

Megoldások az elektronikai ipar termikus problémáira

**Beszámoló a Therminic 2016 (Budapest, Mo.)
és a Semi-Therm 33 (San Jose, USA)
konferenciákról**

Dr. Szabó Péter Gábor

Tartalom

■ Therminic 2016

- Általános információk
- Keynote-ok
- Szekciók
- Érdekesebb előadások
- Magyar vonatkozású cikkek

■ Semi-Therm 33

- Általános információk
- Keynote-ok
- Szekciók
- Érdekesebb előadások
- Magyar vonatkozások

Therminic 2016

Budapest, Magyarország



((22nd INTERNATIONAL WORKSHOP
Thermal Investigations of ICs and Systems))

A konferenciáról

- art'otel Budapest
- 44 plenáris előadás
- 19 poszter
- 3 keynote speech – vitaindító előadás
- General chair:
Chris Bailey, University of Greenwich, UK
- Program chair:
András Poppe, BME, Budapest, Hungary
- [Online proceedings](#)
- Cikkek elérhetőek az [IEEE](#) adatbázisában
- Cikkek továbbvitele a Mircoelectronics Reliability (Q1) folyóiratba



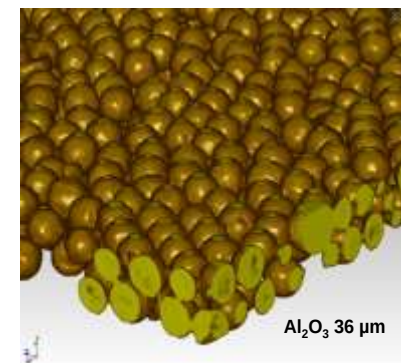
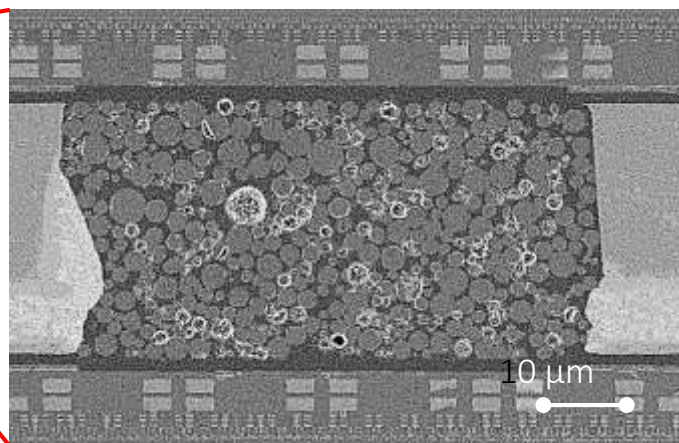
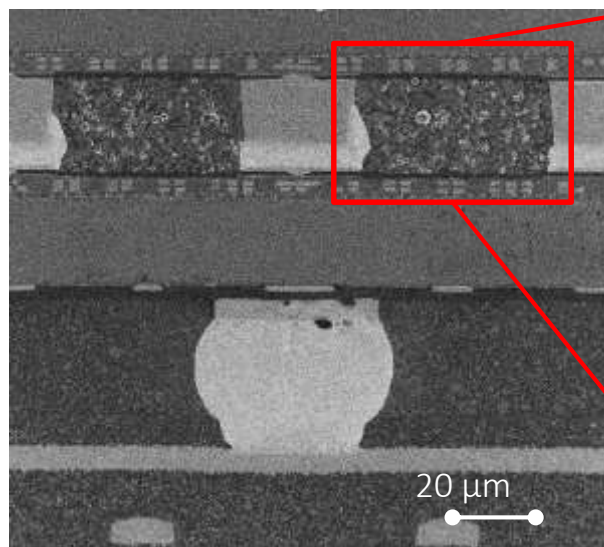
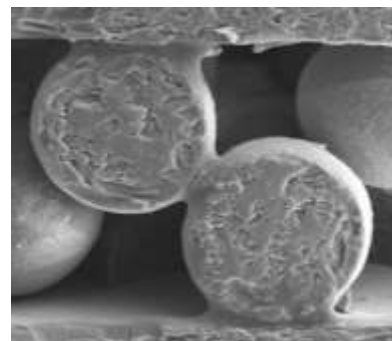
Keynote speeches – I.

- **REVIEW OF PERCOLATING AND NECK-BASED UNDERFILLS WITH THERMAL CONDUCTIVITIES UP TO 3 W/m-K**

Thomas Brunschwiler, IBM Research - Zurich



Thomas Brunschwiler



3D Integration ... thermal limitations and options

Low Power Devices:

- Memory stacks – memory dies on logic
- e.g. Hypbrid Memory Cube



Source: Micron-IBM HMC development

High Power Devices:

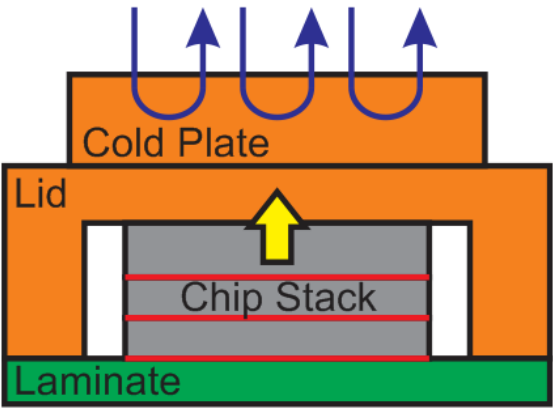
- Micro-processor stacks
 - cores on cache → acceptable
 - cores on cores → extensive temperature



J. Golz, VLSI, © IEEE 2011



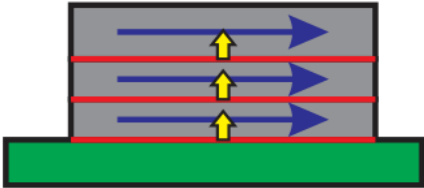
Thermal Packaging Extremes:



Lid-attached cold plate

High Power Devices:

- Large die > 20x20mm²
- Power CPU > 300W
- TSV pitch < 100μm



Scalable with number of tiers

Interlayer cooling

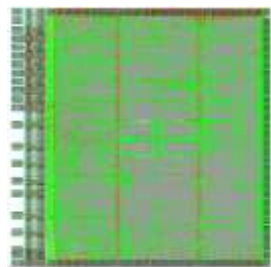
Keynote speeches – II.

■ The Challenges of Going Vertical: Thermal Management and Analysis in 3DICs

Samson Melamed, AIST - Tsukuba, Japan



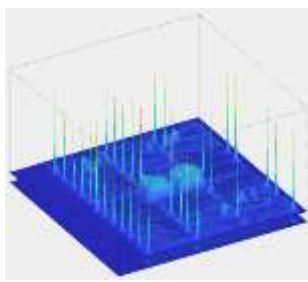
Samson Melamed



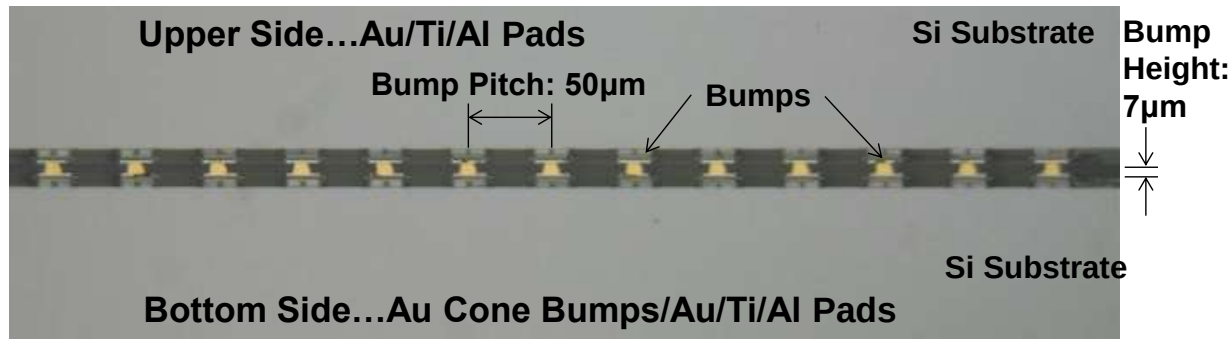
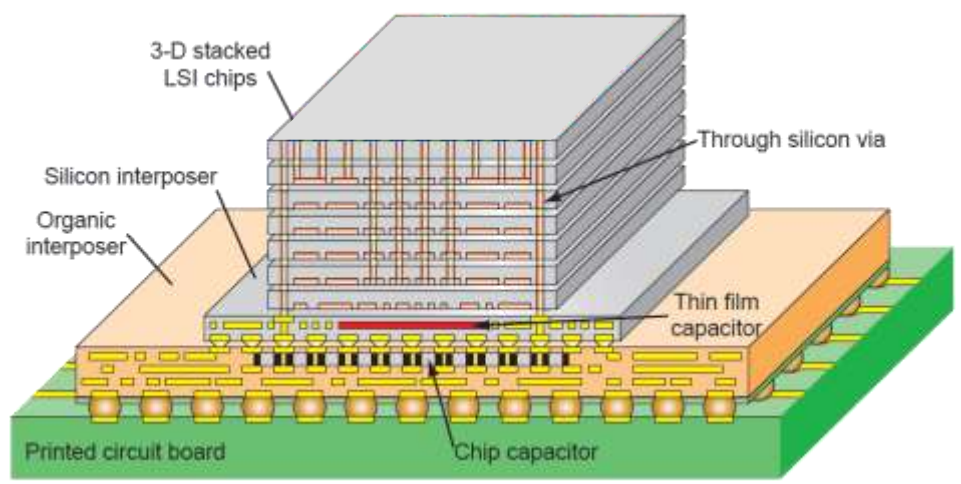
Circuit design



Power
dissipation
locations and
values

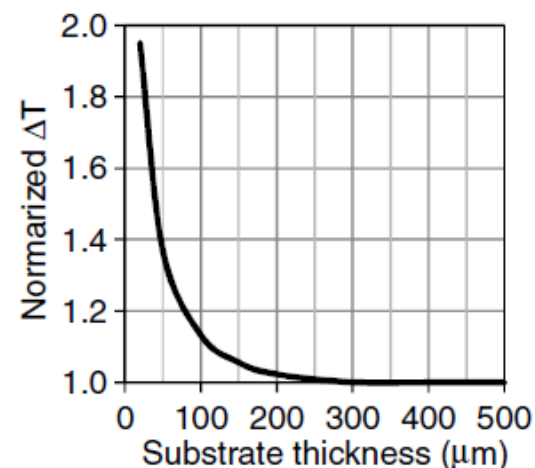
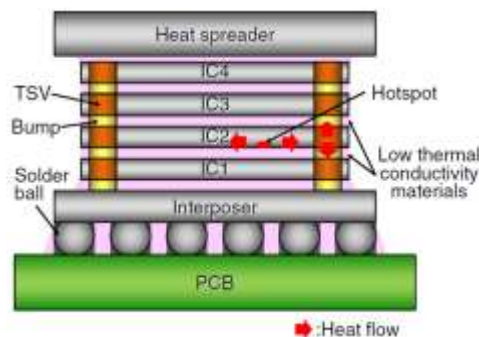
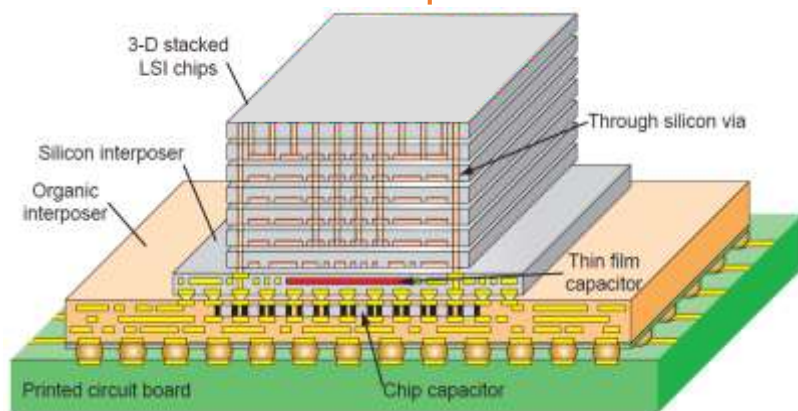
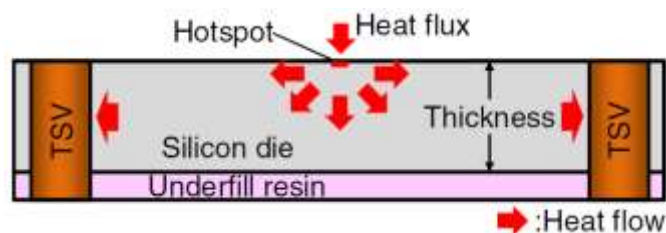


Thermal profile



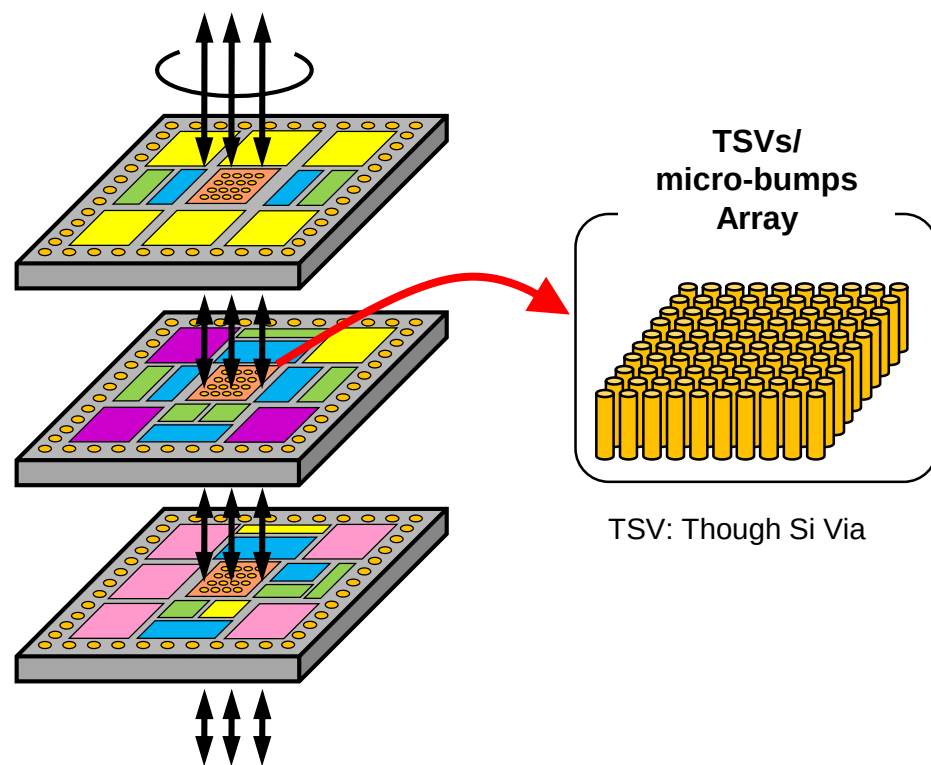
Keynote speeches – II.

- Measuring the thermal effects of die thinning
- $725\text{ }\mu\text{m} \rightarrow 20\text{ }\mu\text{m}$ 4x hőmérsékletnövekedés



Keynote speeches – II.

- Cool interconnect: a 1024-bit wide chip-to-chip bus
- 3D system
- Heterogén multi IC chip stack
- Extrém nagy átviteli sebesség
- Kisebb méretű busz interfész áramkörök

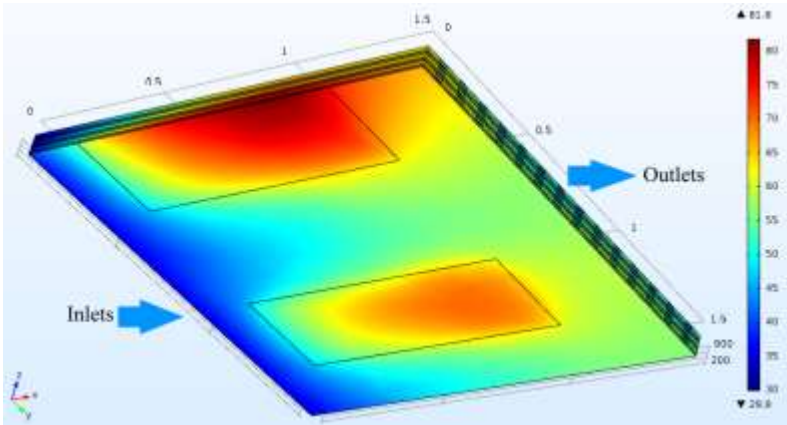
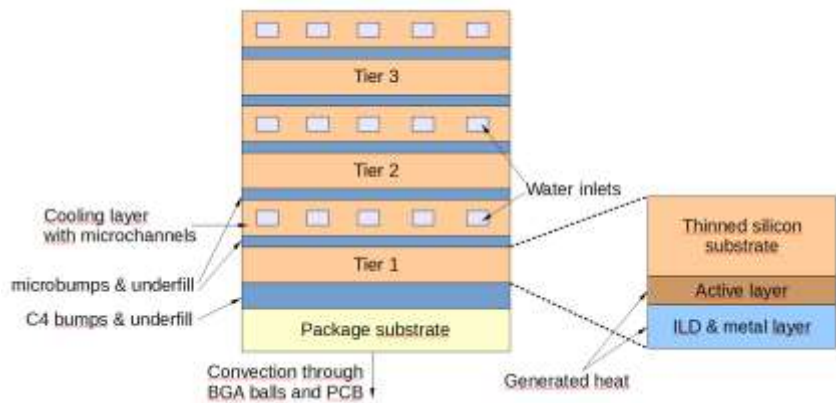


Szekciók

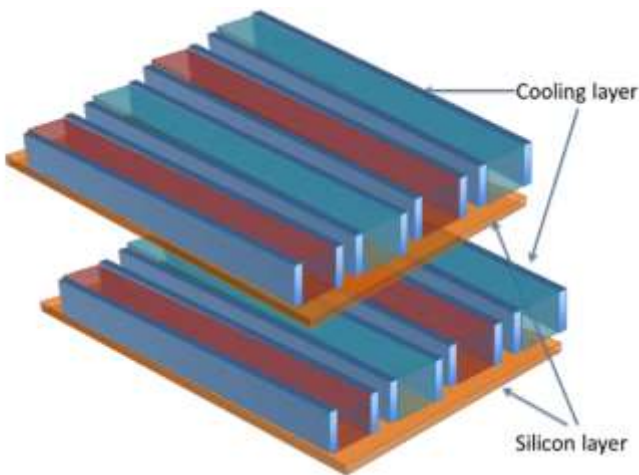
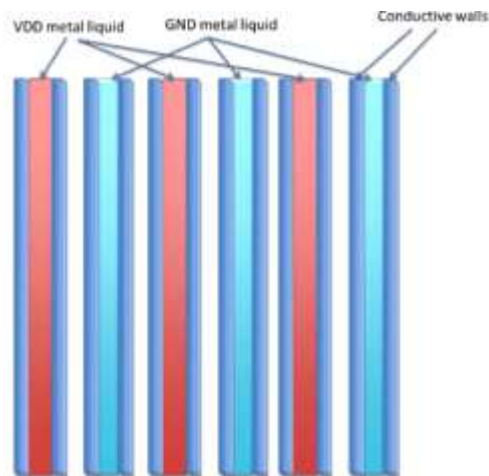
- Advanced Thermal Management
- **Thermo-mechanical Reliability**
- Power Electronics 1: Design
- Compact Thermal Modeling
- **3D IC / Packaging**
- **Quantiheat Project / Nano-scale Thermal Investigations**
- Power Electronics 2: Testing
- **Thermal Design with CFD Simulation**
- **DELPHI4LED Special Session**
- LEDs and LED Lamps
- **Reliability Investigations**
- Thermal Characterization and Modeling
- **Posters**



Analysis of the Impact of Power Distribution on the Efficiency of Microchannel Cooling in 3D ICs



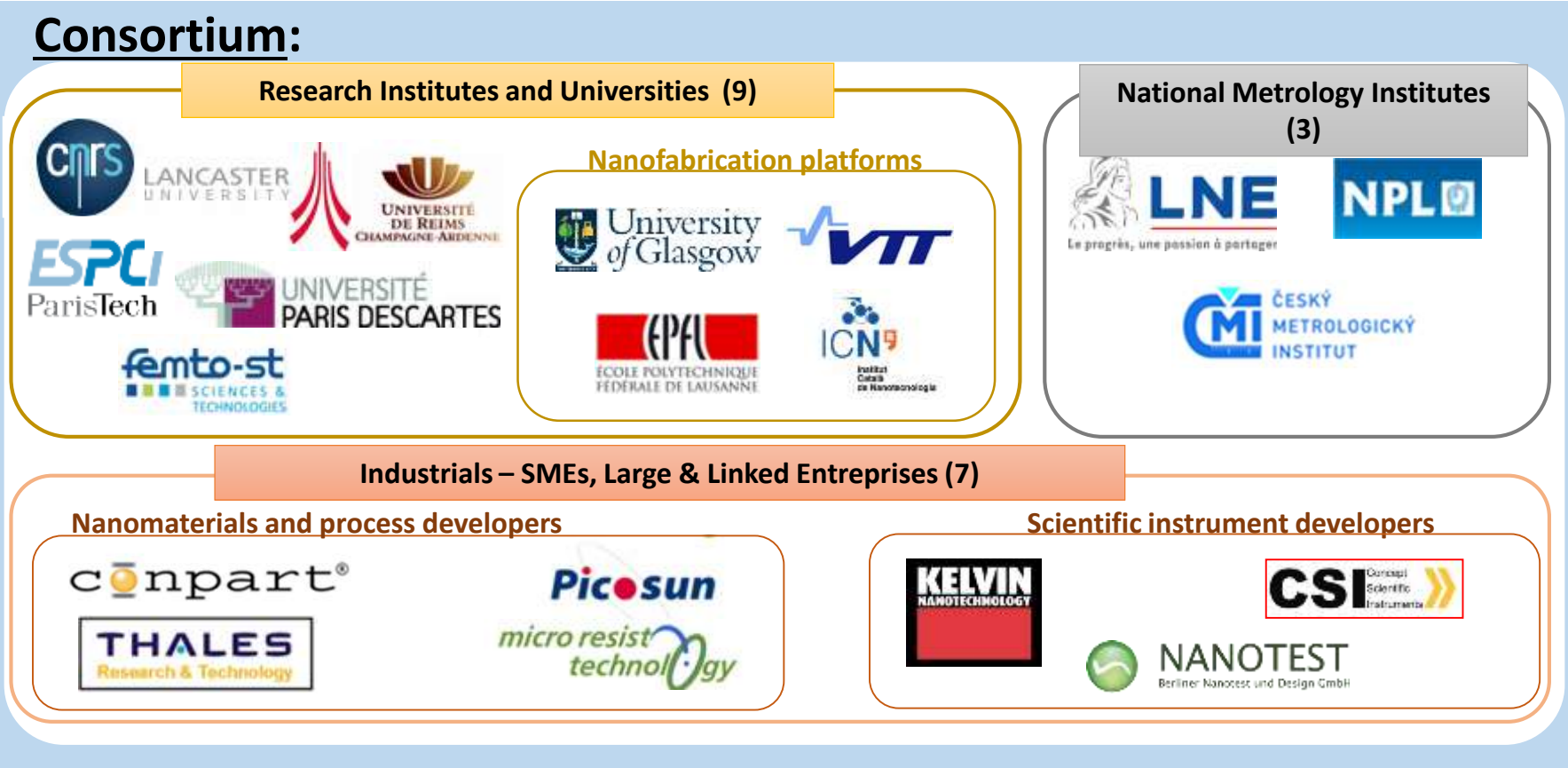
Closing the Power Delivery/Heat Removal Cycle for Heterogeneous Multi-Scale Systems



QUANTIHEAT Project: Main progresses

Coordinator: CNRS **4 year project** (01-12-2013 / 30-11-2017)

Consortium:



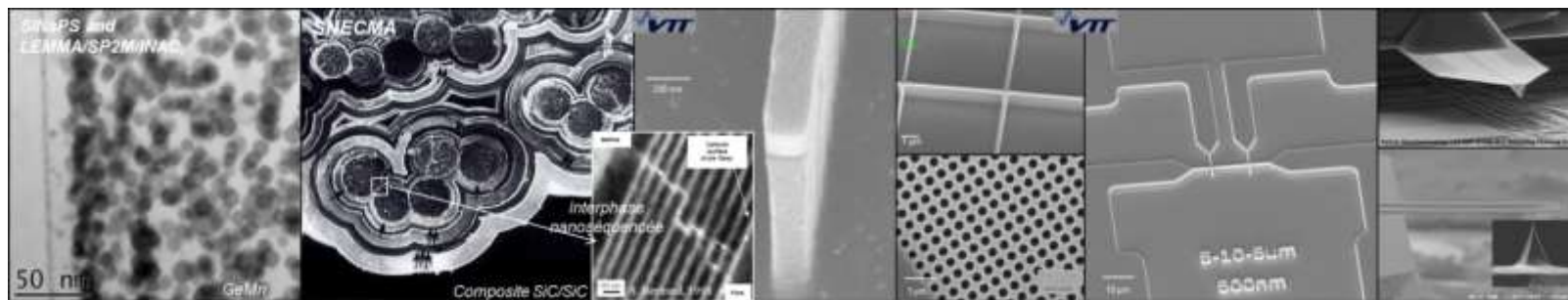
Total Budget = 13 M€ / **EC contribution** = 9,5 M€ (73%)

QUANTIHEAT Project: Main progresses

The Need (1)

- Understanding and managing heat transfer crucial for modern technologies incorporating nanocomponents and nanostructured materials.
- Characterizing thermal properties at the micro- and nanoscales required for development, improvement and optimisation of systems

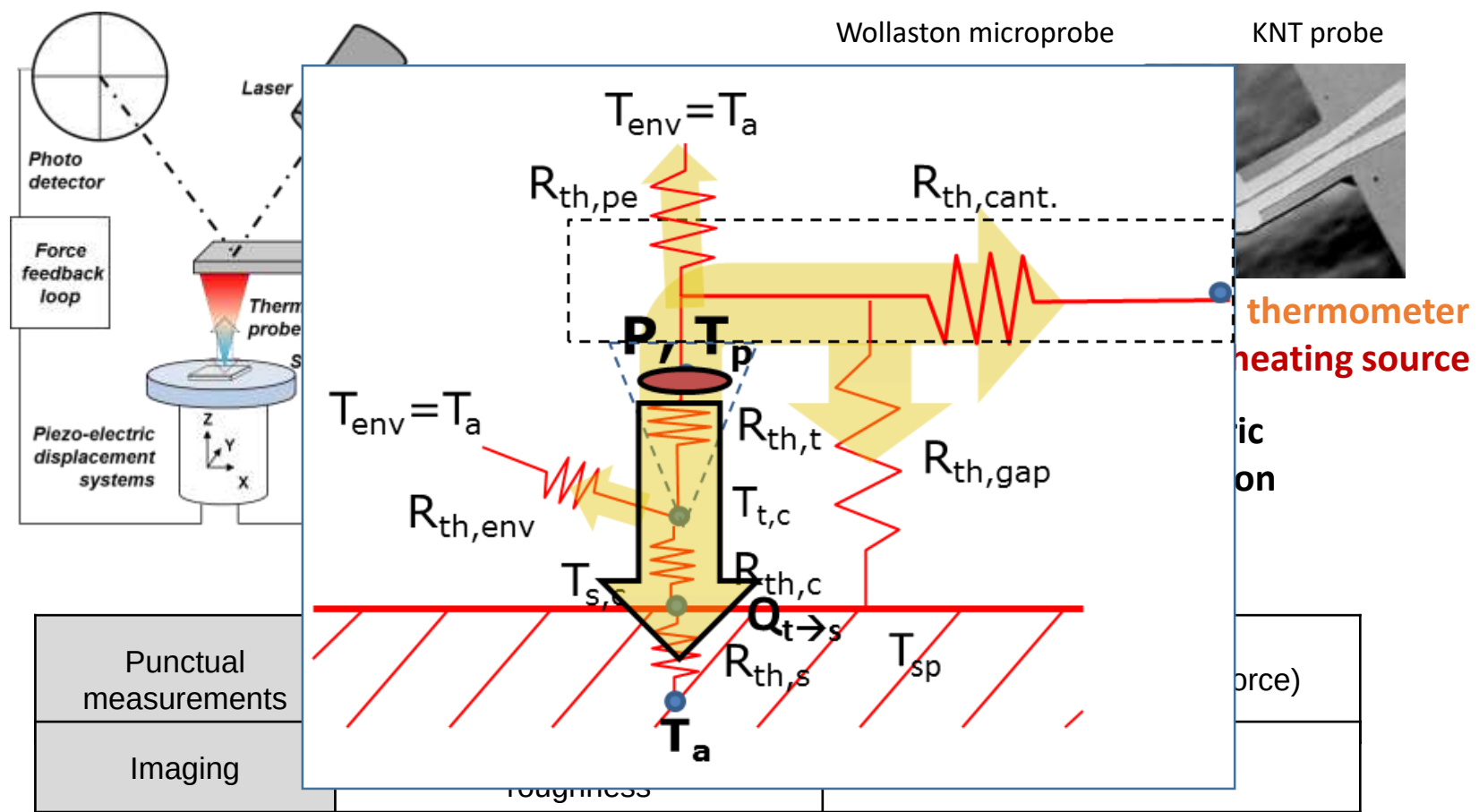
in fields as diverse as microelectronics, micro- and nano-systems and new energy-recovery or energy-conversion device



- A large number of industrial sectors concerned.

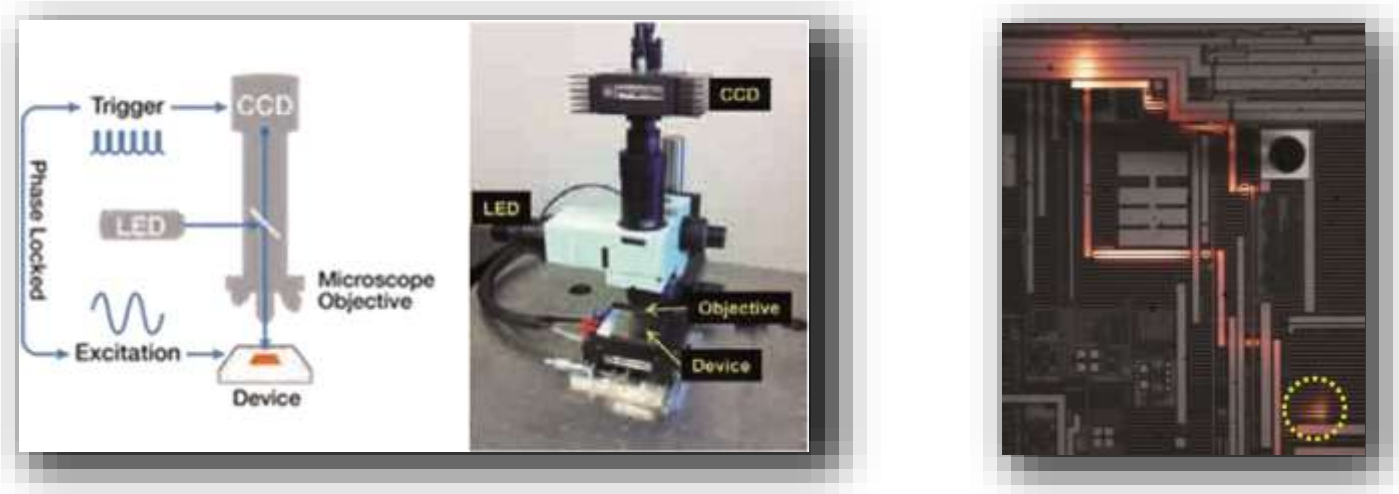
SThM: principle

Atomic Force Microscope (AFM) + Thermal Sensor

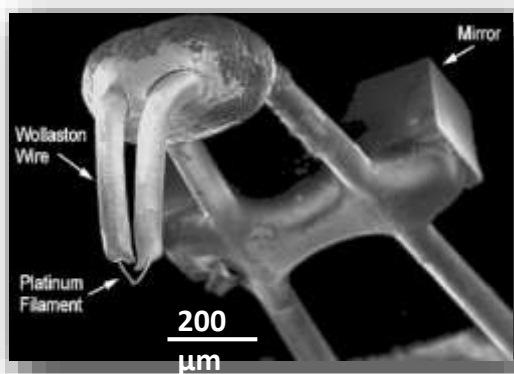


+ Combined with other scanning probe microscopy modes : mechanical, electrical...

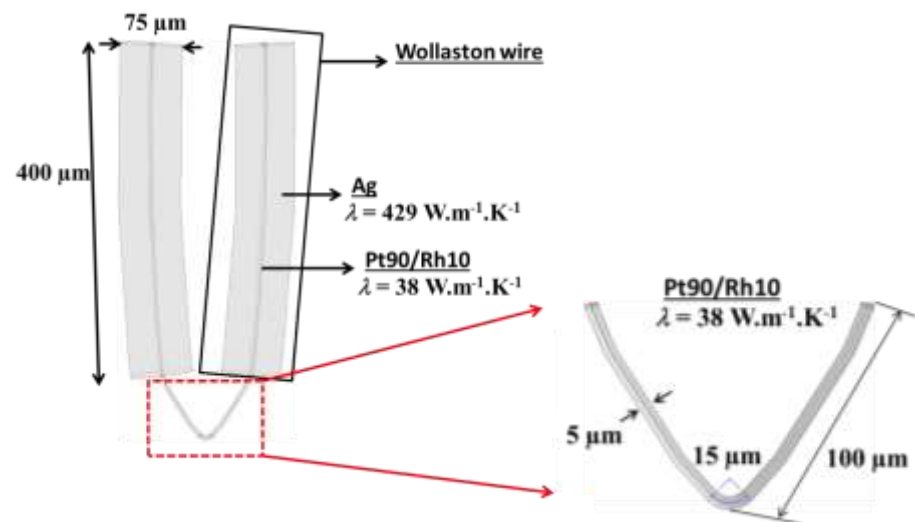
Thermal Analysis of Advanced Microelectronics Devices Using Thermoreflectance Thermography



Calibration methodologies for scanning thermal microscopy

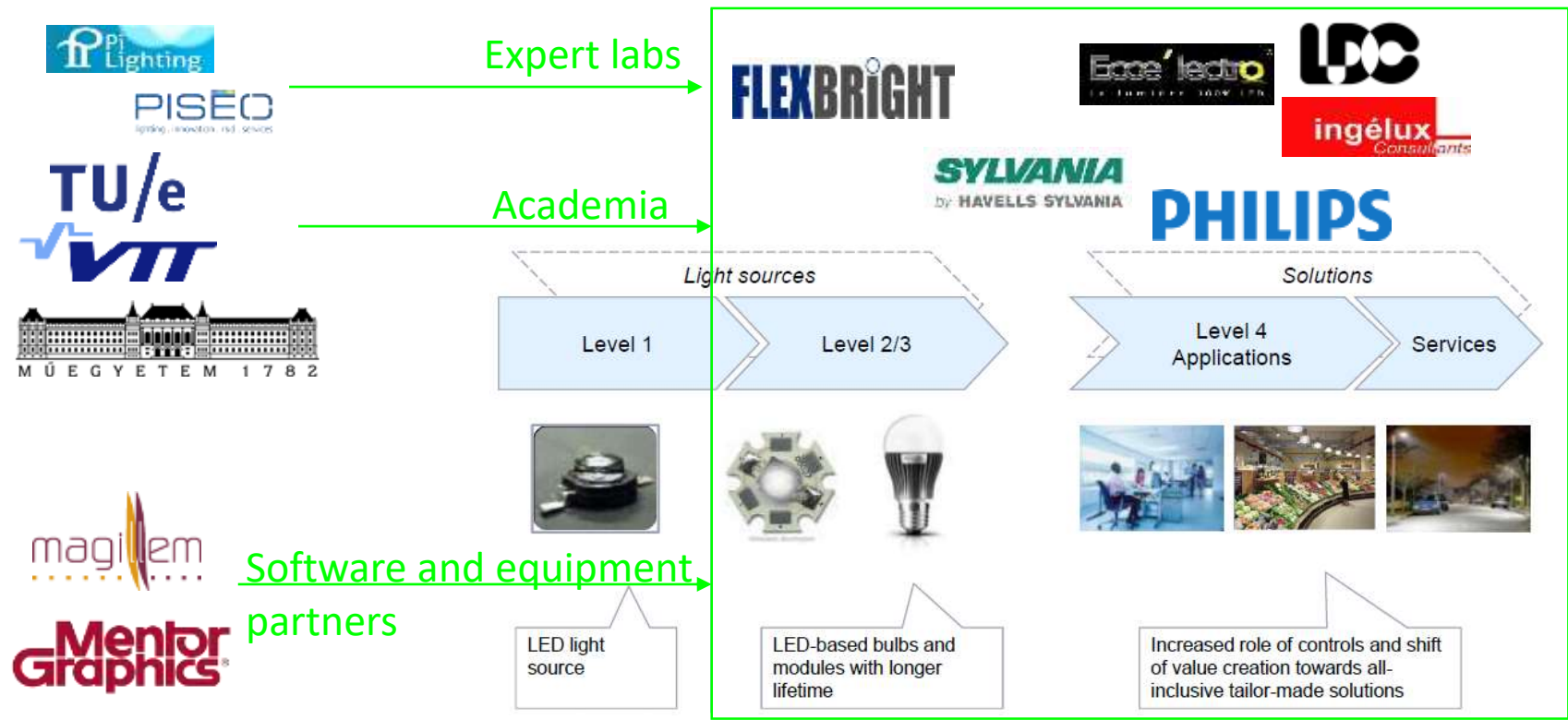


Royall, Kett, Adrews, Craig, *Journal of physical Chemistry B*, 2001



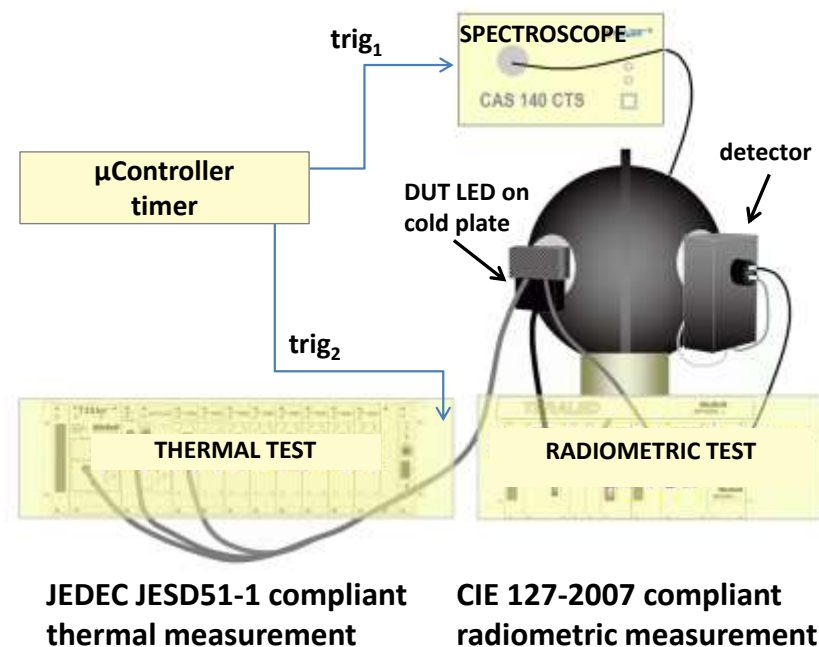
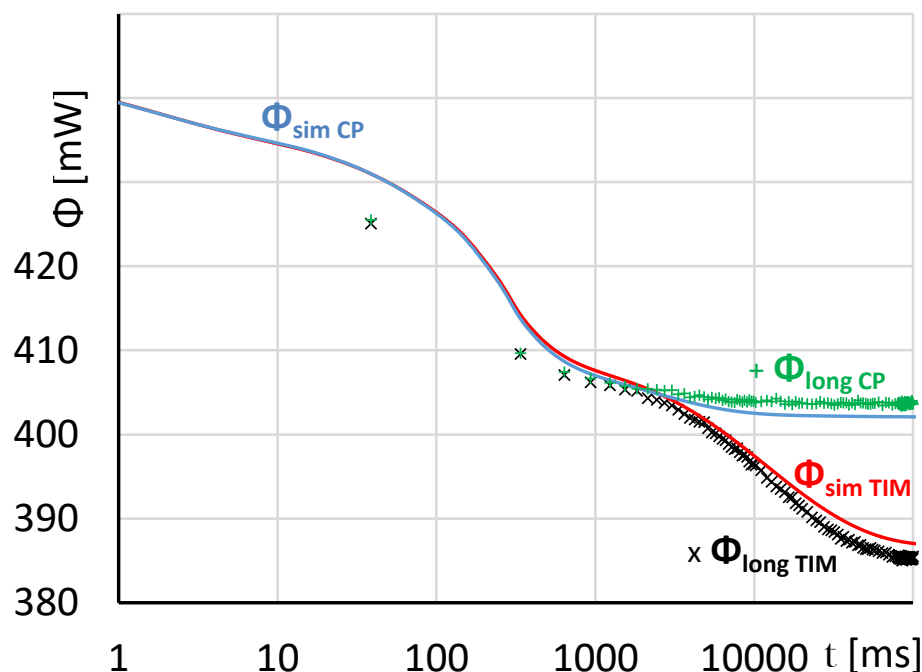
Delphi4LED - From Measurements to Standardized Multi-Domain Compact Models of LEDs

- a new European R&D project for predictive and efficient multi-domain modeling and simulation of LEDs at all integration levels along the SSL supply chain



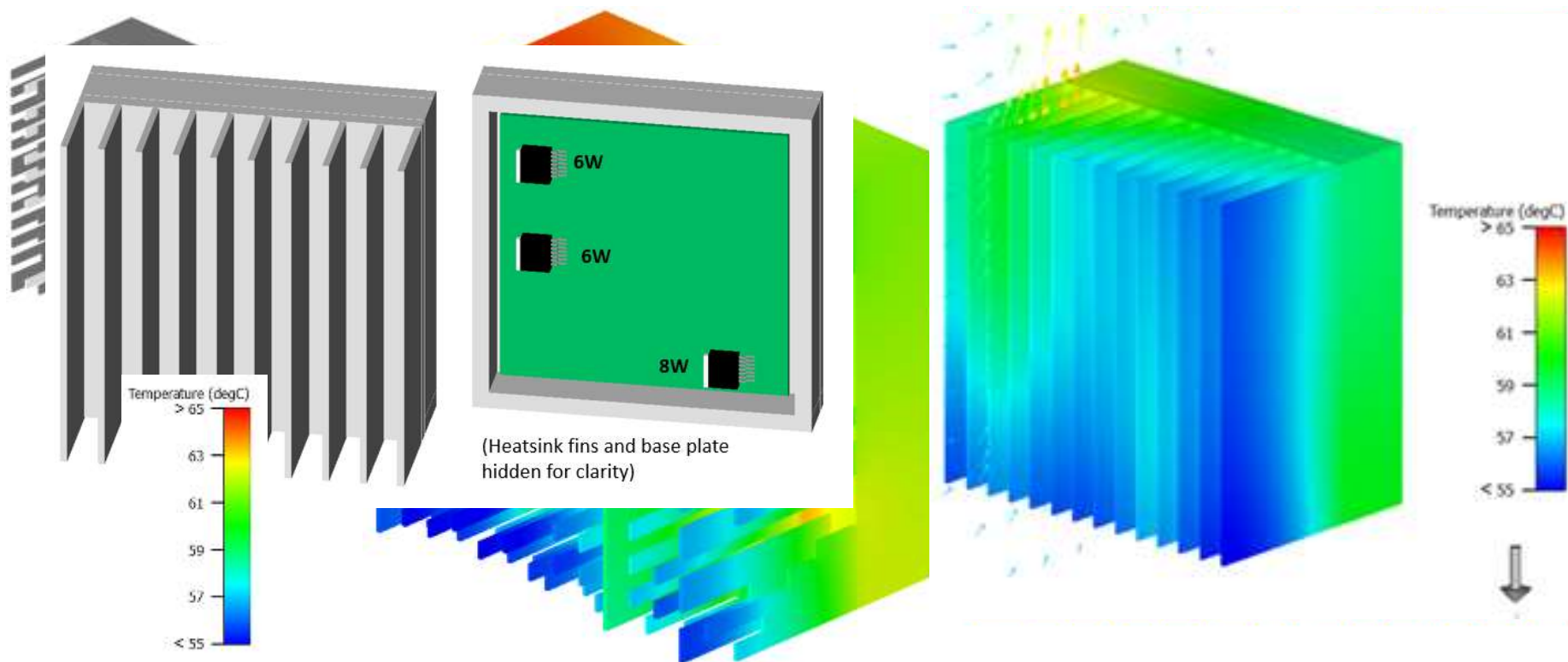
Multi-domain modelling of power LEDs based on measured isothermal and transient I-V-L characteristics

- Tranziens multi domén LED modellezés
- Mikrokontrolleres időzítő a különböző késleltetési idejű műszerek szinkronizálására
- Hosszú és rövid pulzusú mérési módszer az optikai tranziens felvételére



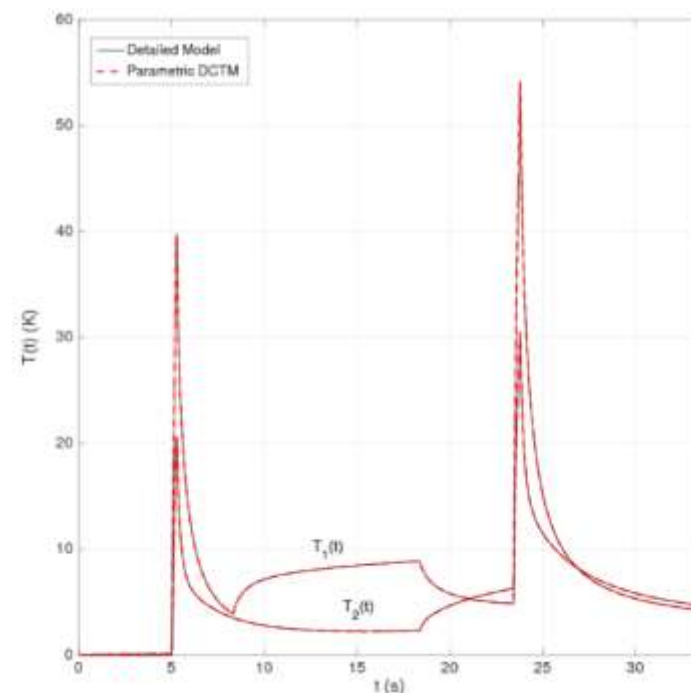
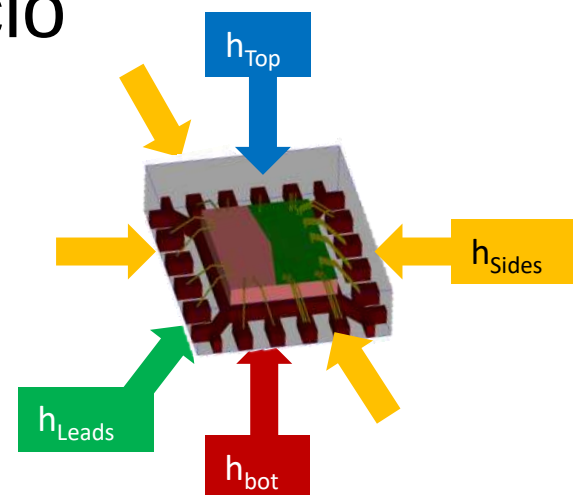
A Novel Approach to Heatsink Mass Minimisation

- Cél, hogy a termikus sarokpontokat figyelve csökkentsük a hűtőborda méretét úgy, hogy ne nagyon növekedjen a hőellenállás
- 50%-os tömegcsökkenés a lemezeken 5%-os R_{th} növekedés árán



Compact Thermal Modelling szekció

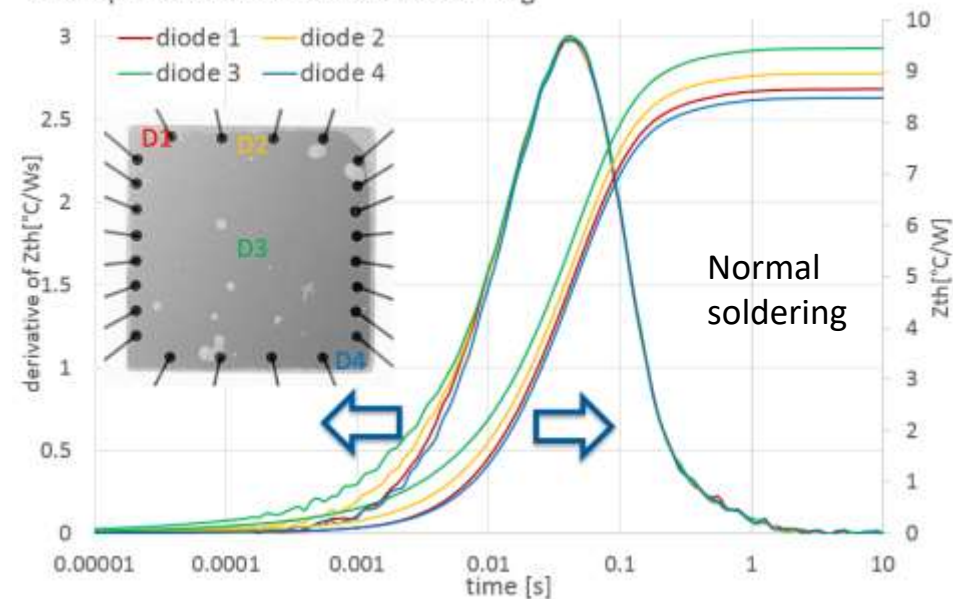
- Különböző modellezési technikák ötvözése a multifizikai effektusok leírására és a számítási gyorsaság növelésére
 - Model Order Reduction és Partial Element Equivalent Circuit kombinációja induktivitások modellezésére
 - JEDEC Compact Thermal Modell előállítása, peremfeltételek vizsgálata
 - Dinamikus CTM előállítása
 - MOR
 - parametrikus modellezés és a részletes (detailed) modell vizsgálata



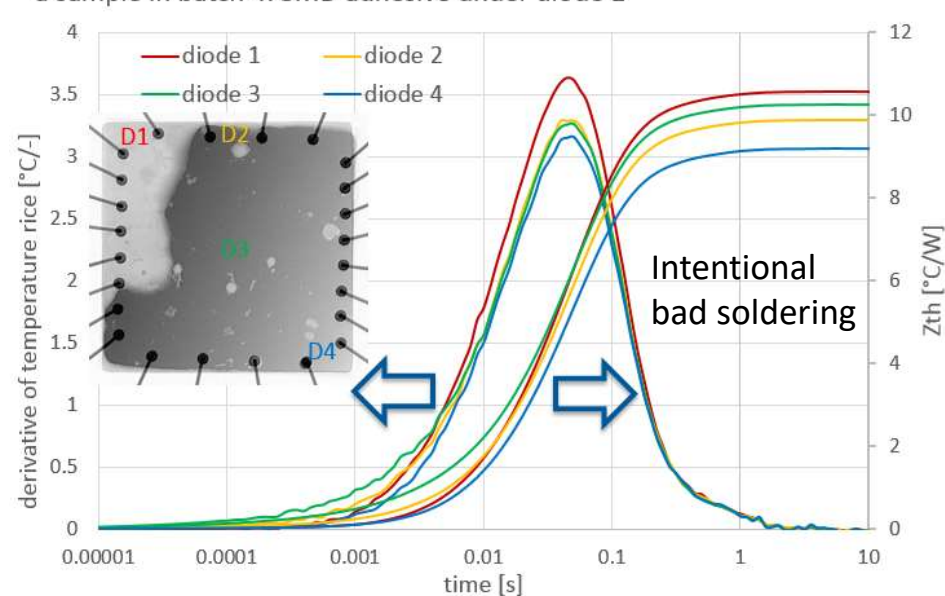
Location resolved transient thermal analysis to investigate crack growth in solder joints

- Termikus tranziens analízis több mérési pontban
- Hibás forrasztások vizsgálata
- Termikus sokk teszt

a sample in batch 3: standard soldering

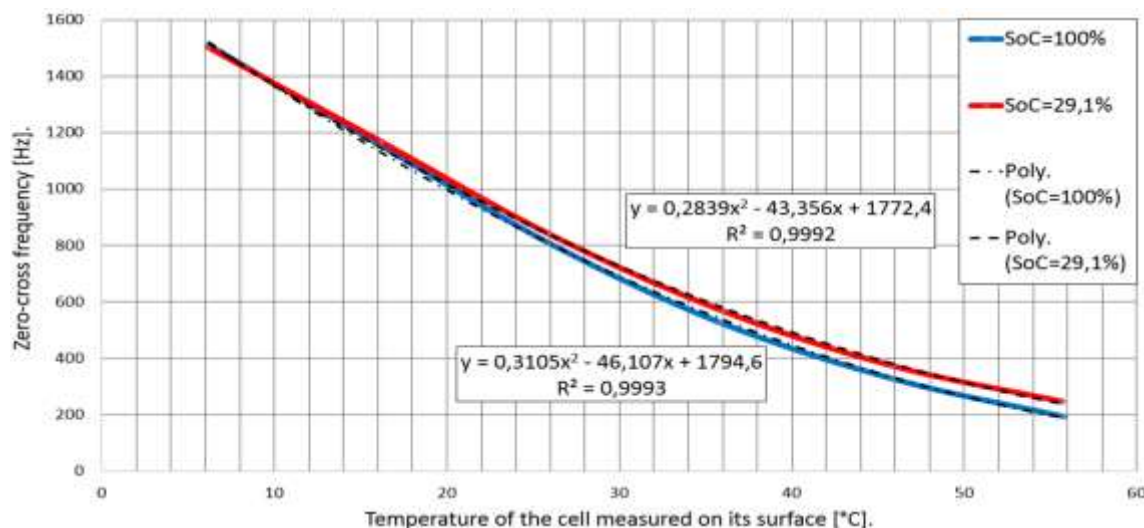
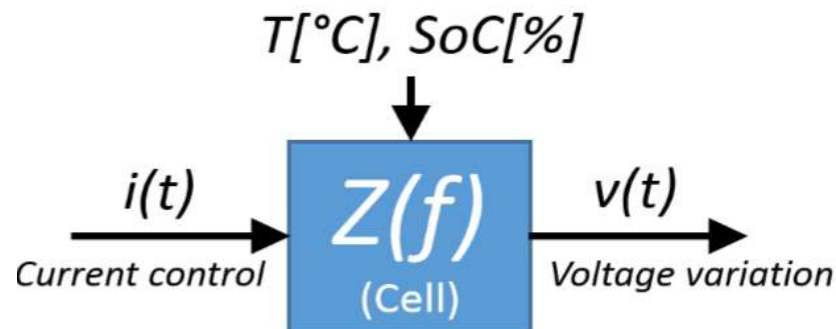


a sample in batch 4: SMD adhesive under diode 1

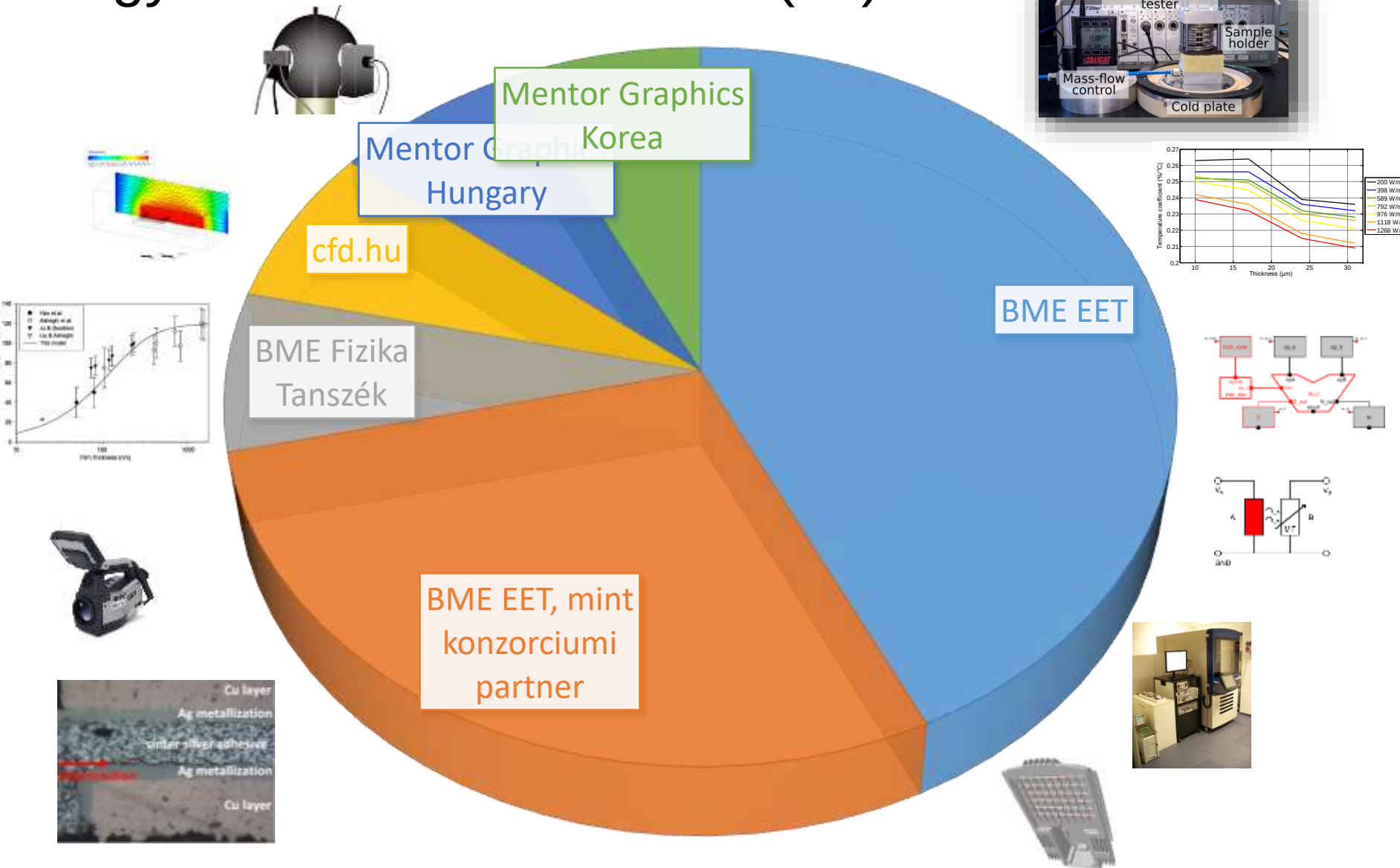


Electronics Module for the Thermal Monitoring of a Li-ion Battery Cell through the Electrochemical Imp. Est.

- Akkumulátor állapotának vizsgálata az átviteli függvény alapján
- Szenzort nem igénylő kiértékelés

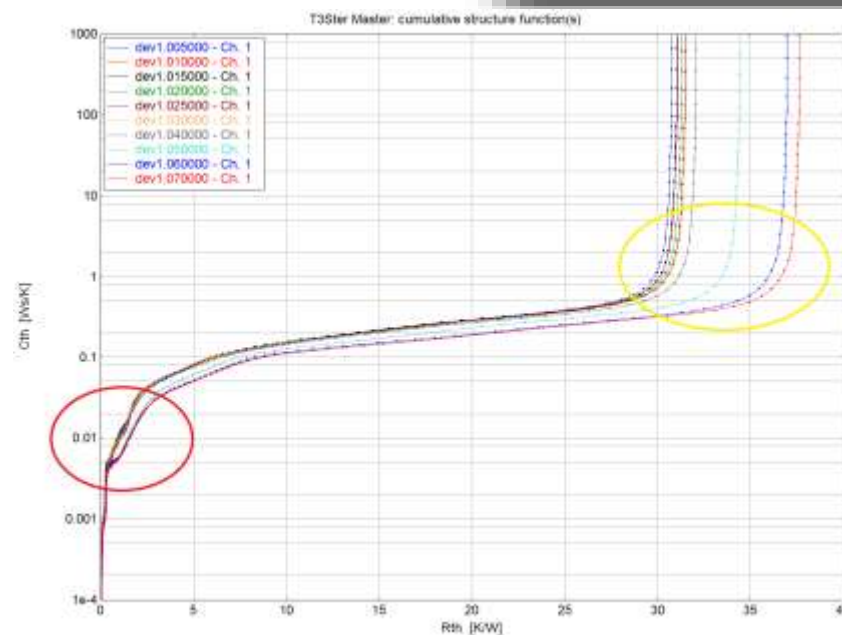
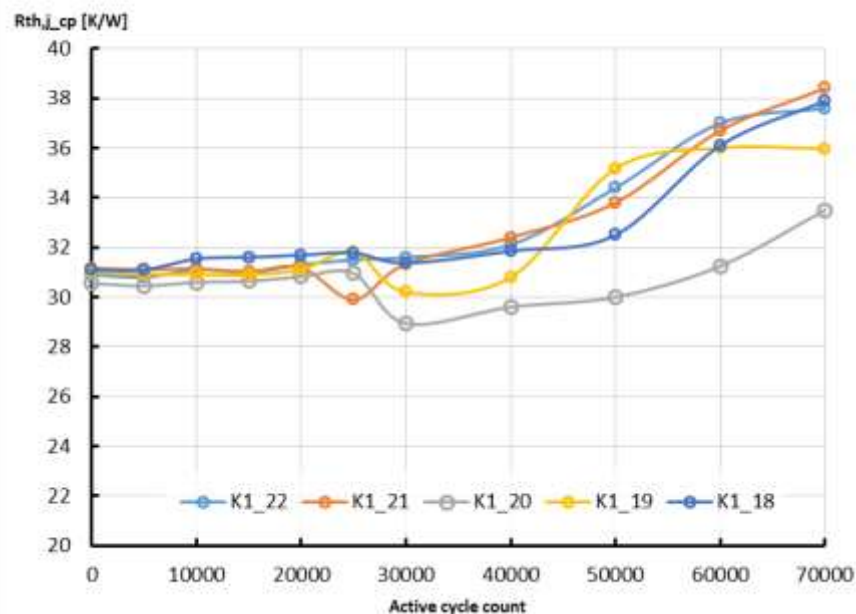
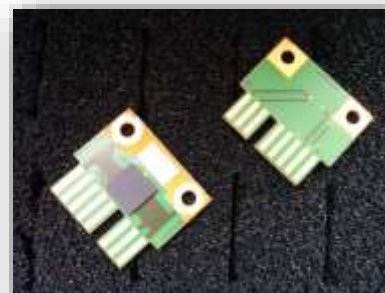


Magyar vonatkozású cikkek (14)



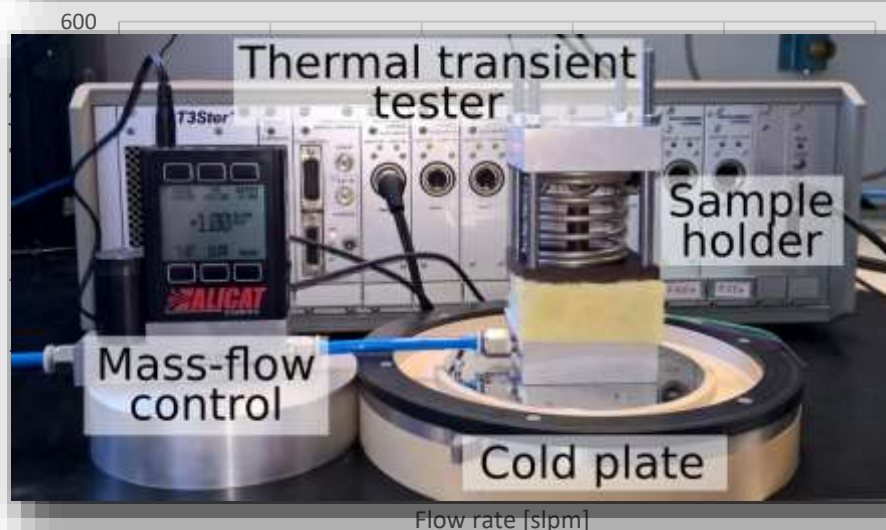
Aging Tendencies of Power MOSFETs

- A Reliability Testing Method Combined with Thermal Performance Monitoring
- Tok és chip szintű degradáció



Fabrication and Characterization of Microscale Heat Sinks

- OTKA 109232 – 2013-2017
- CMOS kompatibilis integrált mikroméretű hűtés
- Tesztstruktúrák a gyártástechnológia finomításához és a korábban készült szimuláció motor validálásához
- Lamináris-turbulens átmeneti áramlási tartomány vizsgálata



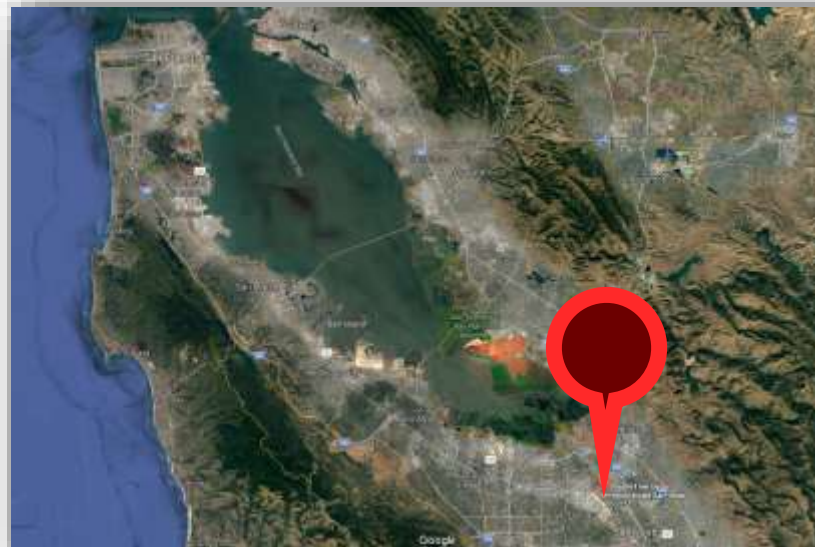
Semi-Therm 33

San Jose, USA



Konferencia helyszíne, elérhetősége

- <http://semi-therm.org/>
- DoubleTree Hotel San Jose, San Jose, USA
- Szilícium-völgy
- Platina, arany, ezüst szintű szponzorok
- Médiatámogatók: Electronics Cooling, Solid State Technology
- Chair: George Meyer, CEO, Celsia Inc



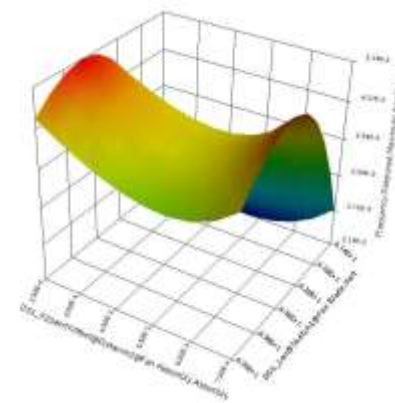
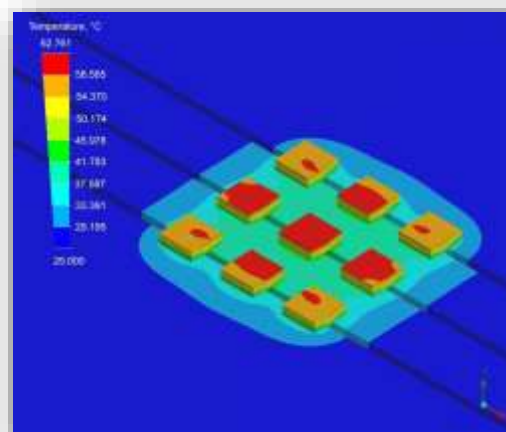
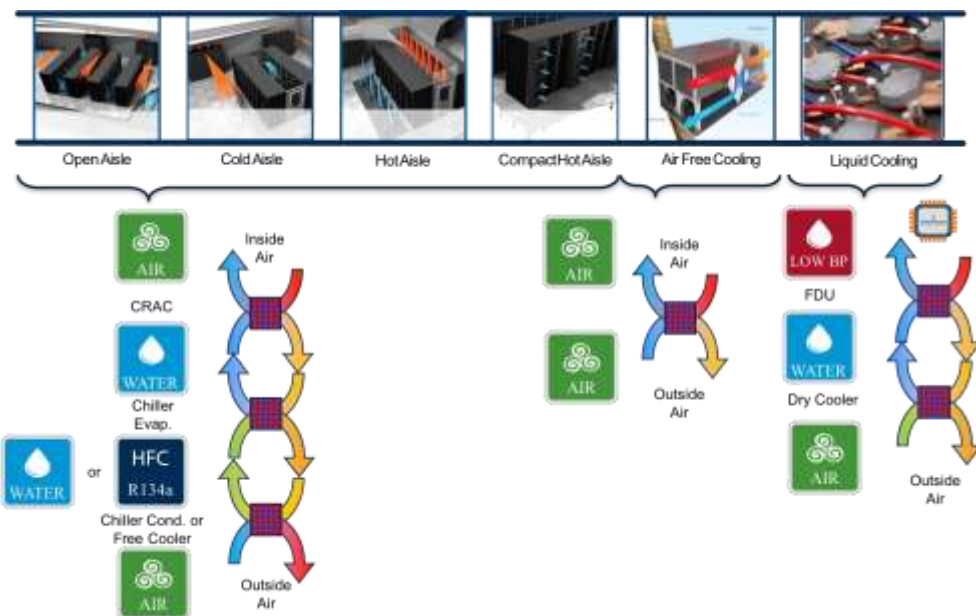
Konferencia felépítése

- Short courses – 1. nap
- „Welcome” (ismerkedési) est
- Keynote speeches: a plenáris előadások előtt és az étkezések alatt
- Plenáris előadások – kb. 4-5 óra minden nap
- Céges bemutatók – standok és prezentációk
- How-to-courses – 2×1 órás esti „bemutató” kurzus
- Díjátadó – best paper, életmű, diák
- Szabványügyi ülések – utolsó nap



Short courses

- A History of Commercial CFD
- **Fundamentals of liquid cooling**
- Transient Thermal Analysis using Linear Superposition
- Spreadsheet Based Thermal Analysis Method
- **Design of Experiments for Thermal Engineering**
- Fundamentals of Power in the Data Center



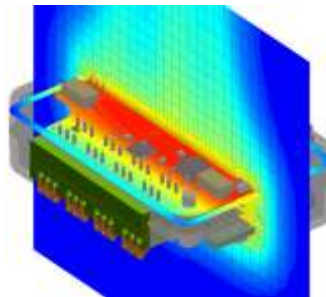
How-to-courses

- Thermocouple Theory and Practice
- [Design of Liquid Cooled Systems](#)
- Design Consideration for Heat Sink Mounting Solution
- [Practical Guidelines for Using Heat Pipes and Vapor Chambers in Heat Sinks](#)

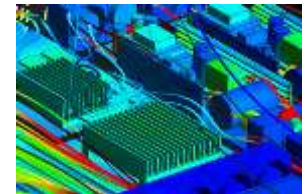


Vendor workshops

- Cradle NA
- **Mentor Graphics**
- Future Facilities
- KULR
- Netzsch



- **ANSYS**
- Calyos
- **ES2**
- Degree Controls



Keynote speeches – I.

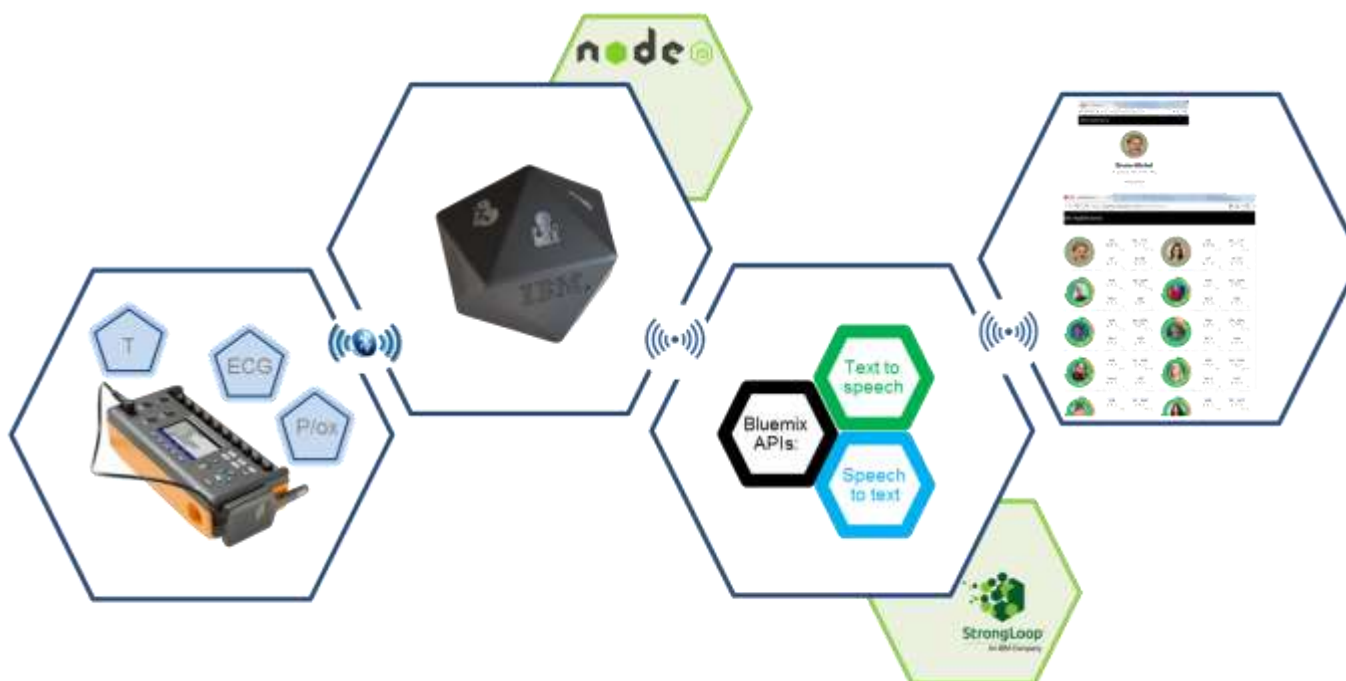
▪ Ultimately Dense and Efficient Future Computers

Bruno Michel, IBM Research – Zurich

- <https://www.zurich.ibm.com/st/smartsystem/#>

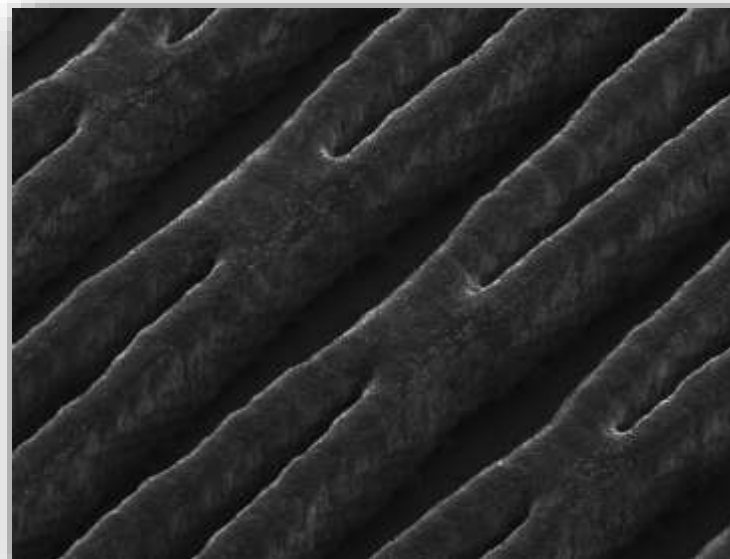
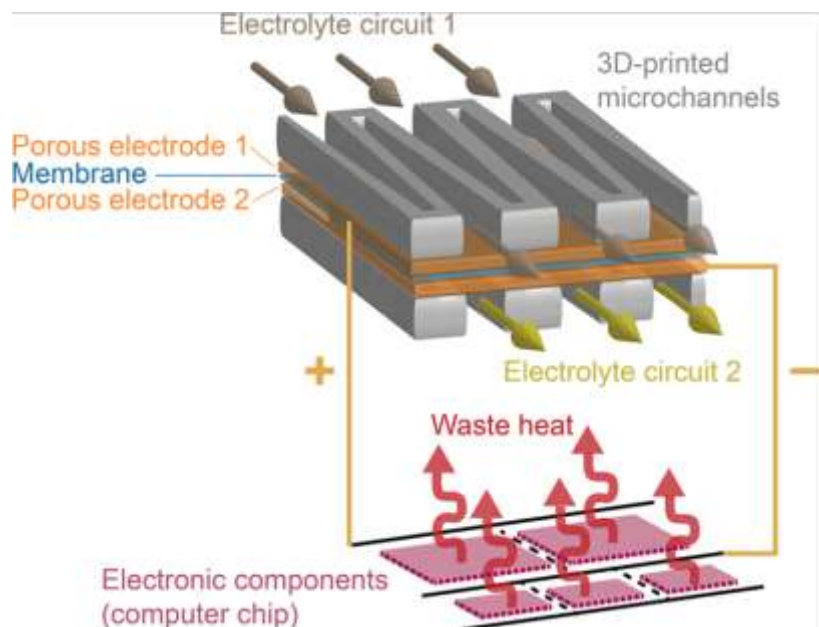
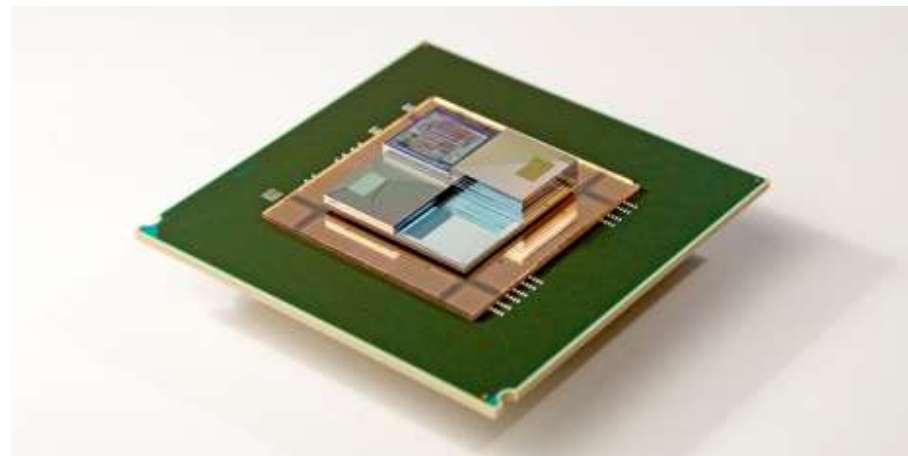


Bruno Michel



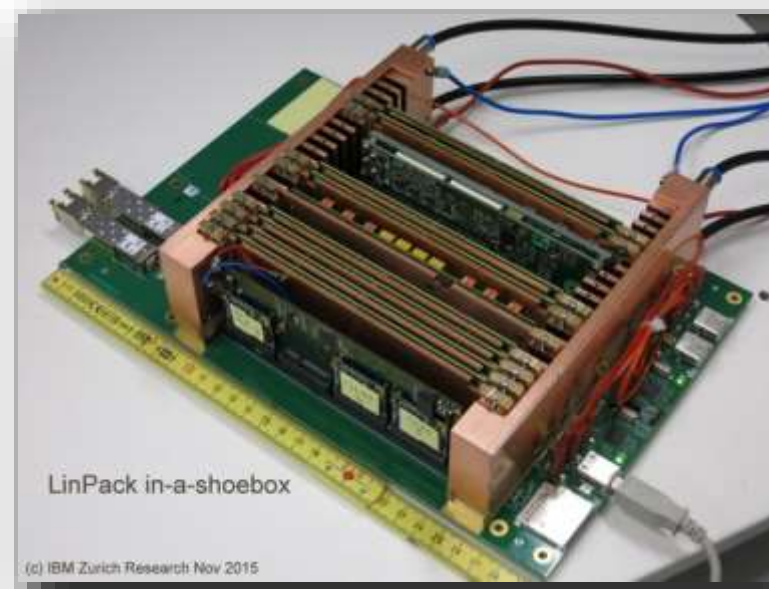
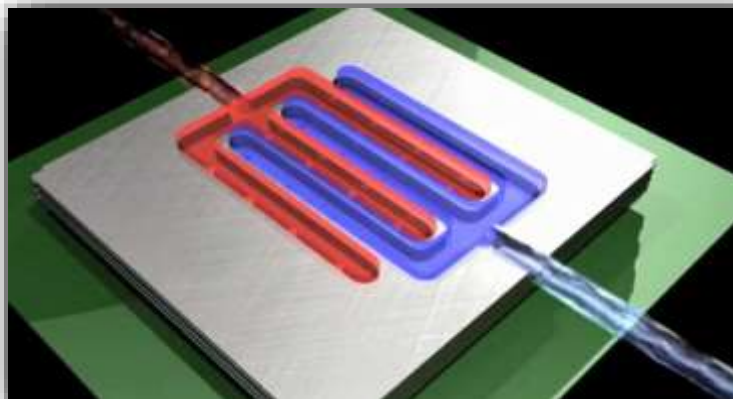
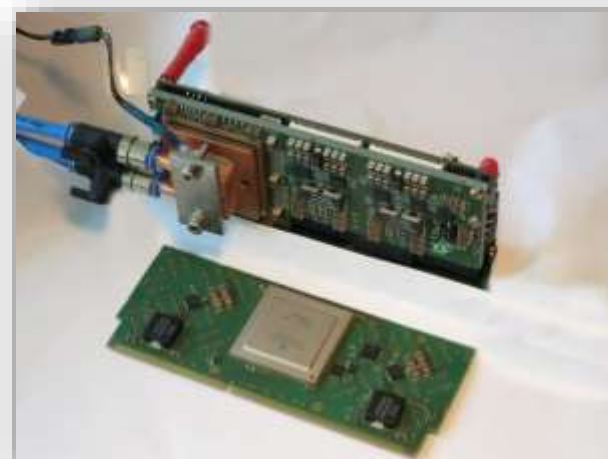
Keynote speeches – I.

- Electrochemical redox flow battery
- Metal 3D printing on Nano level



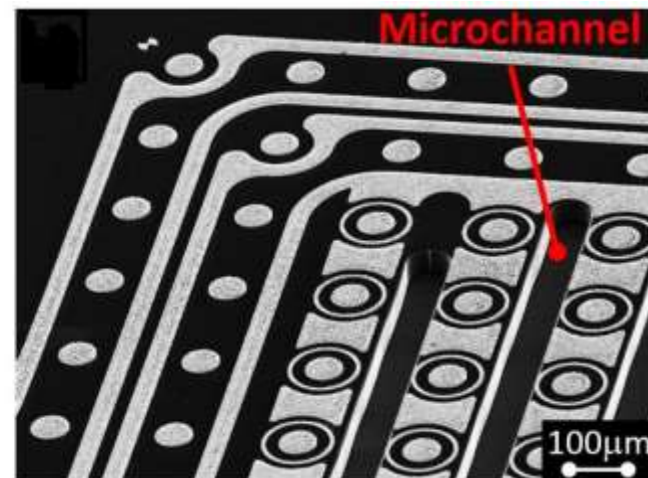
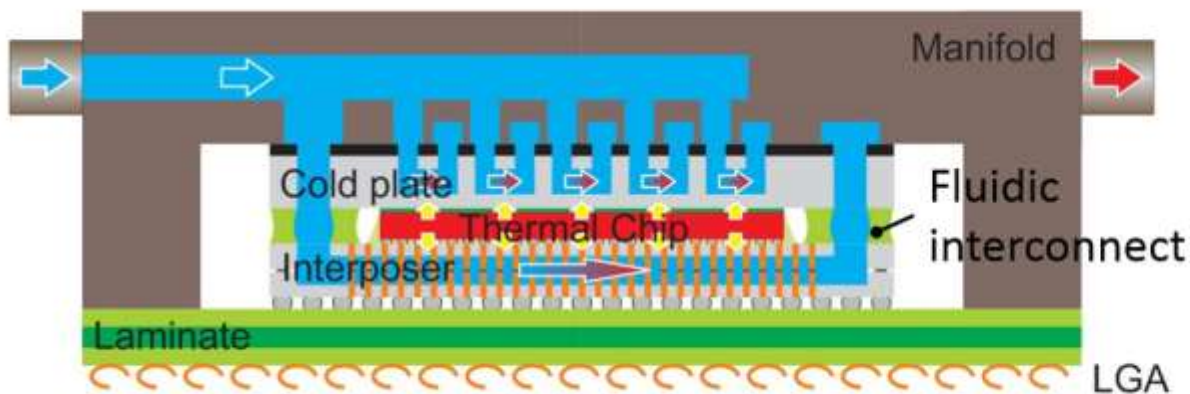
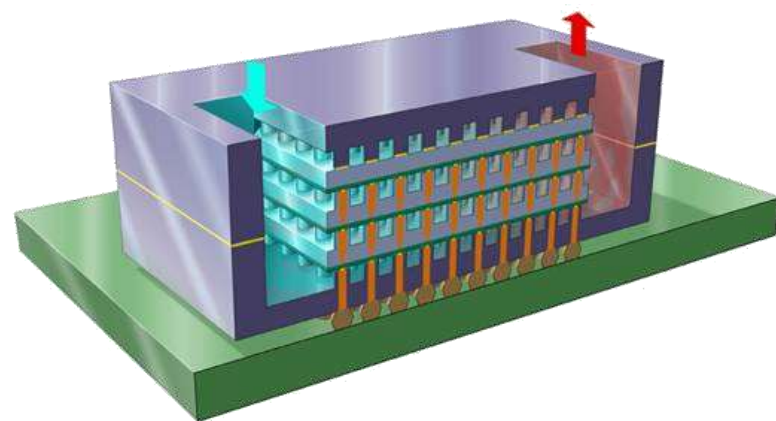
Keynote speeches – I.

- [Microserver](#)
- Bell's law of computer classes
- [The Economist – Future of computing](#)
- [SuperMUC Leibniz Supercomputing Centre – Hot-water cooling,](#)



Keynote speeches – I.

- Functional electronic packaging: embedded liquid cooling
- **Dual-side liquid cooling by liquid cooled silicon interposer**
- Interlayer cooling — True volumetric scaling



Keynote speeches – II.

■ A Holistic View of a Fragmented Data Center Industry

Bahgat Sammakia, Binghamton University

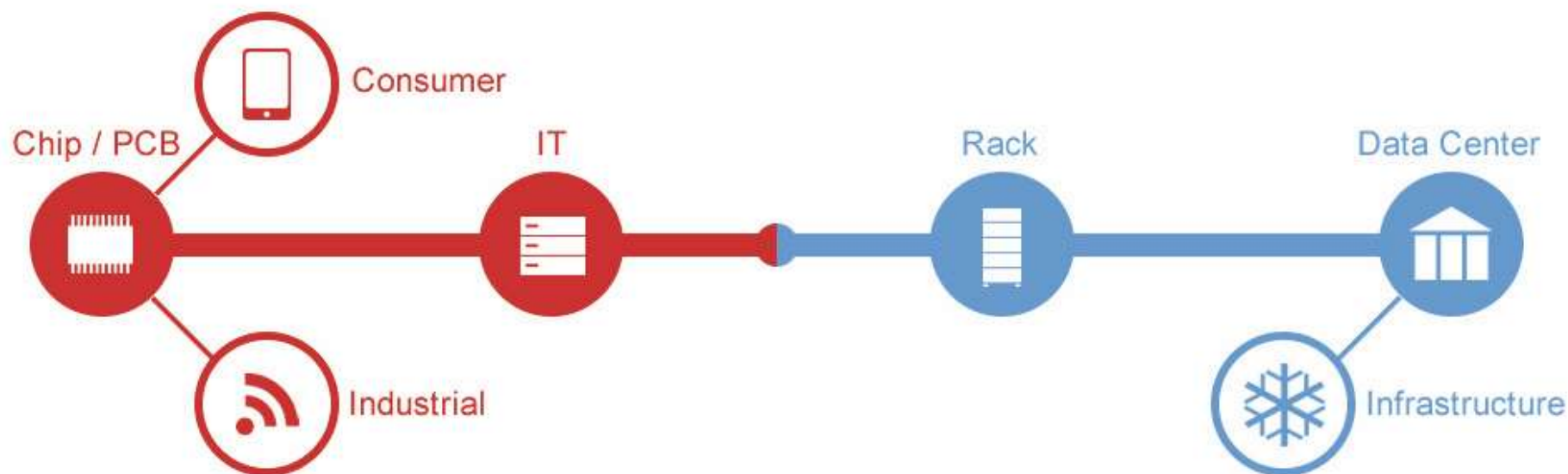
- <https://www.binghamton.edu/es2/>



Bahgat Sammakia

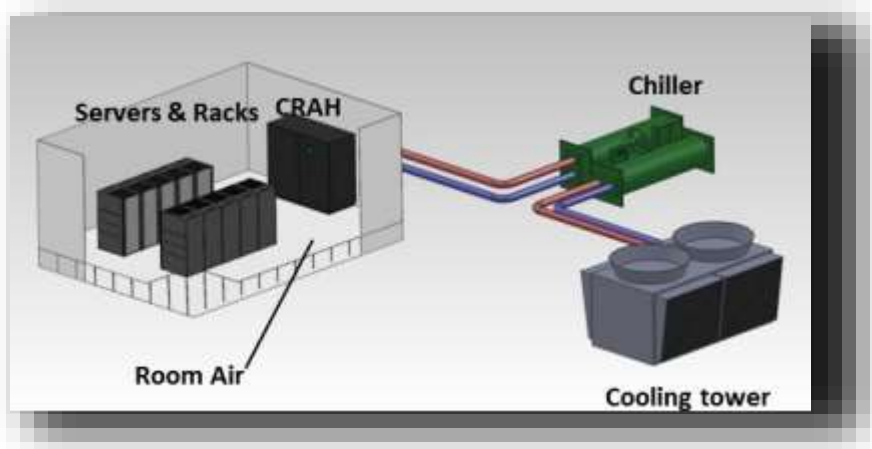
ES2

Center for Energy-Smart
Electronic Systems



Keynote speeches – II.

- Data center track
- Increasing energy consumption
- Waste heat thermal management
- Efficient cooling, cabinet characterization



Keynote speeches – III.

- **Chips, Data Centers to 3D Printing: An Exciting Road Ahead Paved on the Fundamentals of Thermal Sciences**

Chandrakant Patel, Hewlett-Packard

- „Joules is the next currency”
- Dynamic allocation of cooling
- Data mining and knowledge discovery



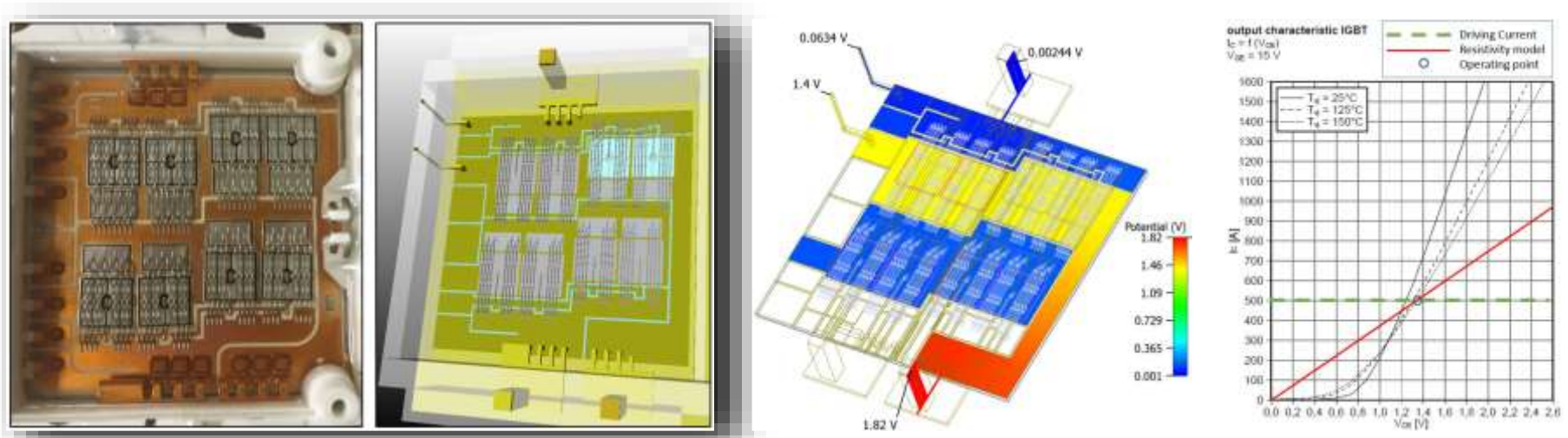
Chandrakant Patel

Szekciók

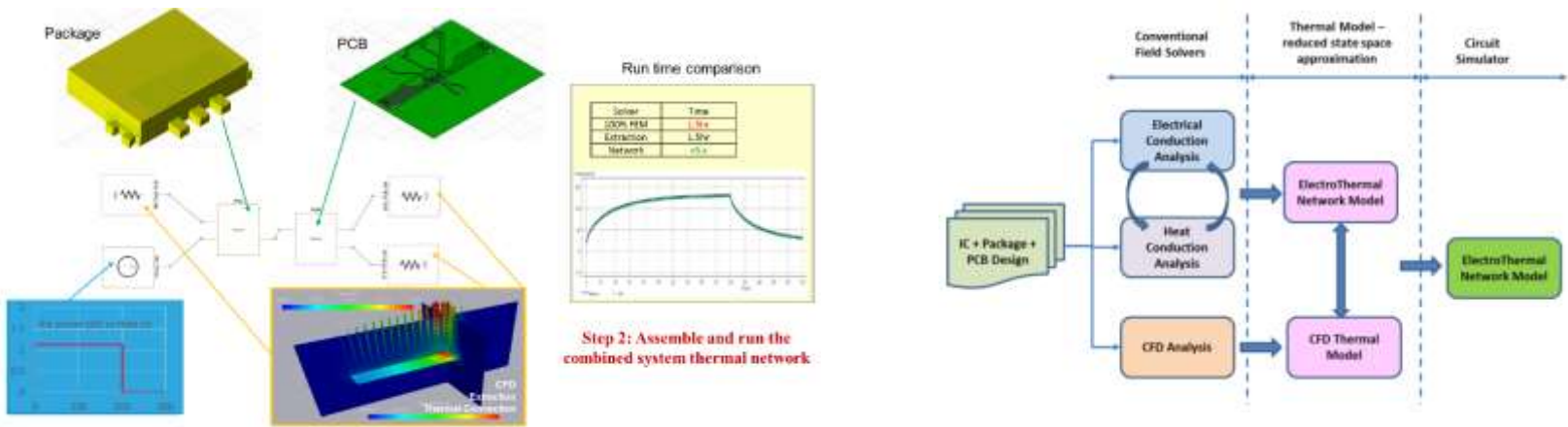
- **Auto/Aerospace/Outdoor Applications**
- **Simulation**
- **Data Center Cooling**
- **Two-Phase Cooling**
- **Heat-Sinks**
- **Measurement**
- **Thermal interface materials**
- **LED**



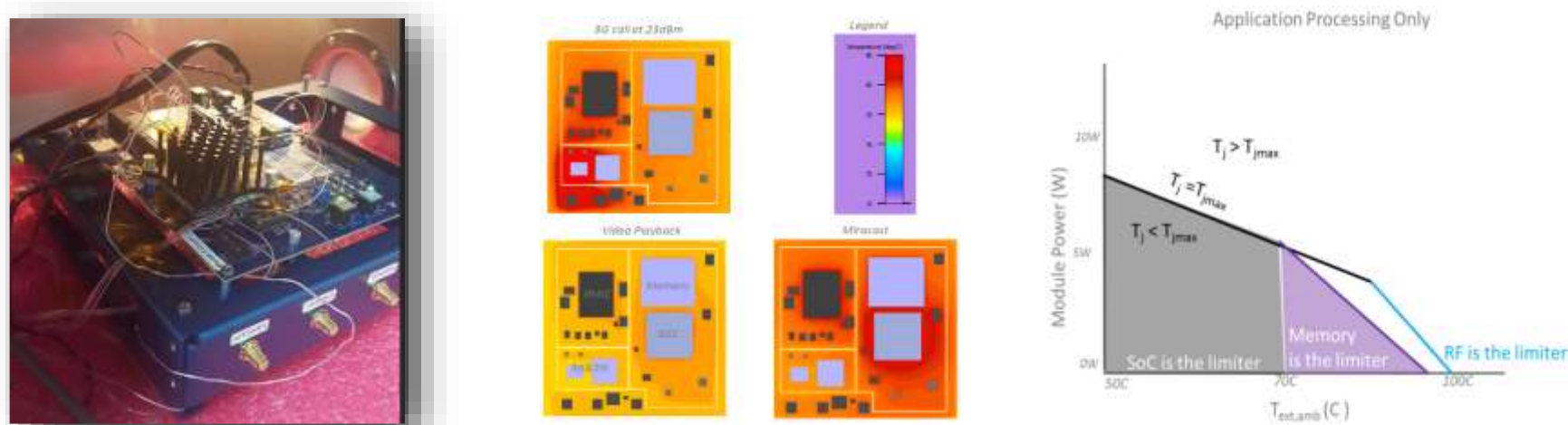
Full-Circuit 3D Electro-Thermal Modeling of an IGBT Power Inverter



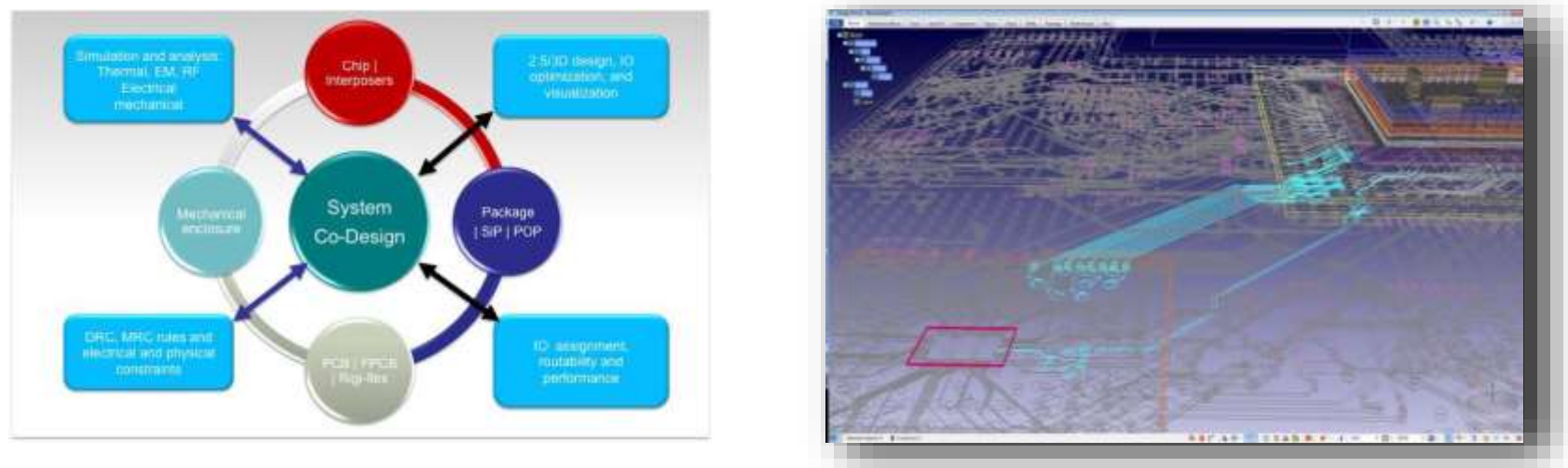
System-Level Electro-Thermal Analysis of RDS(ON) for Power MOSFET



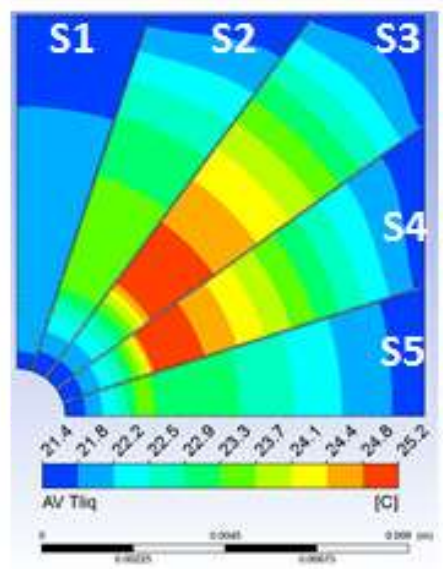
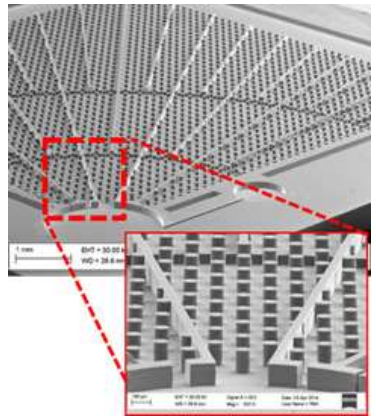
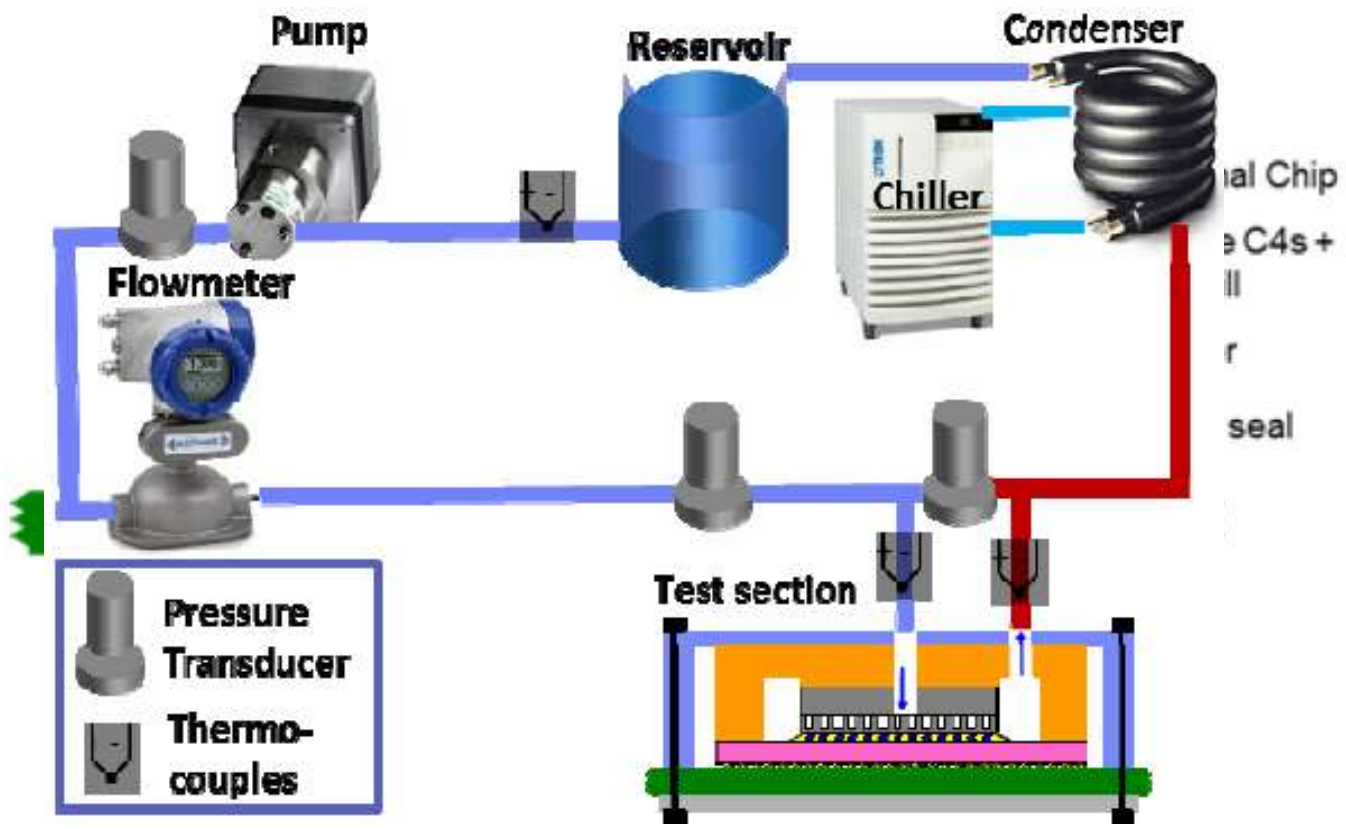
Thermal Power Envelope for IoT Modules



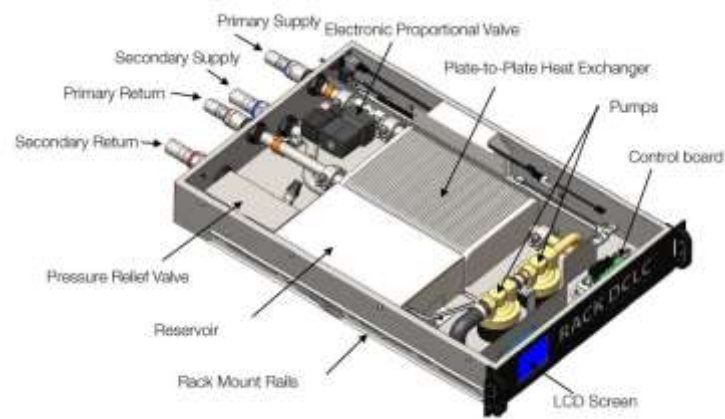
Enabling Faster Design/Performance Decisions for 3D-IC Package Architectures



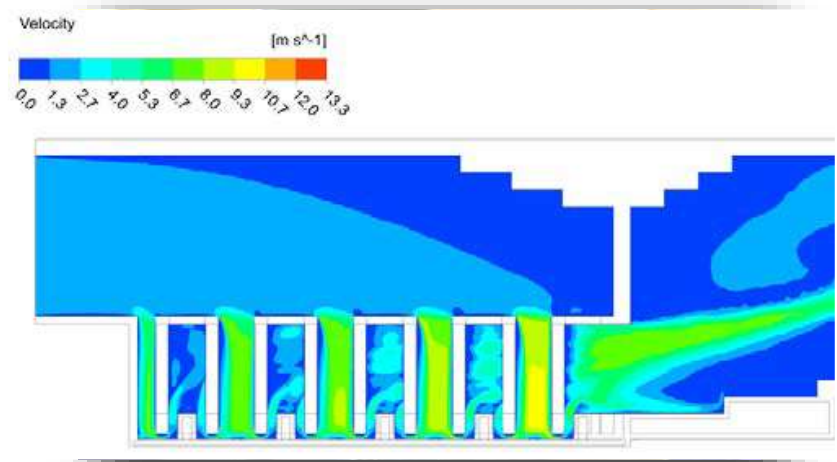
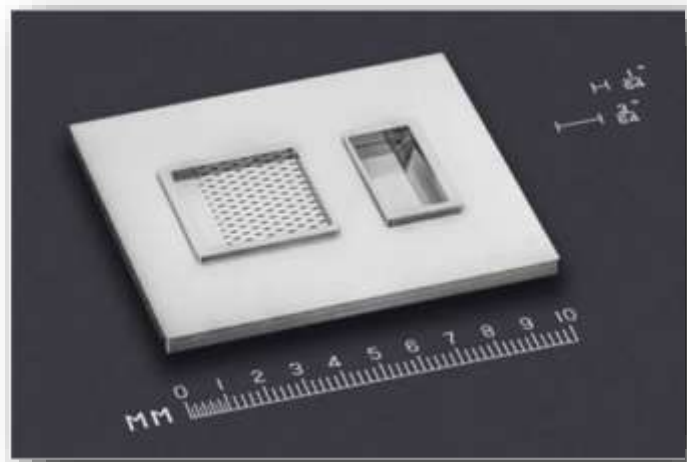
Modeling Embedded Two-phase Liquid Cooled High Power 3D Compatible Electronic Devices



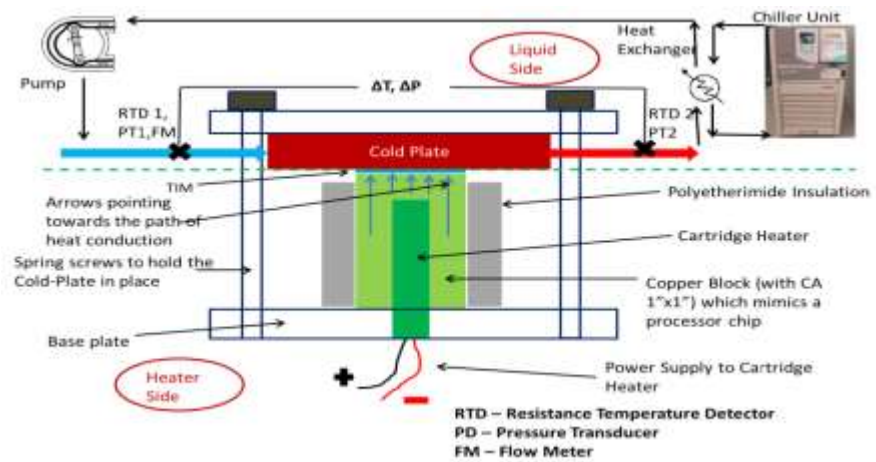
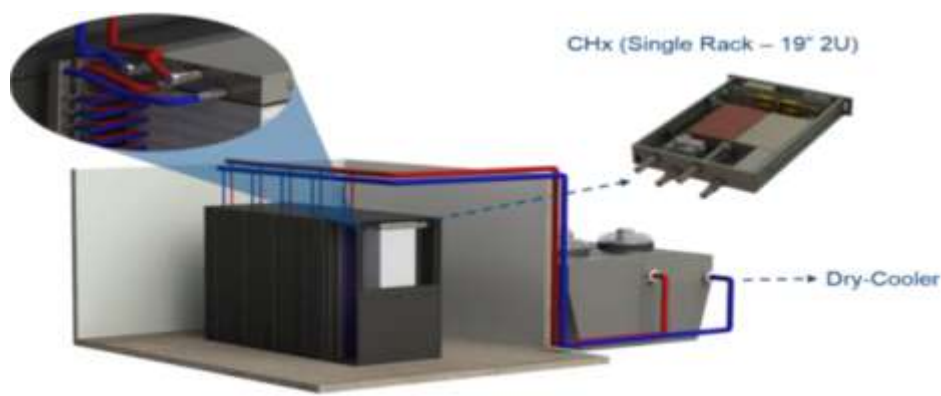
Rack-Level Study of Hybrid Cooled Servers using Warm Water Cooling For Distributed vs. Centralized Pumping Systems



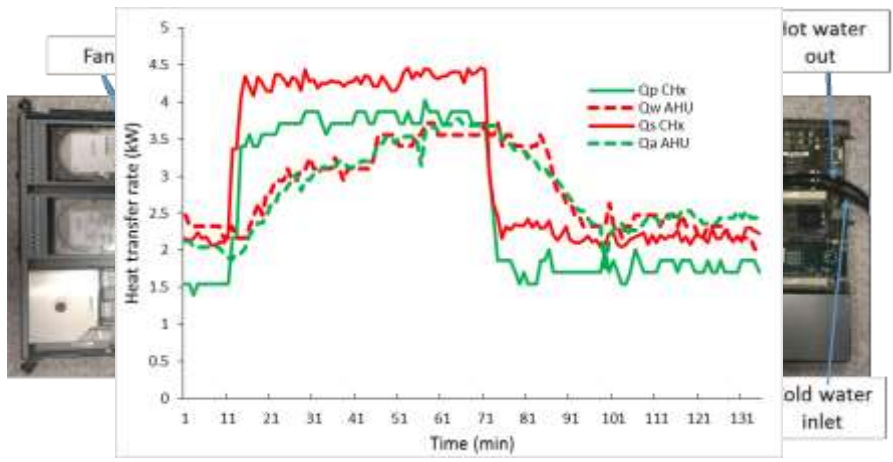
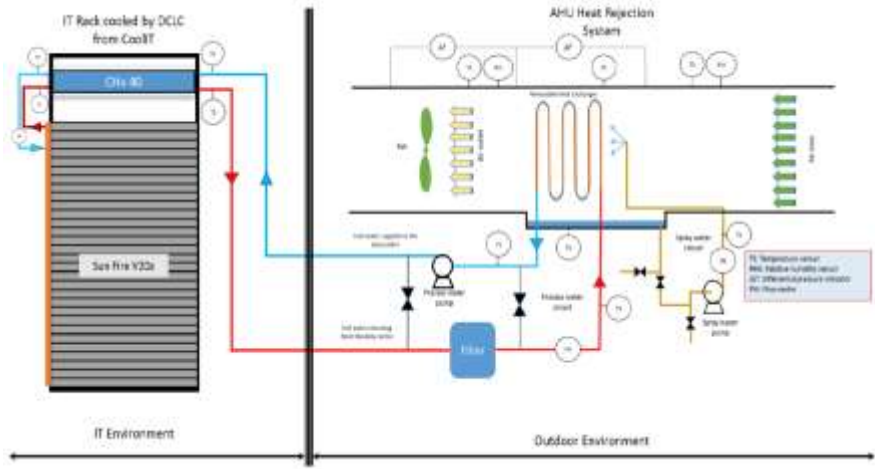
A New Hybrid Heat Sink with Impinging Micro-Jet Arrays and Microchannels Fabricated using High Volume Additive Manufacturing



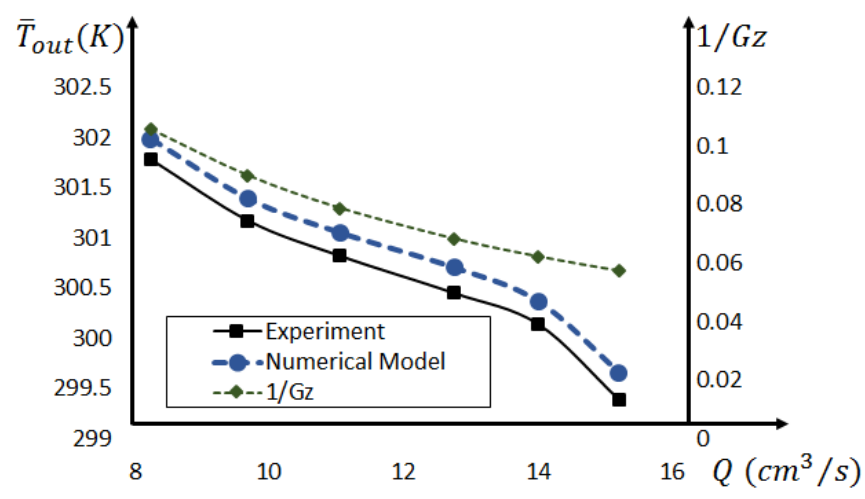
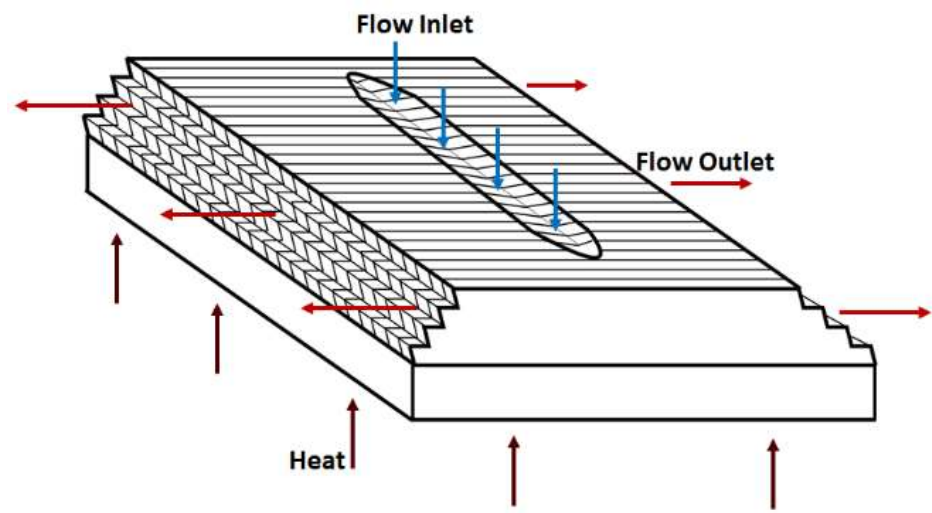
Experimental Characterization of a Cold Plate used in Warm Water Cooling of Data Centers



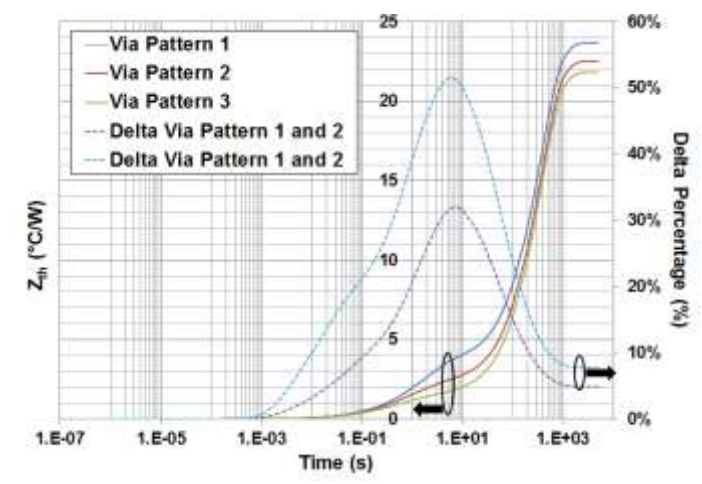
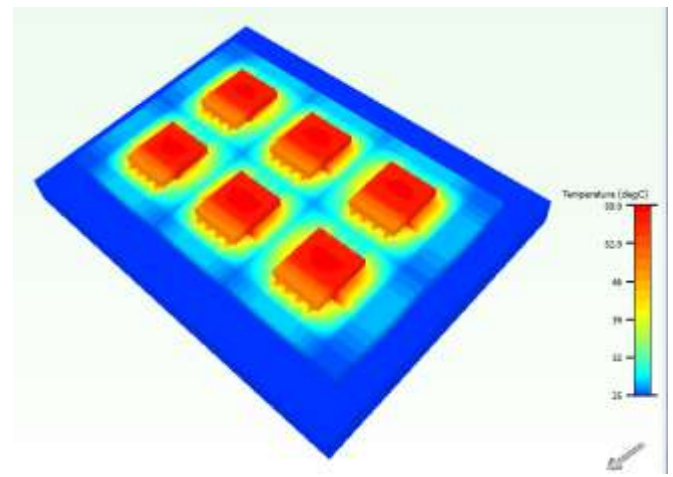
Performance of a Mixed Mode Air Handling Unit for Direct Liquid-Cooled Servers



Numerical Modeling and Optimization of a V-groove Warm Water Cold-plate

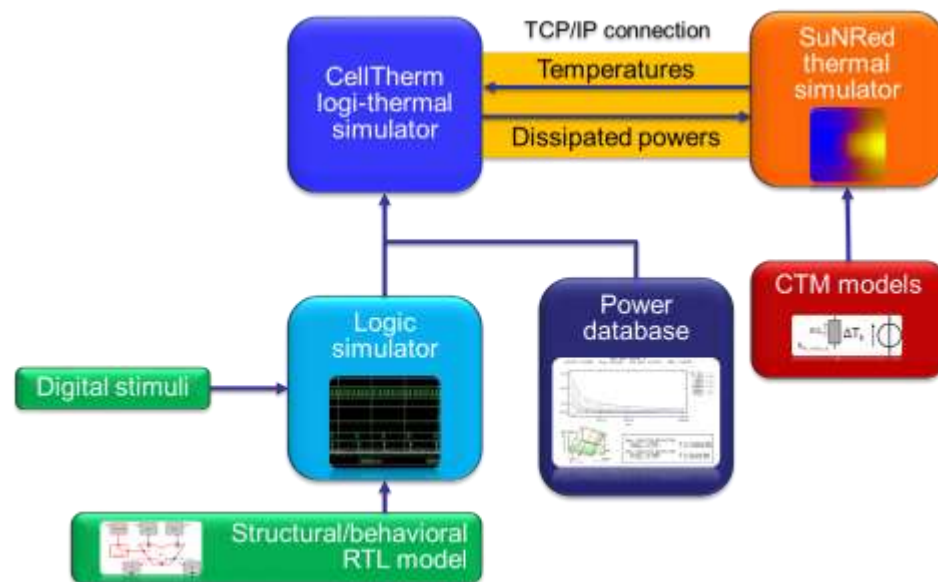


Electro-Thermal Analysis for Automotive High Power MOSFETs



Magyar vonatkozások

- Integrating chip-level microfluidics cooling into system level design of digital circuits
 - Gy. Bognár, G. Takács, L. Pohl, L. Jani, A. Timár, P. Horváth, M. Németh, A. Poppe, P. G. Szabó
- Céges bemutató
 - Poppe András
- JEDEC szabványügyi ülés
 - Poppe András



Köszönetnyilvánítás

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Kapcsolat

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