AT&S

22ND INTERNATIONAL CONFERENCE & EXHIBITION ON
DEVICE PACKAGING
SHERATON GRAND AT WILD HORSE PASS · PHOENIX, AZ
MARCH 2-5, 2026 · WWW.DEVICEPACKAGING.ORG

THE ROLES OF EMERGING IC SUBSTRATES FROM A SIGNAL PERFORMANCE AND POWER DELIVERY PERSPECTIVE

Gerald Weis, Stefano Sergio Oggioni, Karl Kirchheimer, Patrick Fleischhacker

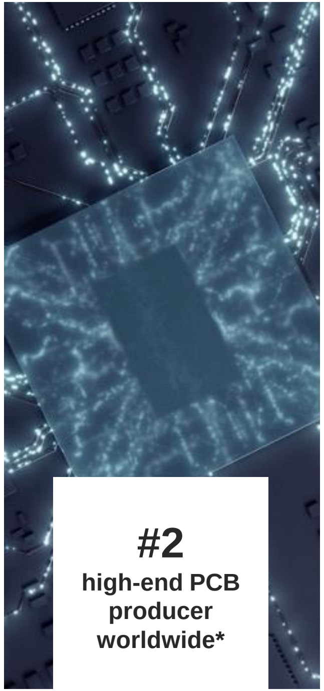
Gerald Weis
AT&S

March 04, 2025

CONTENT

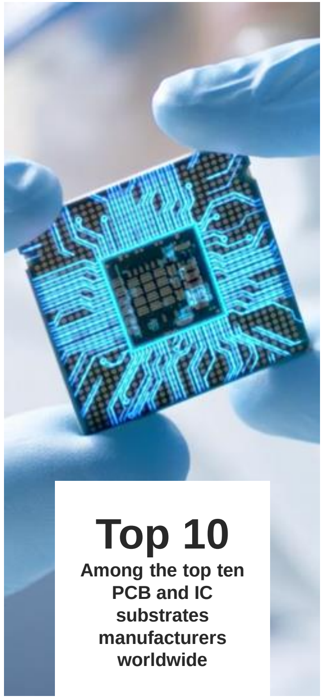
WORLD LEADING HIGH-TECH PCB & IC SUBSTRATES COMPANY

€ 1.55bn
revenue in FY 2023/24



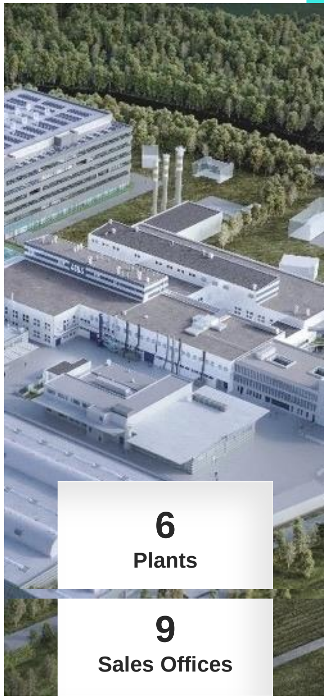
#2
high-end PCB producer worldwide*

#5
IC substrates producer worldwide**



Top 10
Among the top ten PCB and IC substrates manufacturers worldwide

~13,000
employees



6
Plants

9
Sales Offices

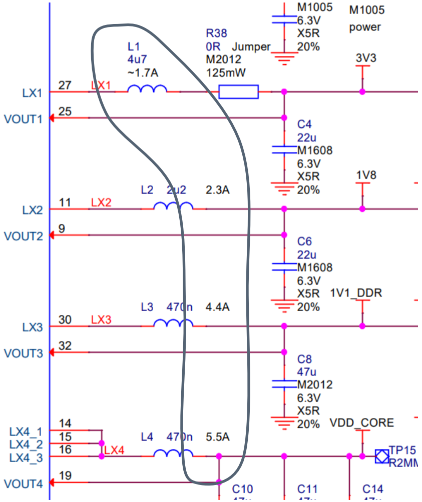
*Source: Prismark, CY2022, as of 15.05.2023

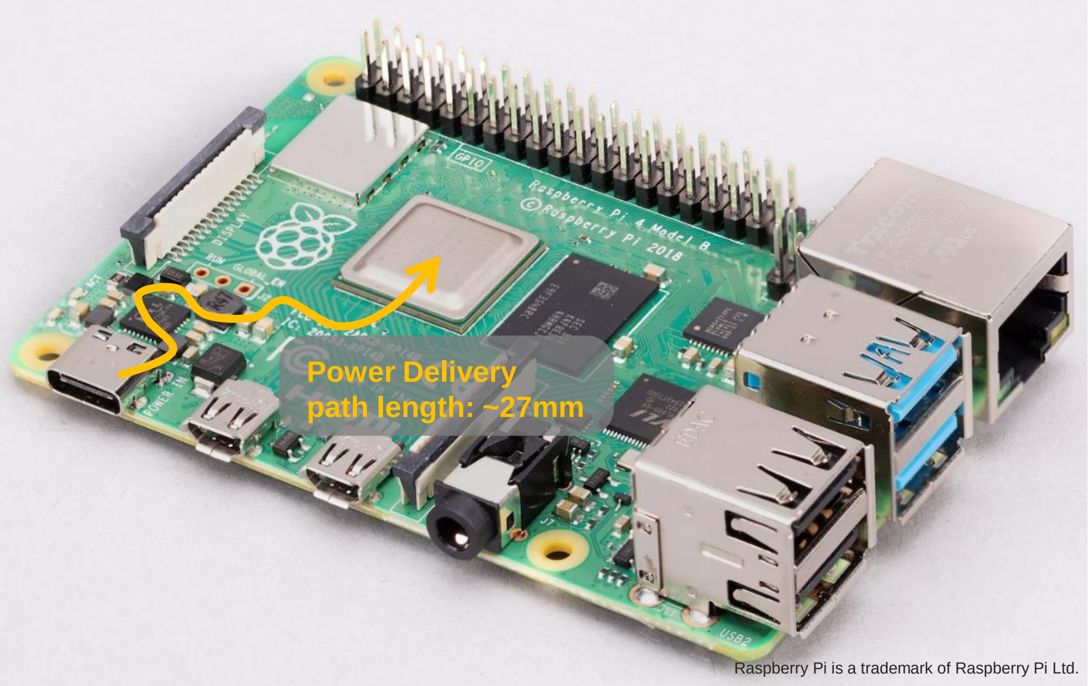
**Source: Prismark, CY2022, as of 31.08.2023

CONTENT

THE ROLES OF EMERGING IC SUBSTRATES

Theory behind power delivery I



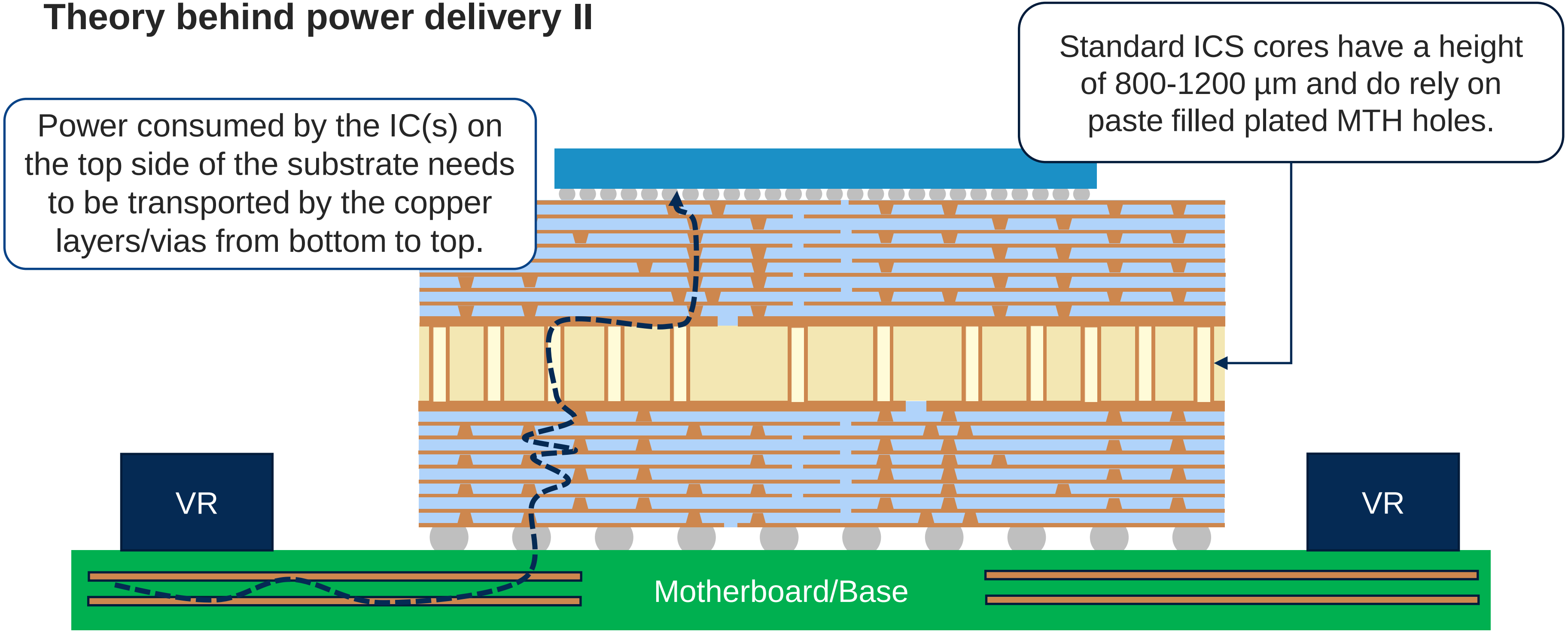


Raspberry Pi is a trademark of Raspberry Pi Ltd.

Source:
https://github.com/raspberrypi/documentation/blob/develop/documentation/asciidoc/computers/raspberry-pi/images/4-model-b.jpg
https://datasheets.raspberrypi.com/rpi4/raspberry-pi-4-reduced-schematics.pdf

THE ROLES OF EMERGING IC SUBSTRATES

Theory behind power delivery II



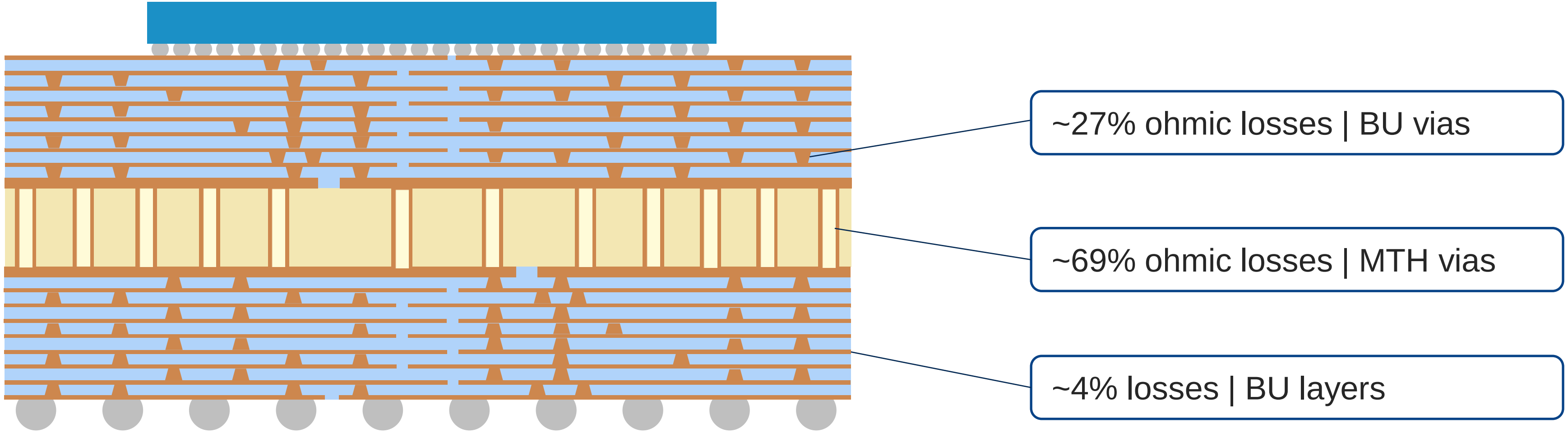
Power consumed by the IC(s) on the top side of the substrate needs to be transported by the copper layers/vias from bottom to top.

Standard ICS cores have a height of 800-1200 µm and do rely on paste filled plated MTH holes.

Illustration only, not to scale

THE ROLES OF EMERGING IC SUBSTRATES

Theory behind power delivery III



~27% ohmic losses | BU vias

~69% ohmic losses | MTH vias

~4% losses | BU layers

Illustration only, not to scale

Use case:

250A, 5000 MTH plating thickness 15µm, in total 100.000 vias, 8-2-8 build-up, power delivery considered only

THE ROLES OF EMERGING IC SUBSTRATES

Power Delivery IV

Which technical possibilities do we have to reduce power delivery losses?

MLC

Optimize core and replace it by a multi-layer core

MLC

Heavy metal

Instead of plated MTH use copper filled through holes

MFC

Redesign overall power supply by the use of embedded components

CONTENT

THE ROLES OF EMERGING IC SUBSTRATES

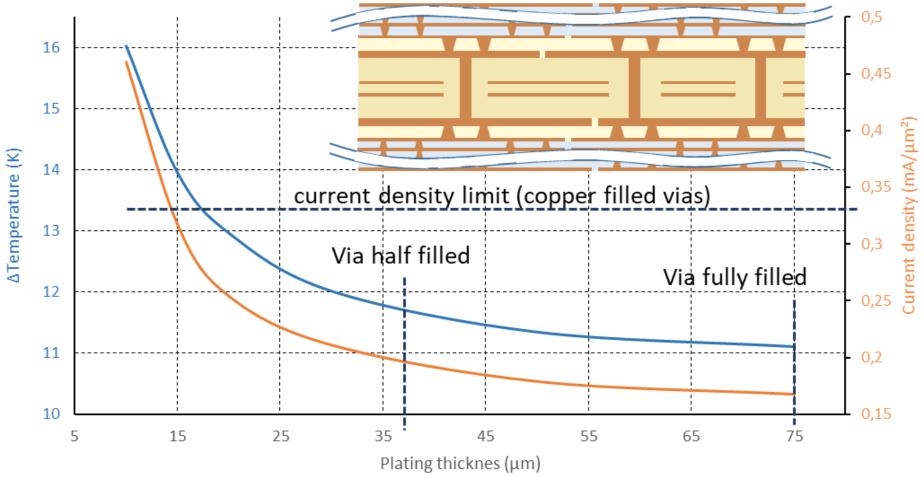
Core via losses vs. temperature

4-layer MLC core
Overall thickness: 800 µm

MTH: 150 µm, laser: 60 µm (filled)
Simulation case: 2A per MTH

Optimization:
reduced MTH length
Decreased losses

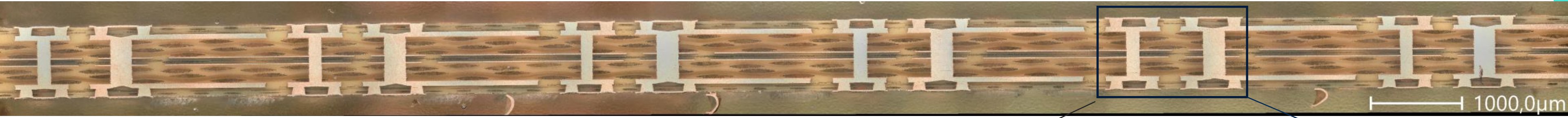
Graphic shows:
Temperature vs. plating thickness
Current density vs. plating thickness



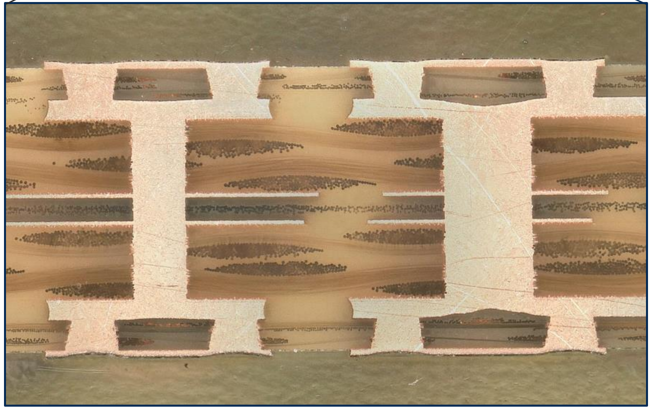
Instead of plated MTH use copper filled through holes

THE ROLES OF EMERGING IC SUBSTRATES

Copper filled holes



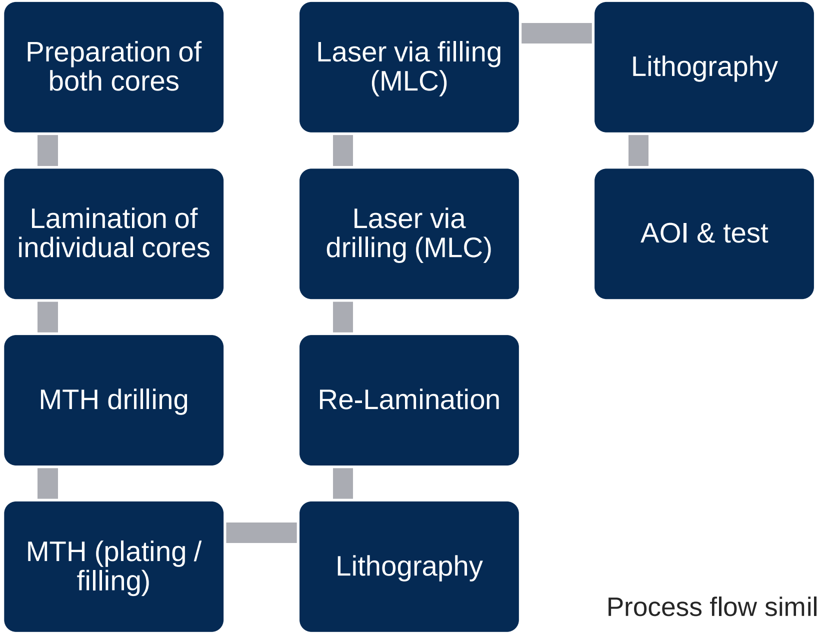
- X-section of filled mechanical through hole
- Differential drilling, i.e. using two different drill diameters
- Filled MTHs with electrolytic copper
- Thick copper layers for (high) lateral transfer
- Multilayer stack-up example consisting of two cores



Instead of plated MTH use copper filled through holes

THE ROLES OF EMERGING IC SUBSTRATES

Simplified process flow



Preparation of both cores

Lamination of individual cores

MTH drilling

MTH (plating / filling)

Lithography

Re-Lamination

Laser via drilling (MLC)

Laser via filling (MLC)

Lithography

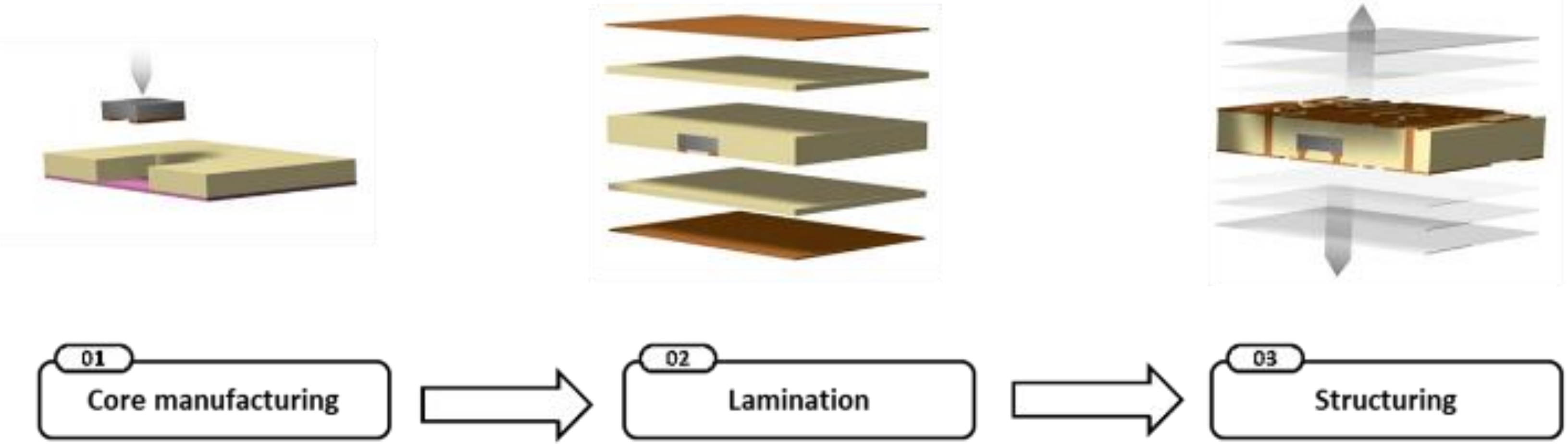
AOI & test

Process flow similar to standard multi-core build-up

Redesign overall power supply by the use of embedded components

THE ROLES OF EMERGING IC SUBSTRATES

Embedding process flow



01 Core manufacturing → 02 Lamination → 03 Structuring

Redesign overall power supply by the use of embedded components

THE ROLES OF EMERGING IC SUBSTRATES

Multi-layer core using embedded components

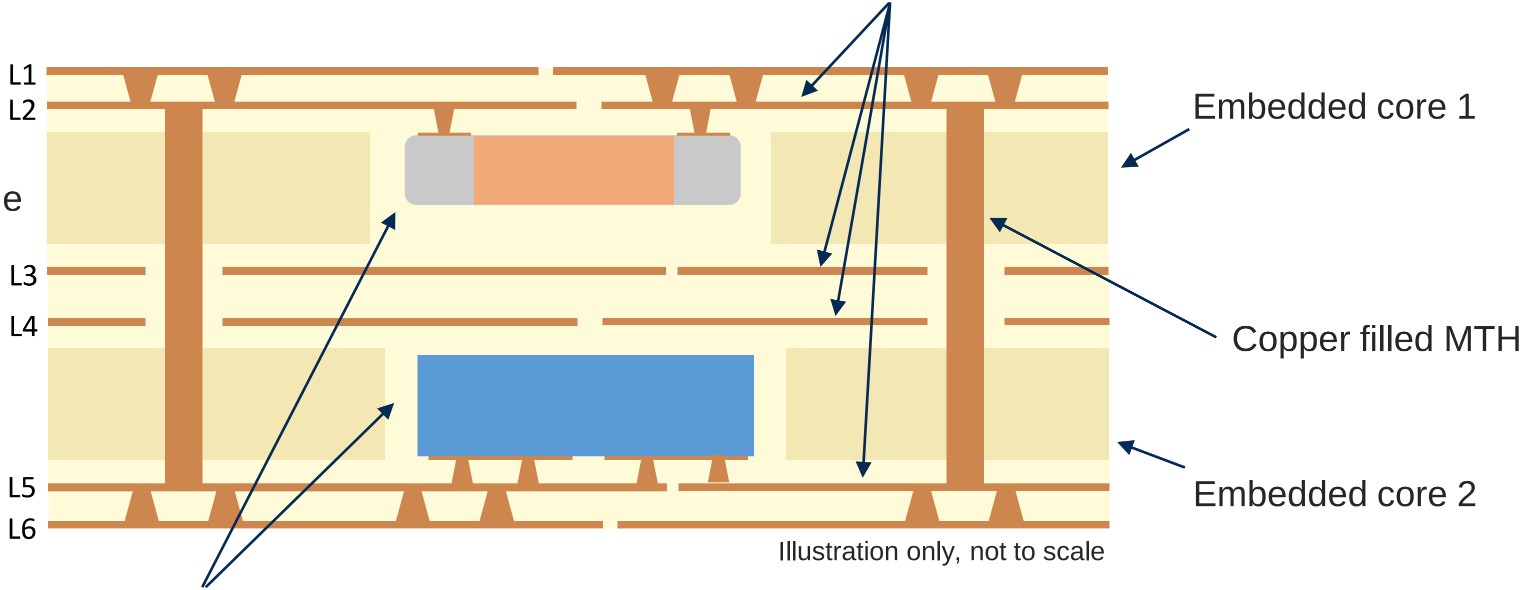
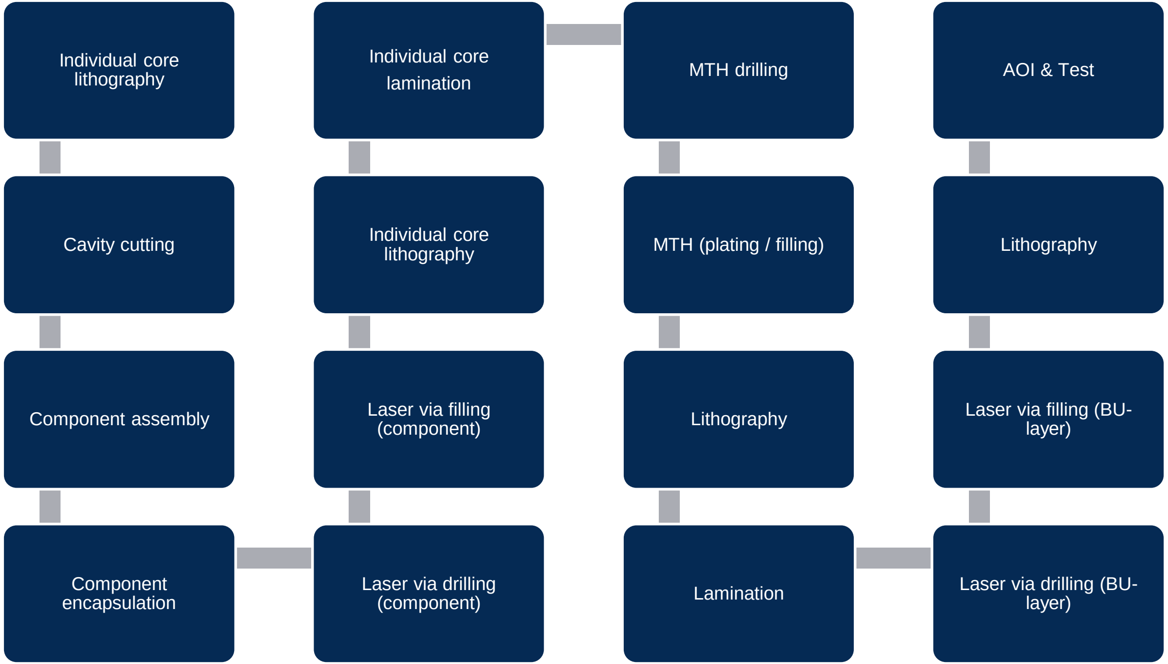


Illustration only, not to scale

Redesign overall power supply by the use of embedded components

THE ROLES OF EMERGING IC SUBSTRATES

Process flow MLC including embedding



- Individual core lithography
- Cavity cutting
- Component assembly
- Component encapsulation
- Laser via drilling (component)
- Laser via filling (component)
- Individual core lithography
- Individual core lamination
- MTH drilling
- MTH (plating / filling)
- Lithography
- Lamination
- Laser via drilling (BU-layer)
- Laser via filling (BU-layer)
- Lithography
- AOI & Test

Redesign overall power supply by the use of embedded components

THE ROLES OF EMERGING IC SUBSTRATES

Traditional vs. Optimized

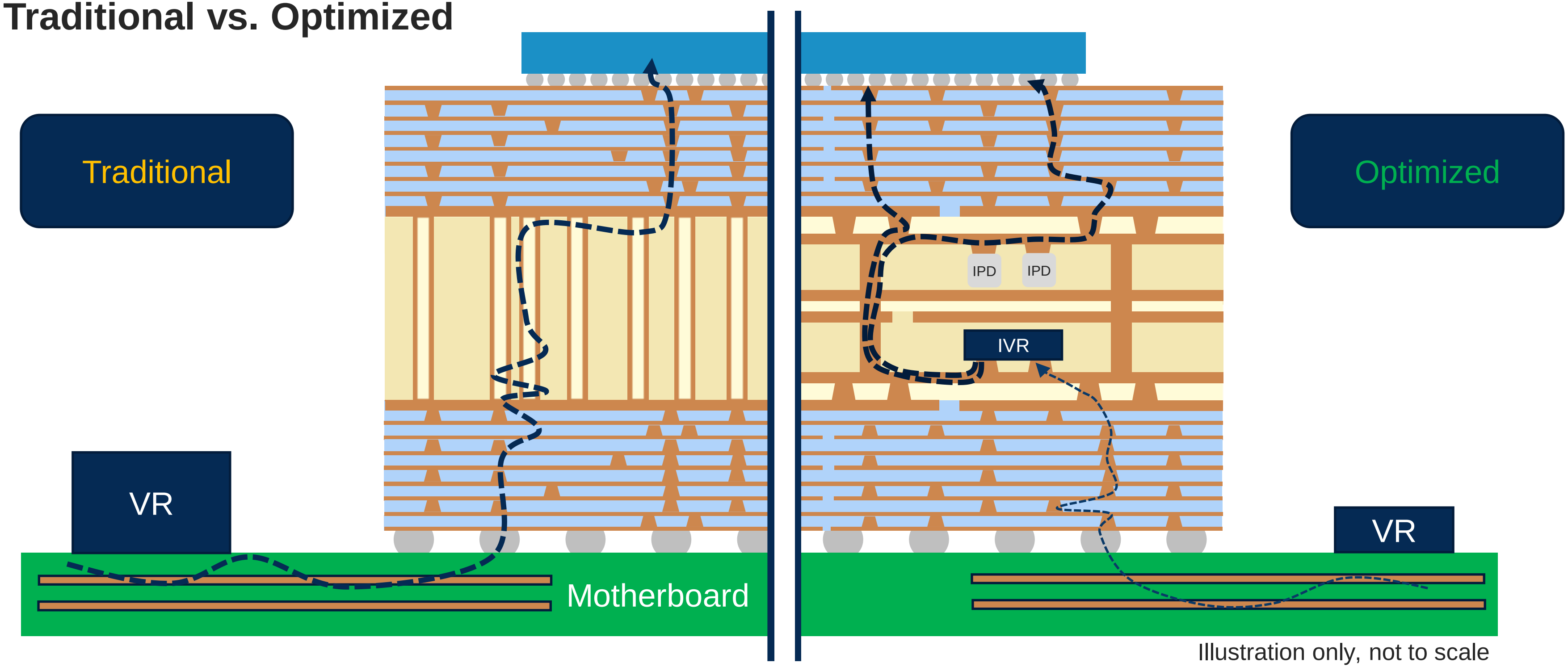
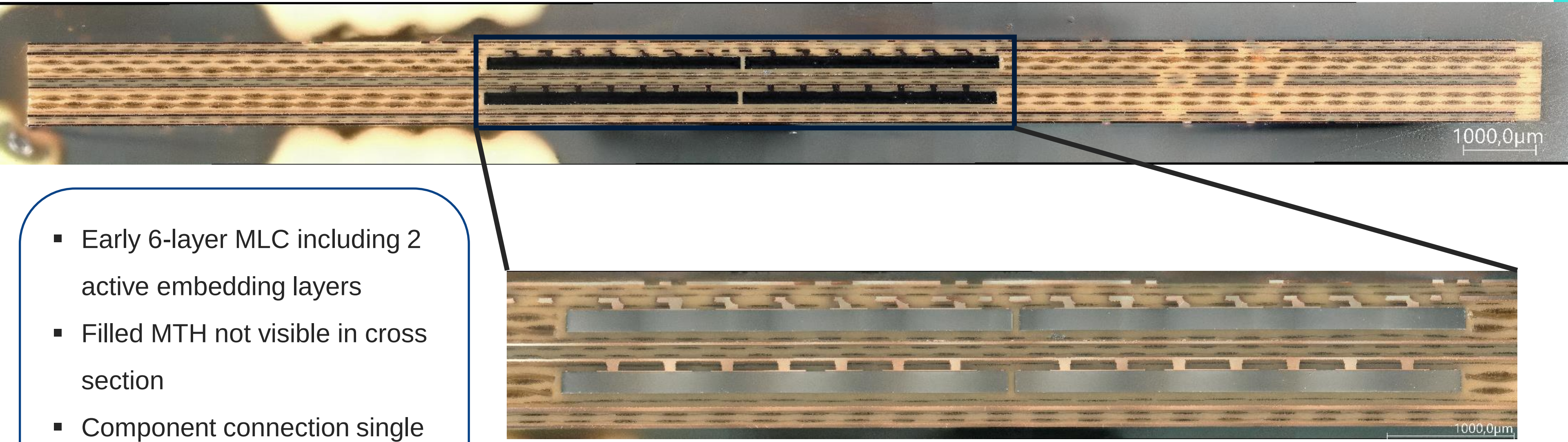


Illustration only, not to scale

Redesign overall power supply by the use of embedded components

THE ROLES OF EMERGING IC SUBSTRATES

Early prototype build

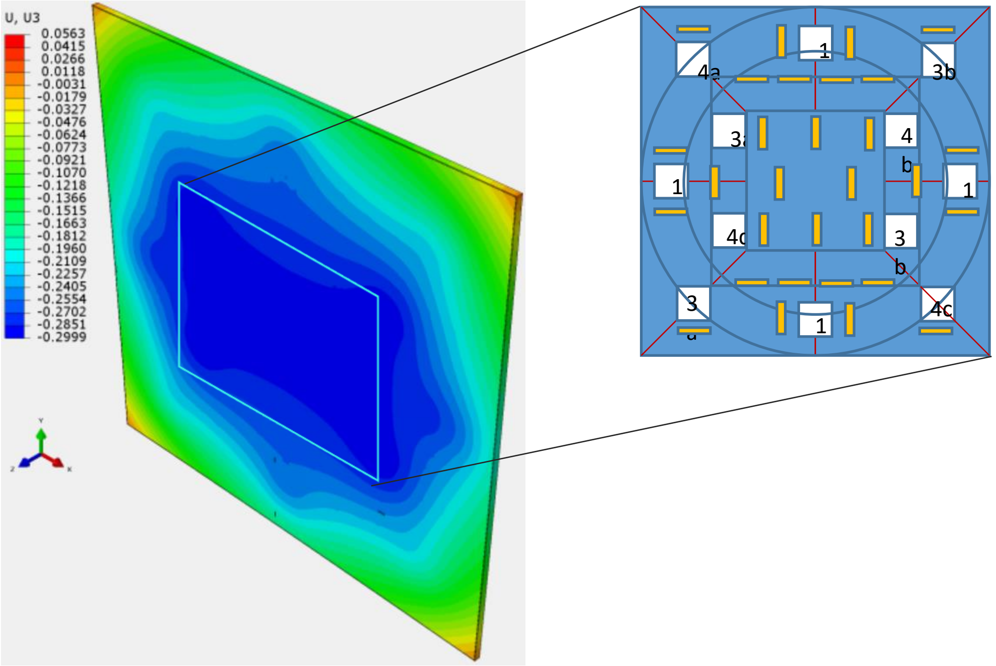


- Early 6-layer MLC including 2 active embedding layers
- Filled MTH not visible in cross section
- Component connection single sided

Redesign overall power supply by the use of embedded components

THE ROLES OF EMERGING IC SUBSTRATES

Warpage



- Graphical mapping for substrate warpage topography including embedded components
- Topography delta in C4 area ~100 µm (blue-ish area).

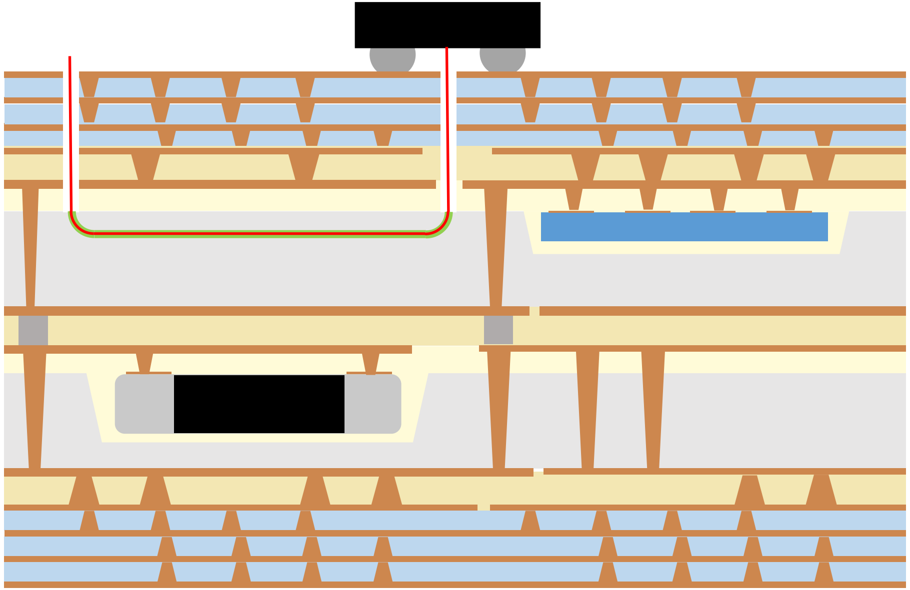
CONTENT

THE ROLES OF EMERGING IC SUBSTRATES

Signal Integrity Improvements

- Embedding might be used for power delivery as well as signal integrity

- Optics are in development and will in near future optimize data throughput



CONTENT

THE ROLES OF EMERGING IC SUBSTRATES

Conclusion

Various scalable options help to improve power efficiency in ICS

Warpage analysis ensure that the C4 area is not effected by the MLC construction

VIRTUAL
FIRST

Depending on the application, electro-thermal simulation helps to optimize cost and performance

VIRTUAL
FIRST

C4 area **not** effected by using a multi-layer core

Embedding of actives and passives enables various possibilities in power delivery and signal integrity

Glass core supports optical channels for increased data throughput in future
(in development)

ACKNOWLEDGEMENT

This work is funded by the Austrian Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology and the Austrian Federal Ministry of Labour and Economy, and implemented by Austria Wirtschaftsservice (aws) and the Austrian Research Promotion Agency (FFG) as part of the **Important Project of Common European Interest (IPCEI) *on Microelectronics and Communication Technologies***. The funding is provided by *Next Generation EU*. The IPCEI on *Microelectronics and Communication Technologies* is also supported by public authorities from other European member states.

Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

Federal Ministry
Republic of Austria
Digital and
Economic Affairs

aws austria wirtschaftsservice

FFG
Forschung wirkt.

Funded by
the European Union
NextGenerationEU

IPCEI Microelectronics and
Communication Technologies

DISCLAIMER

This presentation is provided by AT & S Austria Technologie & Systemtechnik Aktiengesellschaft, having its headquarter at Fabriksgasse 13, 8700 Leoben, Austria, or one of its affiliated companies (“AT&S”), and the contents are proprietary to AT&S and for information only.
AT&S does not provide any representations or warranties with regard to this presentation or for the correctness and completeness of the statements contained therein, and no reliance may be placed for any purpose whatsoever on the information contained in this presentation, which has not been independently verified. You are expressly cautioned not to place undue reliance on this information.

This presentation may contain forward-looking statements which were made on the basis of the information available at the time of preparation and on management‘s expectations and assumptions. However, such statements are by their very nature subject to known and unknown risks and uncertainties. As a result, actual developments, results, performance or events may vary significantly from the statements contained explicitly or implicitly herein.
Neither AT&S, nor any affiliated company, or any of their directors, officers, employees, advisors or agents accept any responsibility or liability (for negligence or otherwise) for any loss whatsoever out of the use of or otherwise in connection with this presentation. AT&S undertakes no obligation to update or revise any forward-looking statements, whether as a result of changed assumptions or expectations, new information or future events.
This presentation does not constitute a recommendation, an offer or invitation, or solicitation of an offer, to subscribe for or purchase any securities, and neither this presentation nor anything contained herein shall form the basis of any contract or commitment whatsoever. This presentation does not constitute any financial analysis or financial research and may not be construed to be or form part of a prospectus. This presentation is not directed at, or intended for distribution to or use by, any person or entity that is a citizen or resident or located in any locality, state, country or other jurisdiction where such distribution, publication, availability or use would be contrary to law or regulation or which would require any registration or licensing within such jurisdiction.