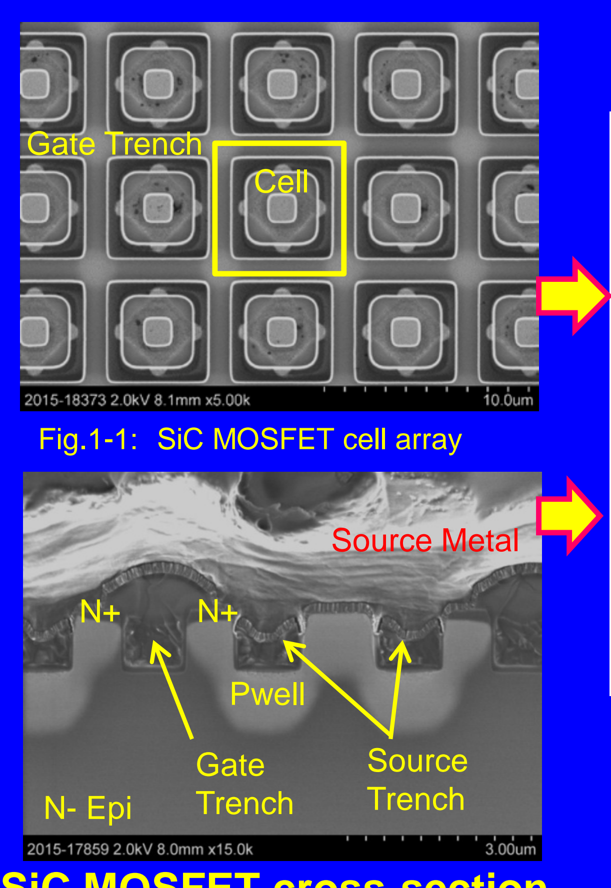
TSMC InFO features explained:
- Thickness 20% down
- Heat generation 10% down
- I/O speed 20% up

Our RE also reveals some of the remaining challenges!

Early detection of technology trends

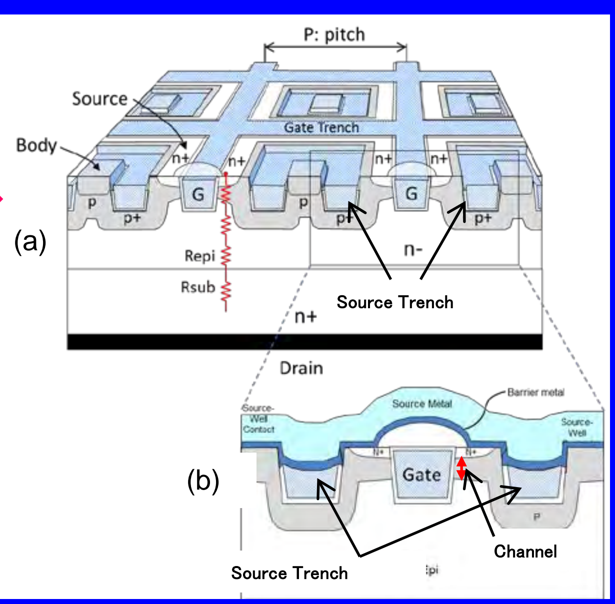
Example: Finding the Not So Obvious...

- RE reveals essential features, materials not shown in the datasheet, nor discussed in conferences!

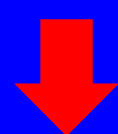


SiC MOSFET cross-section

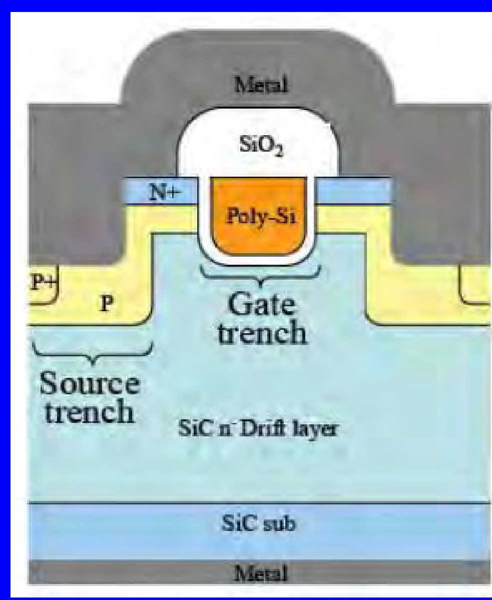
This is what we give you



Reconstructed details



This is what you get



Essential details not shown or published anywhere

Ramifications on device reliability, Q/A, F/A

Example: Deep Analysis

Image sensor material analysis: find ultra-low volume of Al within ZrO2 layer within an

- Measure the characteristic X-ray energy
- Convert to atomic %
- Characteristic X-ray has specific energy of element by element

Amorphous Si

Start

TiN (Cl)

ZrO_2 (Al)

TiN

ZrO_2 (Al)

TiN (Cl)

SiO_2

End

Atomic %

Quantitative analysis

Start

EDX Line profile analysis

End

Atom-%

① Si:74.17% O:17.99%

② Ti:29.84% N:23.95% O:23.66% Cl:1.70%

③ Zr:21.48% O:62.88% Al:1.82%

④ Ti:30.35% N:22.31% O:34.73%

⑤ Zr:24.55% O:59.82% Al:1.89%

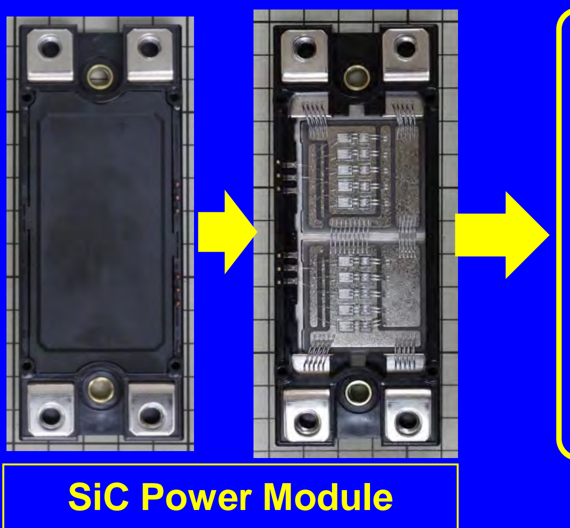
⑥ Ti:30.71% N:22.55% O:24.96% Cl:1.25%

⑦ Si:39.61% O:54.71%

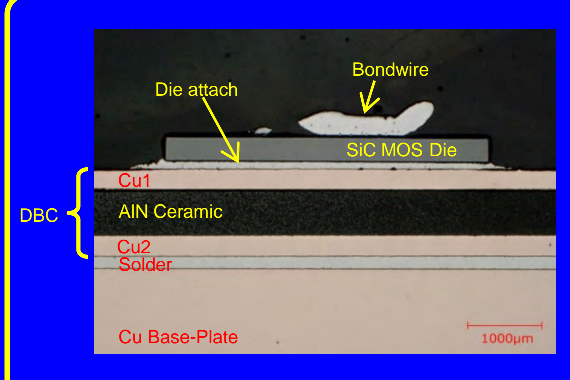
Virtually no limit to the level of details

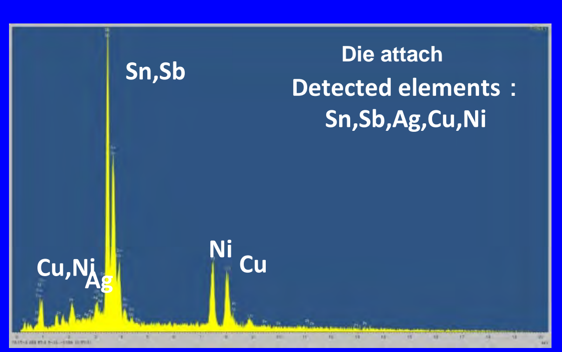
Example: RE-based Physical Modeling

❑ Ex.: RE analysis and thermal model of SiC power module

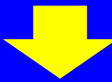


SiC Power Module

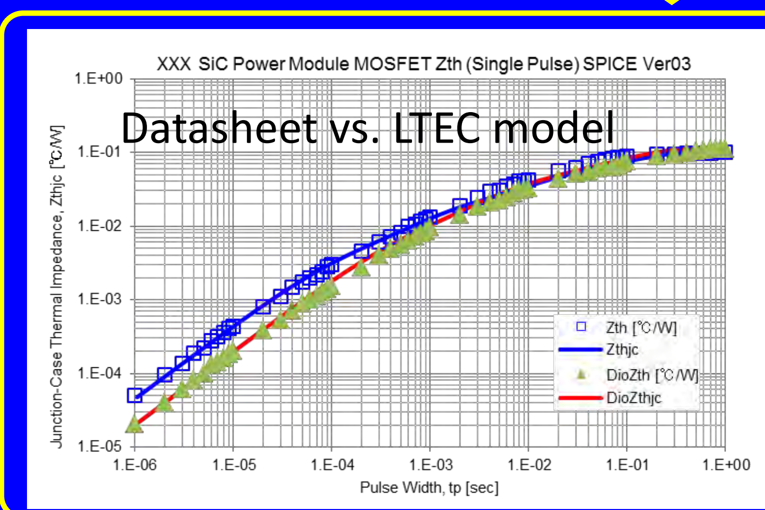


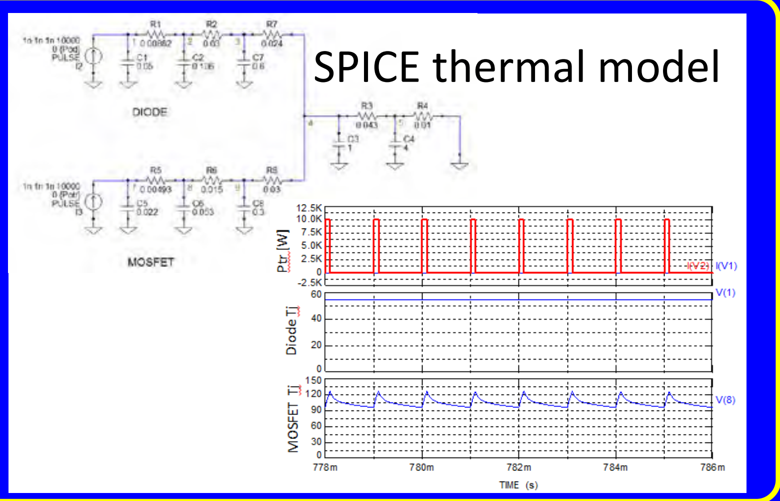


Power module physical and materials analysis through RE



Electro-thermal model





RE improves your system/device/component modelling

Example: Avoid Re-inventing the Wheel

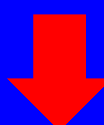
ROAD CLOSED

59% **41%**

INNOVATION

- ❑ A USPTO study found that

"For the patents where at least one claim was held unpatentable, the prior art used by PTAB had been in front of the examiner during prosecution 59 percent of the time." *Source: USPTO, Jan. 2015*



Proactive RE & IP search saves $

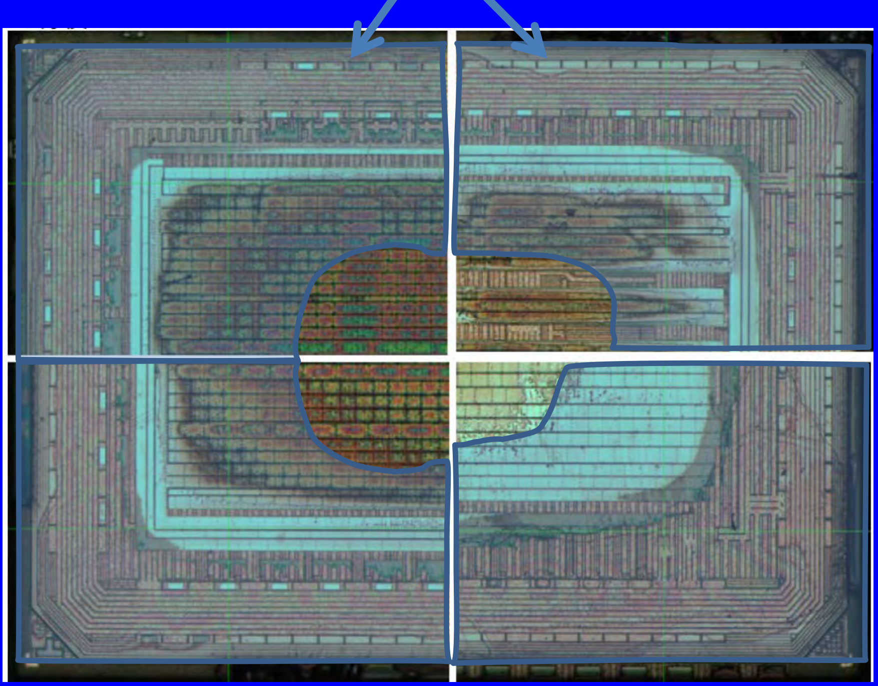
Tools of Our Trade

Advanced Productivity Enhancement and Modeling Tools

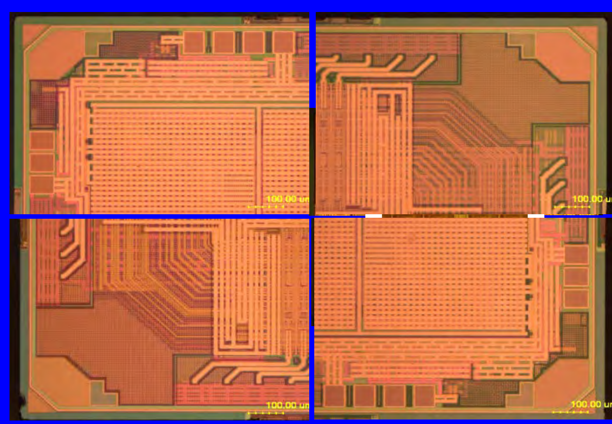
The Art of Delayering

Fatal over-polishing may occur in the die peripheral portion can be easily predicted.

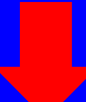
Over-polished region



Typical over-polishing



Proprietary delayring Technology down to 10nm

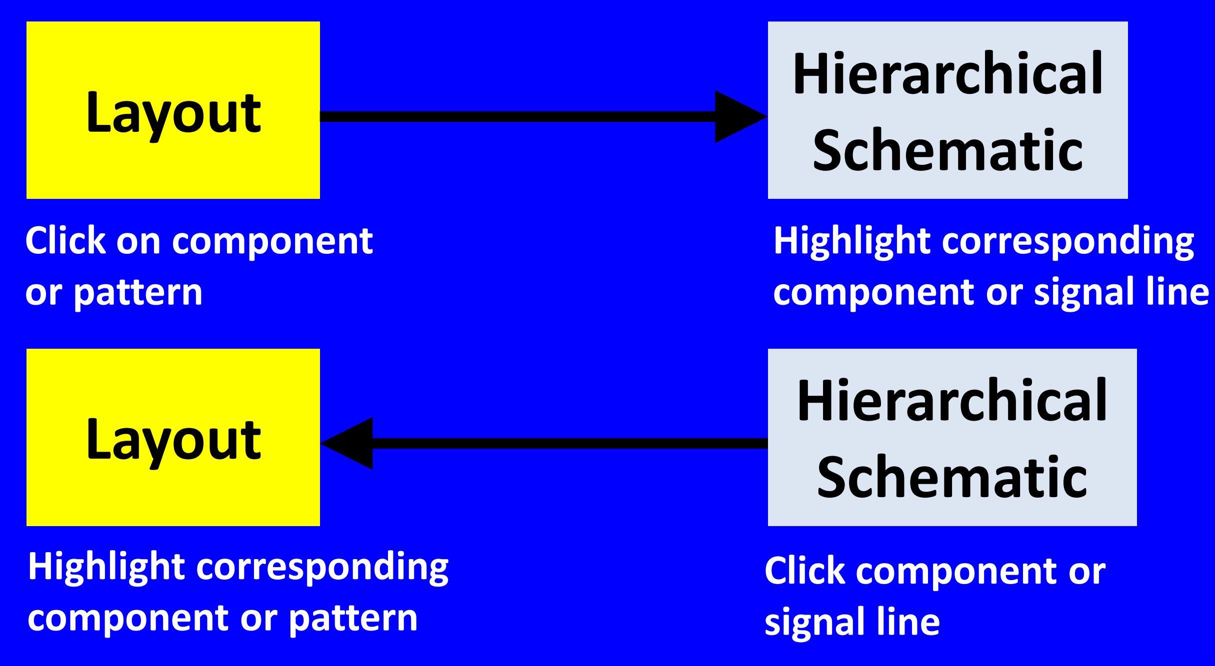


De-layering deep submicron technologies, advanced FOWLP, interposers, RDL, is challenging!

Enhancing Productivity: PCB Schematic Viewer

Facilitates cross-probing between

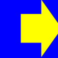
- ❑ schematic diagram and components in the PCB, or
- ❑ schematic diagram and components in the reconstructed layout images



Several varieties for enhanced productivity

Advanced Schematic Viewer

1. Click the signal line in the layout viewer



2. Highlight the corresponding signal line in the circuit viewer

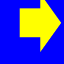
2. Highlight the corresponding signal line in the layout viewer

1. Click the signal line in the schematic viewer

Signal cross – probing: easy to navigate

Advanced Schematic Viewer

1. Click the component in the layout viewer



2. Highlight the corresponding component in the schematic viewer

2. Highlight the corresponding component in the layout viewer

1. Click the component in the schematic viewer

Cross-referencing components vs. schem.

Pattern Matching Tool

Google search term: "youtube LTEC pattern matching"

https://www.youtube.com/watch?v=Z2Vkgr3JWVw&list=PLe5EA9FhfOlwkxABwYRQ3jzPJkLhAO81P

Target Pattern On SEM image or layout

Matching Patterns

Potentially High $ reward

Helps identify infringing patterns

Modeling Mechanically and Electrically Integrated (Mechatronic) Systems

(Example)

Example: System-level Analysis

DC-DC Converter

2	Air duct1
4	DC/DC Converter supplies the 12V battery
5	Lithium-ion battery
6	Air duct 2
8	Battery cooling fan bracket
10	Battery cooling blower fan
11	Air duct 3

Air cooling system. The airflow is distributed to the DC-DC converter by the fan ⑩ through duct ②

Useful for electronic subsystem designers!

Why "Outsourced"? Example: "Mechatronics"

We perform both RE and modeling

Images of the
12V DC-DC converter

Air flow opening

28.8

21.0

75.4

67.3

92.3

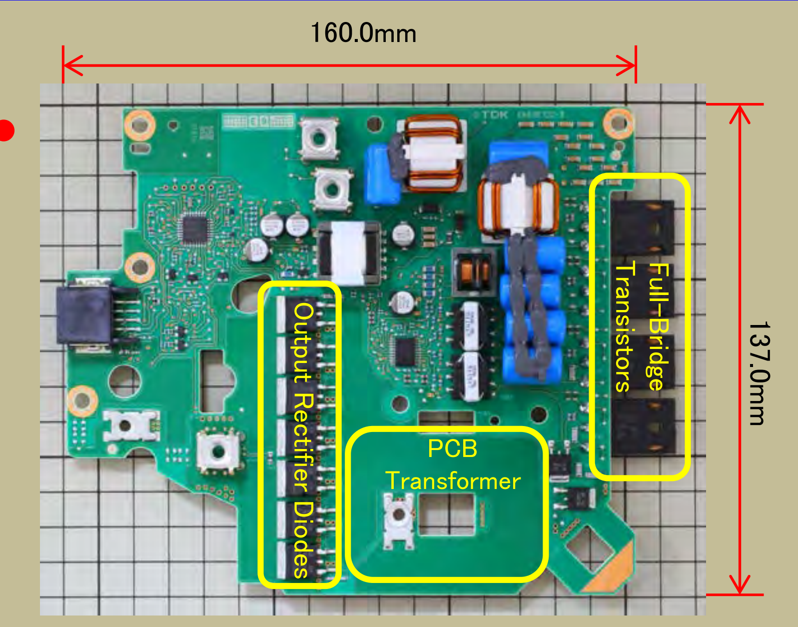
100.0

Air flow openings

Objective: precise thermal modeling of the heatsink-device/component Interface

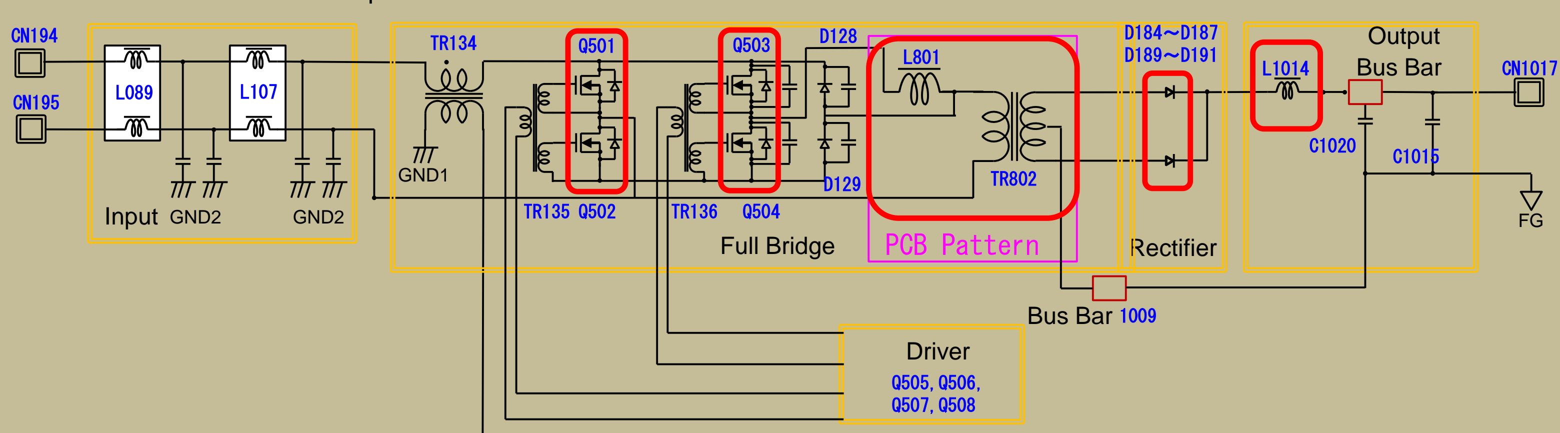
IC designers are unfamiliar with the thermal environment in integrated mechanical-electronic systems

Why "Outsourced"? Example: Mechatronics



DC-DC converter:
PCB (after transformer removal)

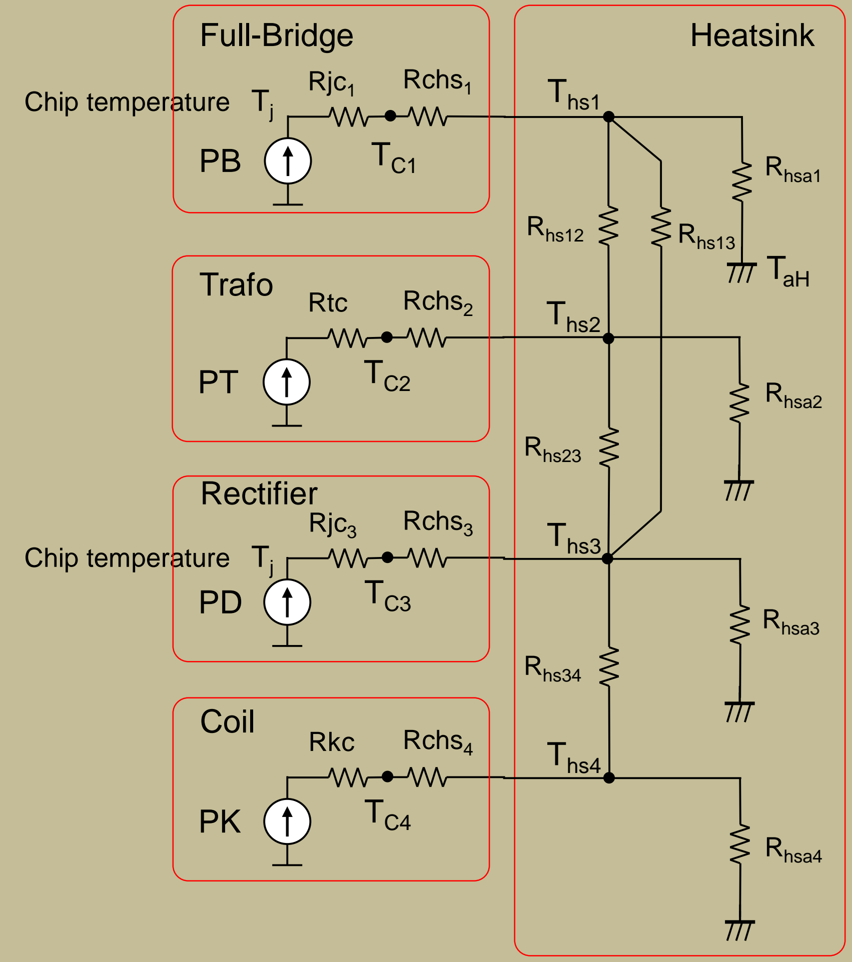
De-construction and preparation for modeling in the actual design environment



DC-DC converter circuit and its main heat sources.

Model Development

DC-DC Converter Thermal Network



Temperatures			
Tj1	FB Transistors Tj	100.6	℃
Tj3	Rectifier Diodes Tj	132.8	℃
Tt	Transformer Temperature	90.6	℃
Tk	Coil Temperature	111.6	℃
Ths1	FB Transistor-Heat sink interface	86.6	℃
Ths2	Transformer-Heat sink interface	84.6	℃
Ths3	Rectifier Diode-Heat sink interface	82.4	℃
Ths4	Coil Heat sink Interface	81.6	℃
TAVG	Heat sink Interface Average Temp	83.8	℃
Rth、hs	Heat sink AVG thermal Resistance	0.48	℃/W
TaH	Ambient (Heatsink Fin surface) temperature	50	℃
PB	Full-Bridge power loss (k=4)	28	W
PD	Rectifier Diode dissipation	24	W
PT	Transformer power loss	12	W
PK	Output Coil power loss	6	W

Estimated device/components' temperatures

Note the high Tj value of the rectifier diodes

Network representation for the DC-DC converter.

Why "Outsourced"? Example: Mechatronics

Temperature Distribution Heatsink-device/component Interface

Diode PD=24W

Full-Bridge PB=28W

- 90.0-92.0
- 88.0-90.0
- 86.0-88.0
- 84.0-86.0
- 82.0-84.0
- 80.0-82.0
- 78.0-80.0
- 76.0-78.0
- 74.0-76.0

Heatsink-device/component interface

The data format is compatible with the designers' "toolbox."

Summary

- Deep RE is a complex labor-intensive process
- A highly competitive market, the emergence of high-temp. electronics, mechanical-electrical integration, new materials and methods, create the demand for Collaborative Outsourced Reverse Engineering (CORE)

- CORE
  - provides up-to-date competitive intelligence
  - provides direction to product development teams
  - enhances product positioning
  - effectively reduces the time to market
  - mitigates risks

In-house or outsourced RE can be an integral part of product development

Summary (2)

- Collaborative Outsourced Reverse Engineering (CORE)
  - Provides expertise in performing deep analysis
  - Provides a broad horizon of visibility of the competitive landscape
  - Has proprietary tool set and unique know-how to enhance productivity
  - Facilitates close, dynamic, interactive, direct collaboration with product development teams

Questions?

More Questions?

Please visit us at Booth 1339

Thank you!