Too Hot To Test? Advanced Thermal Management

Ferdinand Wimmer / Markus Kindler
ATT Systems GmbH

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Wafer Test Trends – Too Hot To Test?

Testing of high power IC’s (i.e. AI/Processors) + 1TD DRAM is approaching an inflection point

High power density of DUT’s need better thermal chuck to dissipate the peak power at a wide temperature range

Standard chucks are not able to sense temp increase and to dissipate the applied energy – device damage, burned probes, inaccurate test results

Heterogenous integration will further increase power densities:>10X with processor + 8-die HBM stacked on a base wafer

Active temperature control solutions are required: Low Thermal Resistance – MultiSense Temp Control – Liquid Cooling

ATT’s Low Thermal Resistance (LTR) chuck technology addresses these challenges

What is a Thermal Chuck System?

Air Cooled

-40C to +200C

-60C to +200C

Modular Base Chuck System

Universal chuck and controller

2 independent cooling circuits

+20C to +200C without chiller

Liquid Cooled

-20C to +200C

-40C to +200C

-60C to +200C

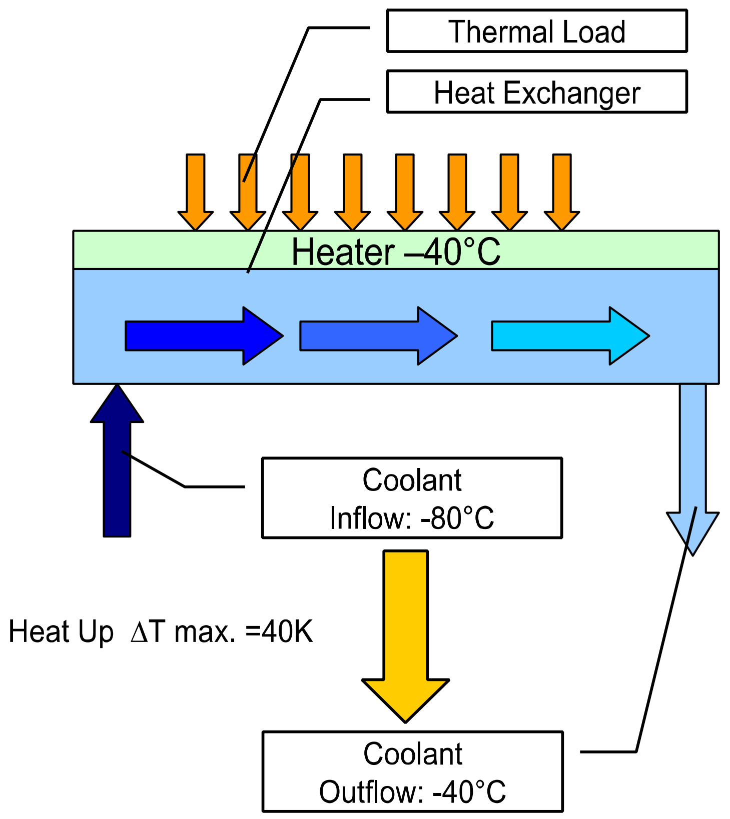
High Power Testing – Why Liquid Cooling?

Air-Cooled

Liquid Cooled

Cooling with air

What power do we need to test at -40°C



Maximu

$\varsigma_{AIR} =$

$c_{AIR} =$

$m_{AIR} =$

$\Delta T_{\max}$

$P_{\max} =$

As the id
100W to

0l/min
$/ dm^3$
$/(KgK)$
$0g$

600W heat load applied by testing following
lated

$P_{load} = 600W$

$/(KgK)$ $c_{ZT130} = 1{,}1 KJ/(KgK)$

$0g$ $m_{Zt13m} = 18000g$

$= 1{,}15K$ $\Delta T = \frac{Q_{Last} \cdot t}{c \cdot m} = 2{,}35K$

Conclusion:
Liquid cooled systems are the tools of choice due to the high cooling power and better temp. uniformity!

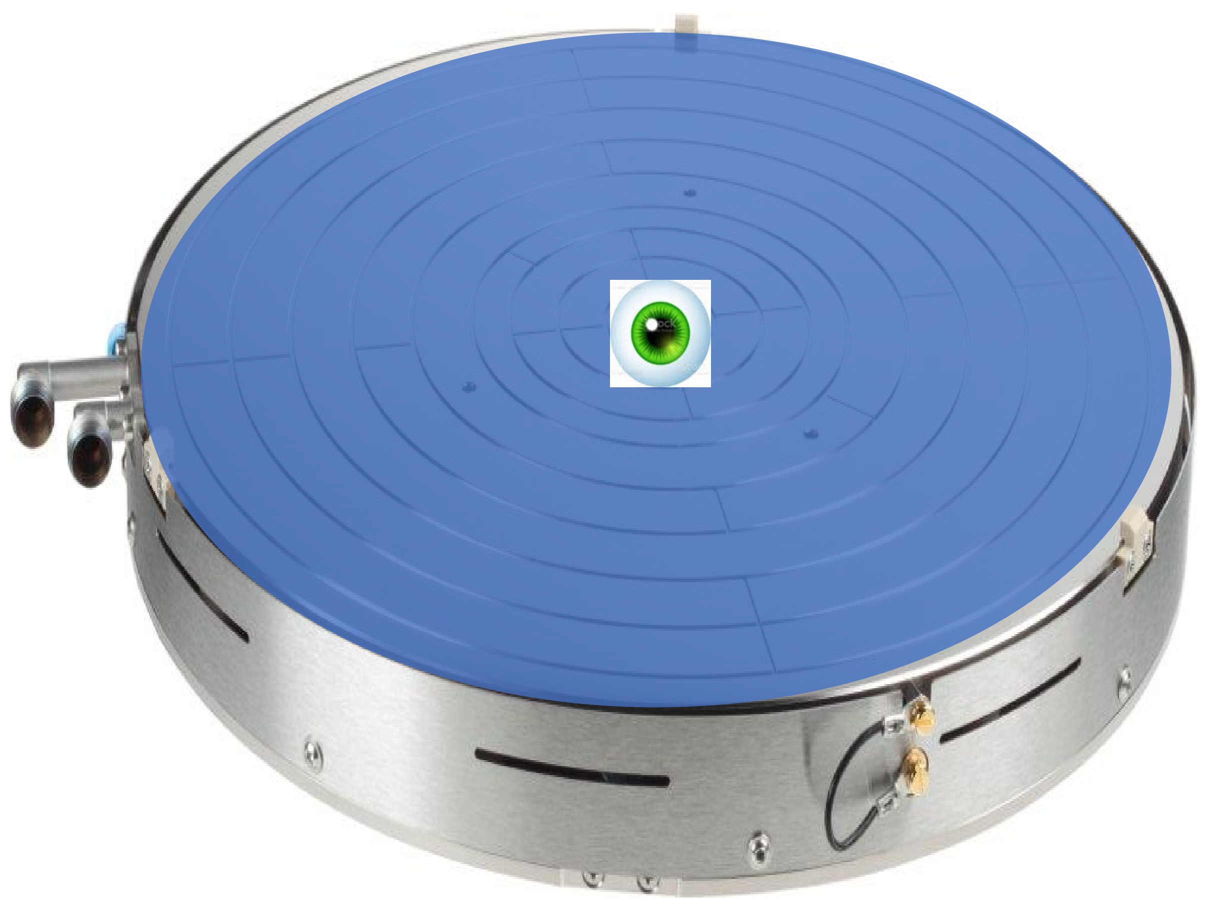
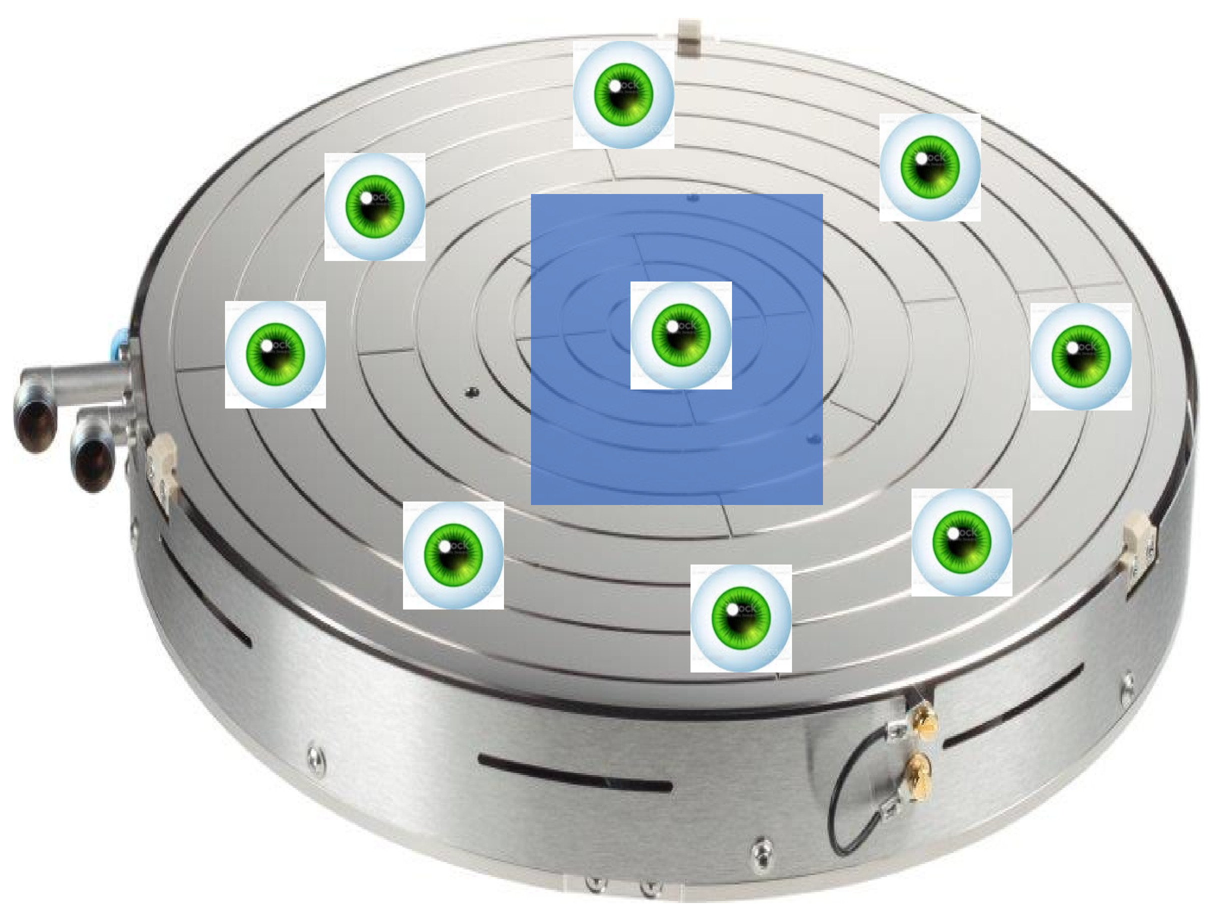
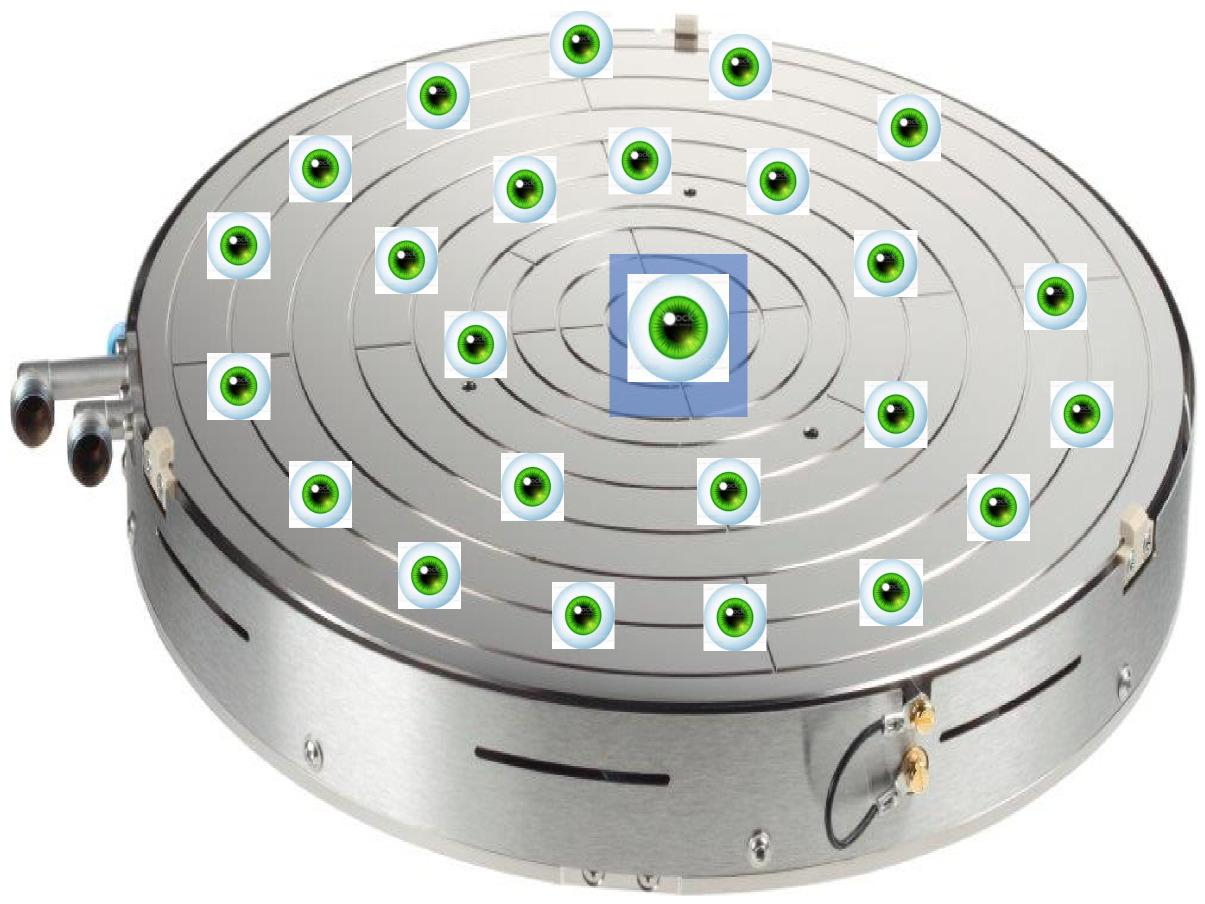
Max. Cooling Capacity is lov | igh at >3000W

Effective Cooling Capacity is | mp. uniformity

ΔT high – impact on temp. u | consumption

High air-flow@high pressur | quire other fluids

Active Temperature Control – MultiSense

Full Wafer Contact	100x100mm	20x20mm
		

Full Wafer Contact: Uniformly distributed thermal load - one control sensor is sufficient

Smaller Contact Areas: Require multiple control sensors to detect temp changes

Number of built-in sensors is limited due to chuck complexity – total of 9 control sensors

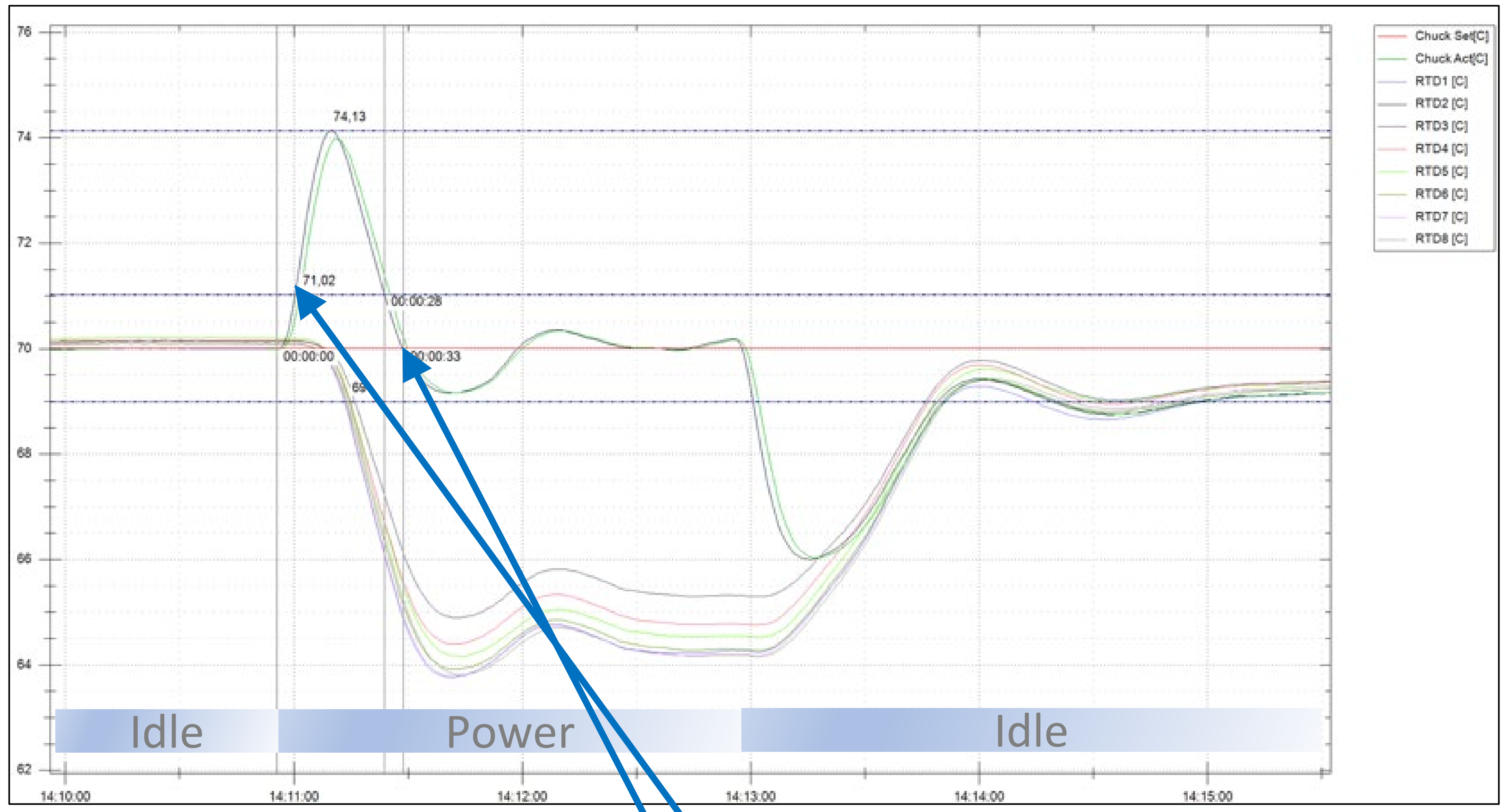
MultiSense AddOn sensors is scalable, currently up to 21 sensors

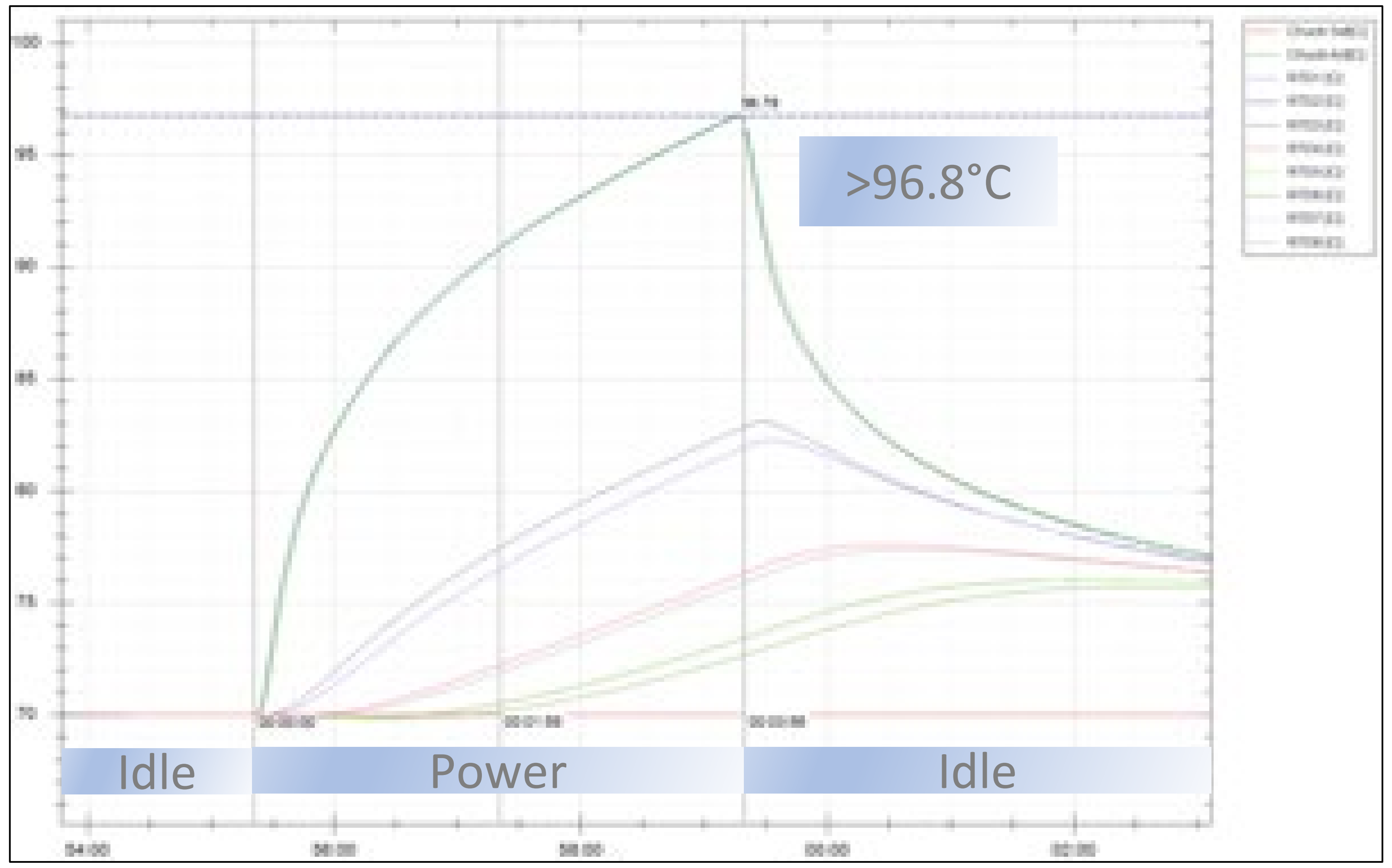
Requires advanced temp control algorithms

MultiSense vs. No MultiSense

+70°C, 200W, 21x22mm contact area, 2 min test time, liquid cooled

With MultiSense	Test Set-Up	Without MultiSense

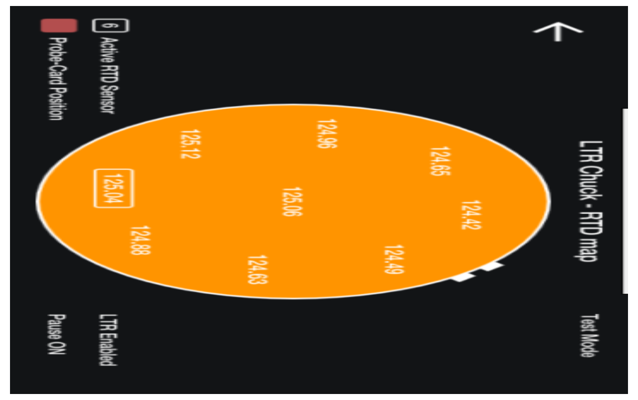


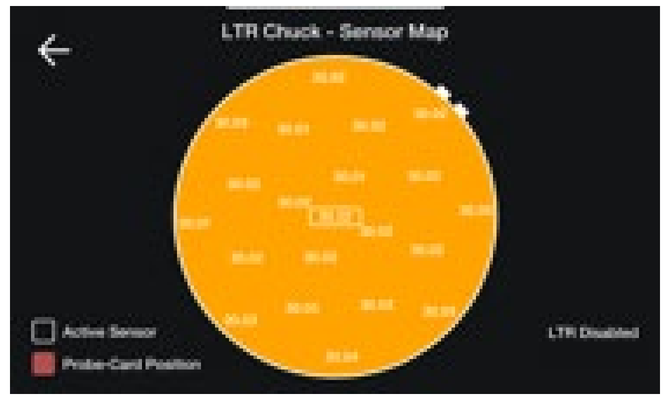


With MultiSense	Test Set-Up	Without MultiSense
Limited temp increase – 74.1°C	Resistor 21x22	Uncontrolled temp rise to >96°C
+/- 1°C after 28 sec	200W max	No temp change detection
Power dissipated after 33 sec	Test Time: 2 min	No Active Temp Control

Low Thermal Resistance Chuck Technology

- Developed for High Power (HP) and High Accuracy (HA) Applications
- AI devices, GPU’s, CPU’s, Stacked Memories, Heterogenous integrated devices
- Low Thermal Resistance chuck design w/ MultiSense Active Temp Control
- Scalable number of temp control sensors (e.g. 9 or 21 sensors)
- Scalable cooling power options, upgradeable as needed (600W to >20KW)
  (temp range dependent)





COMPASS a FormFactor users' group conference

Applications Examples

Full Wafer Contact
DRAM, Flash, HBM

Contact Area: Large
Parallelism: High

Power/Die: Low
Density: Low (3W/cm²)

Heat transfer: up to 2000W
Temp. Range: -40°C to +125°C

100x100mm
E.g. Microcontroller

Contact Area: Medium
Parallelism: Medium/Low

Heat transfer: up to 1000W
Temp. Range: -40°C to +125°C

Power/Die: Medium/High
Density: Medium (10W/cm²)

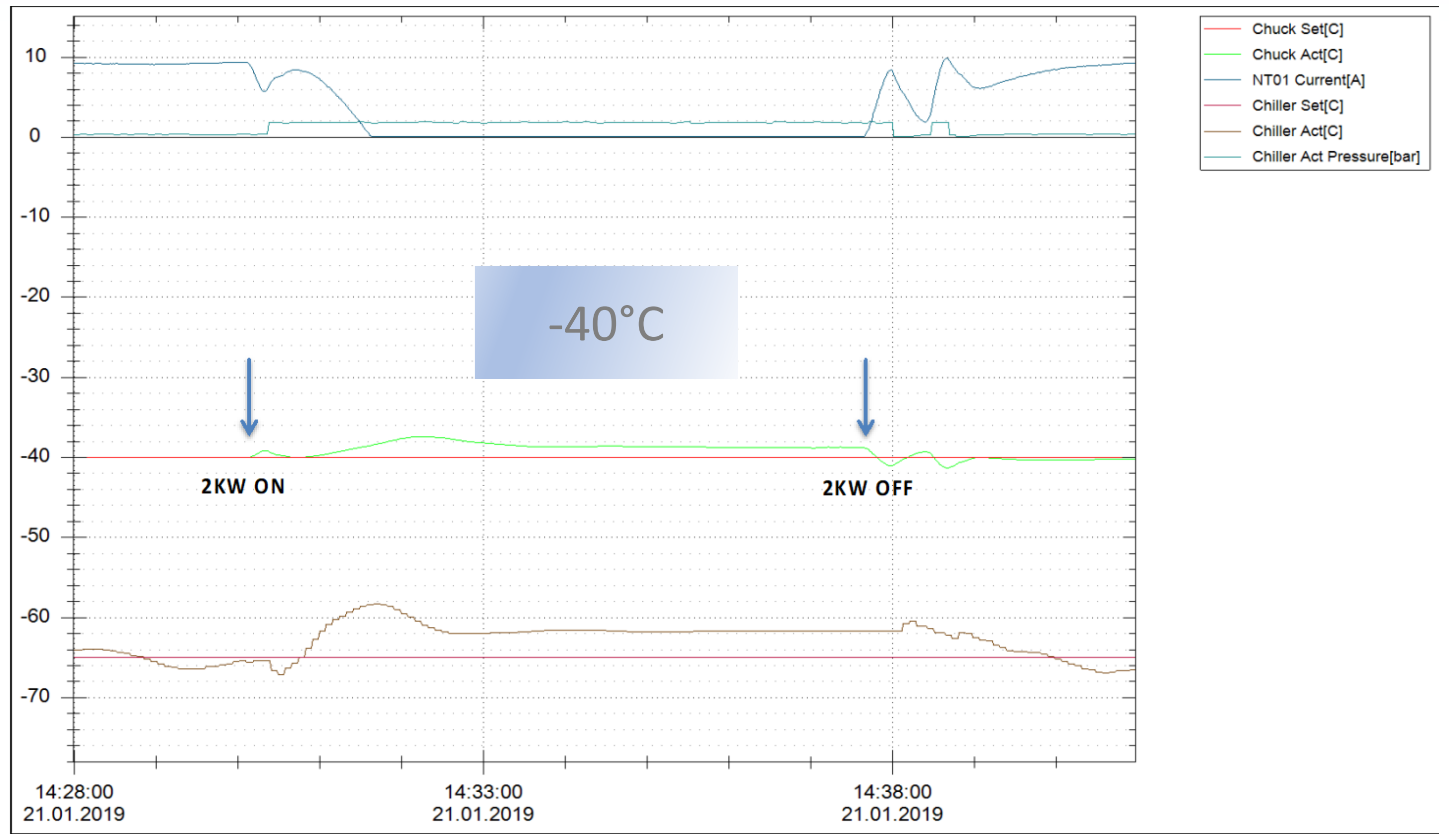
20x20mm
E.g. 5G or GPU devices

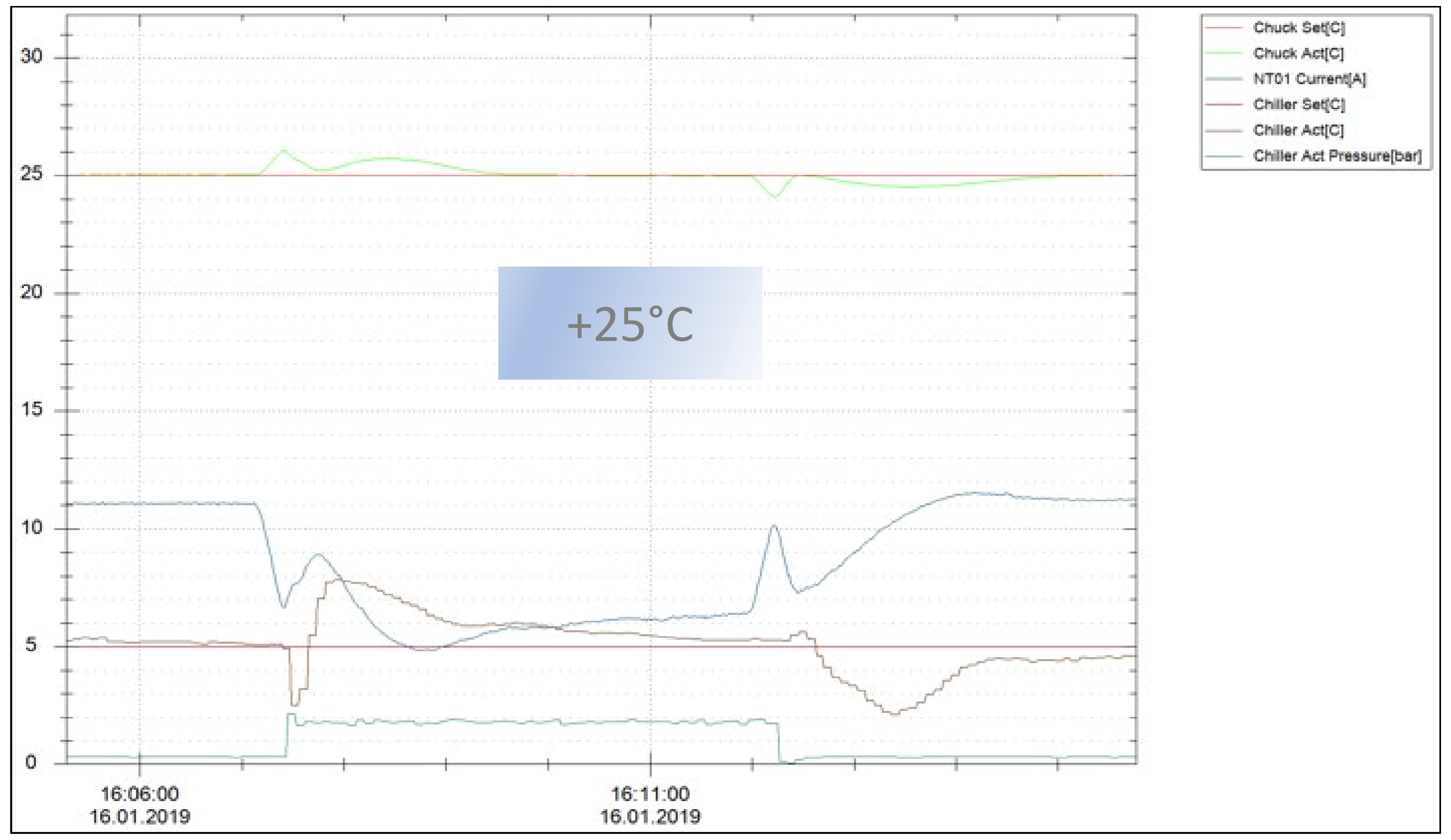
Contact Area: Small
Parallelism: Low

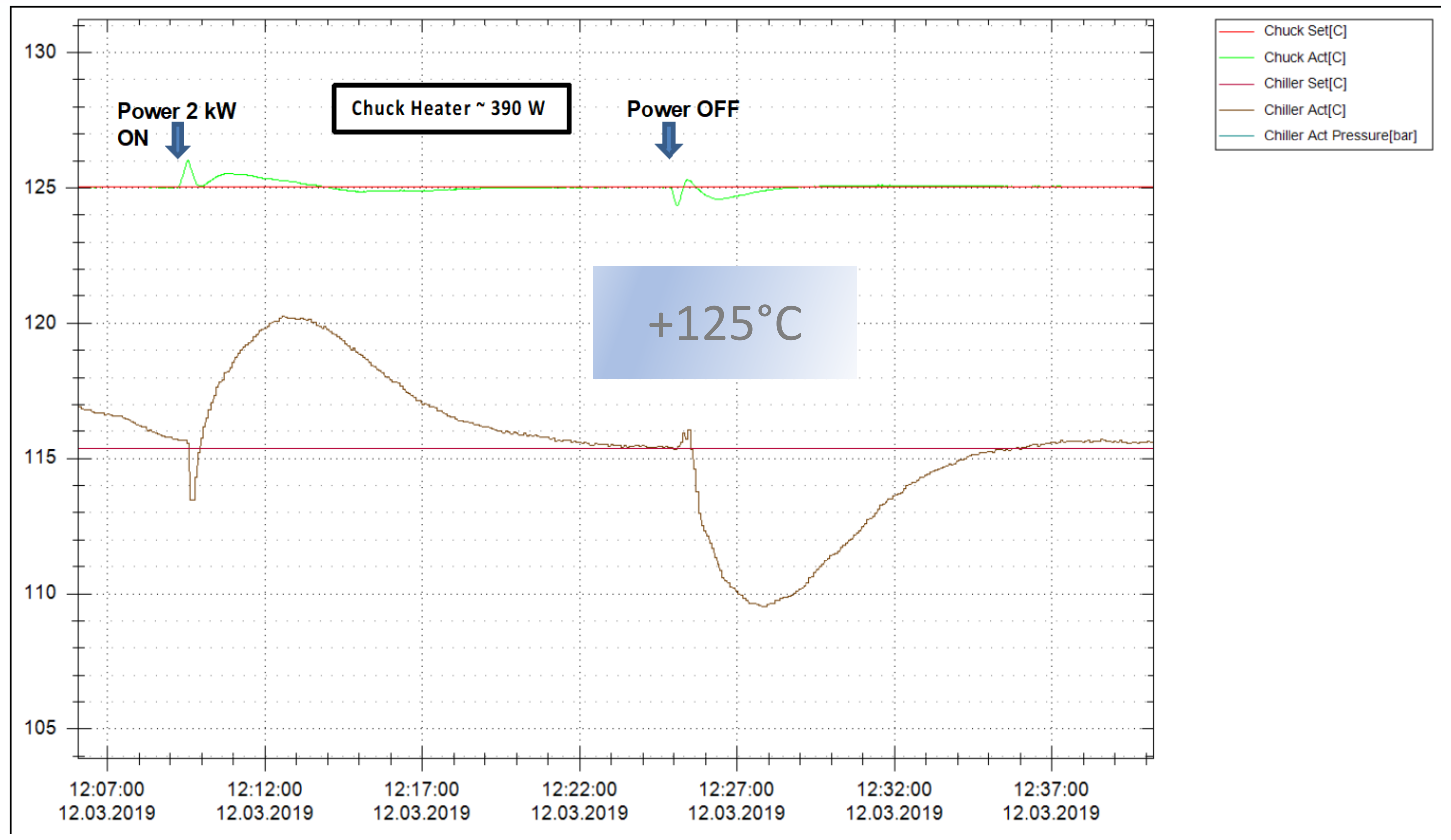
Power/Die: High
Power Density: High (125W/cm²)

Heat transfer: up to 500W
Temp. Range: -40°C to +125°C

Customer Study – Full Wafer Contact – 2000W





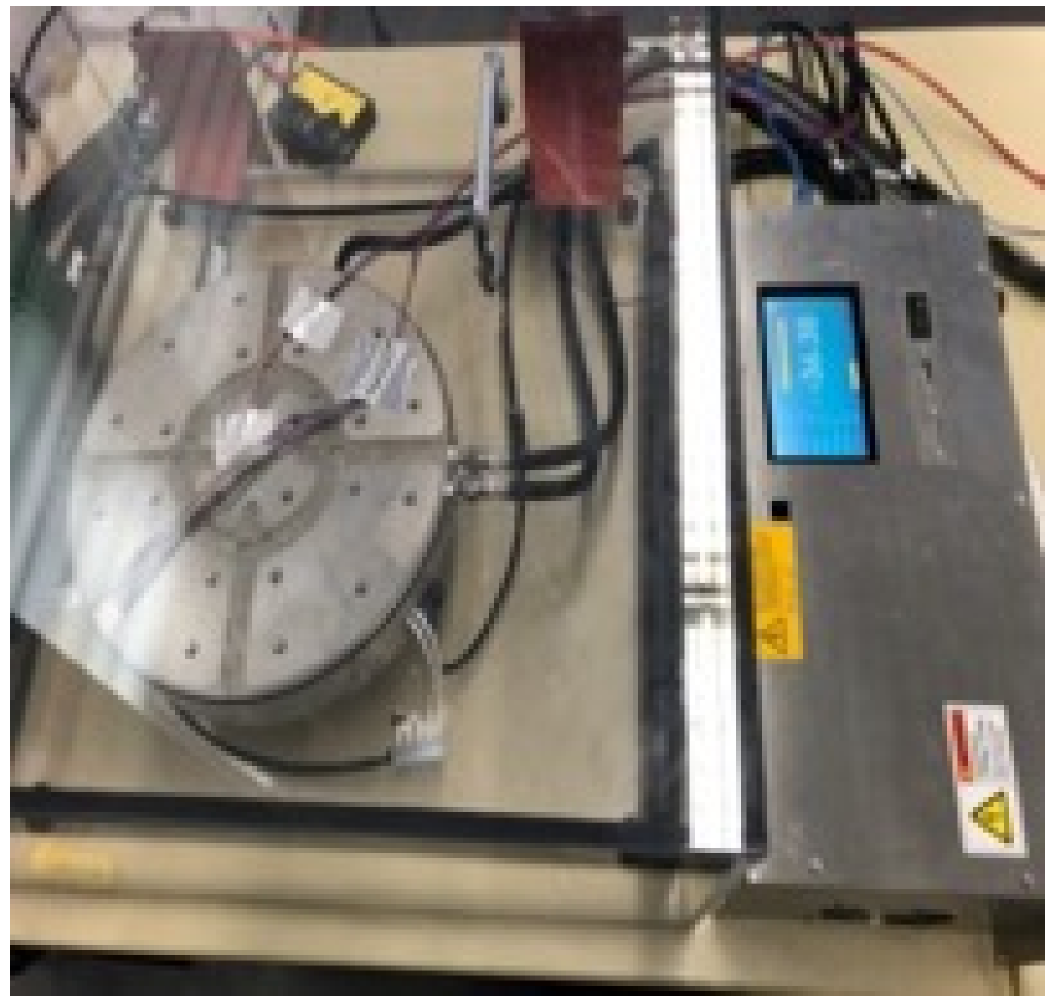


Full Wafer Contact – High Bandwidth Memory Testing

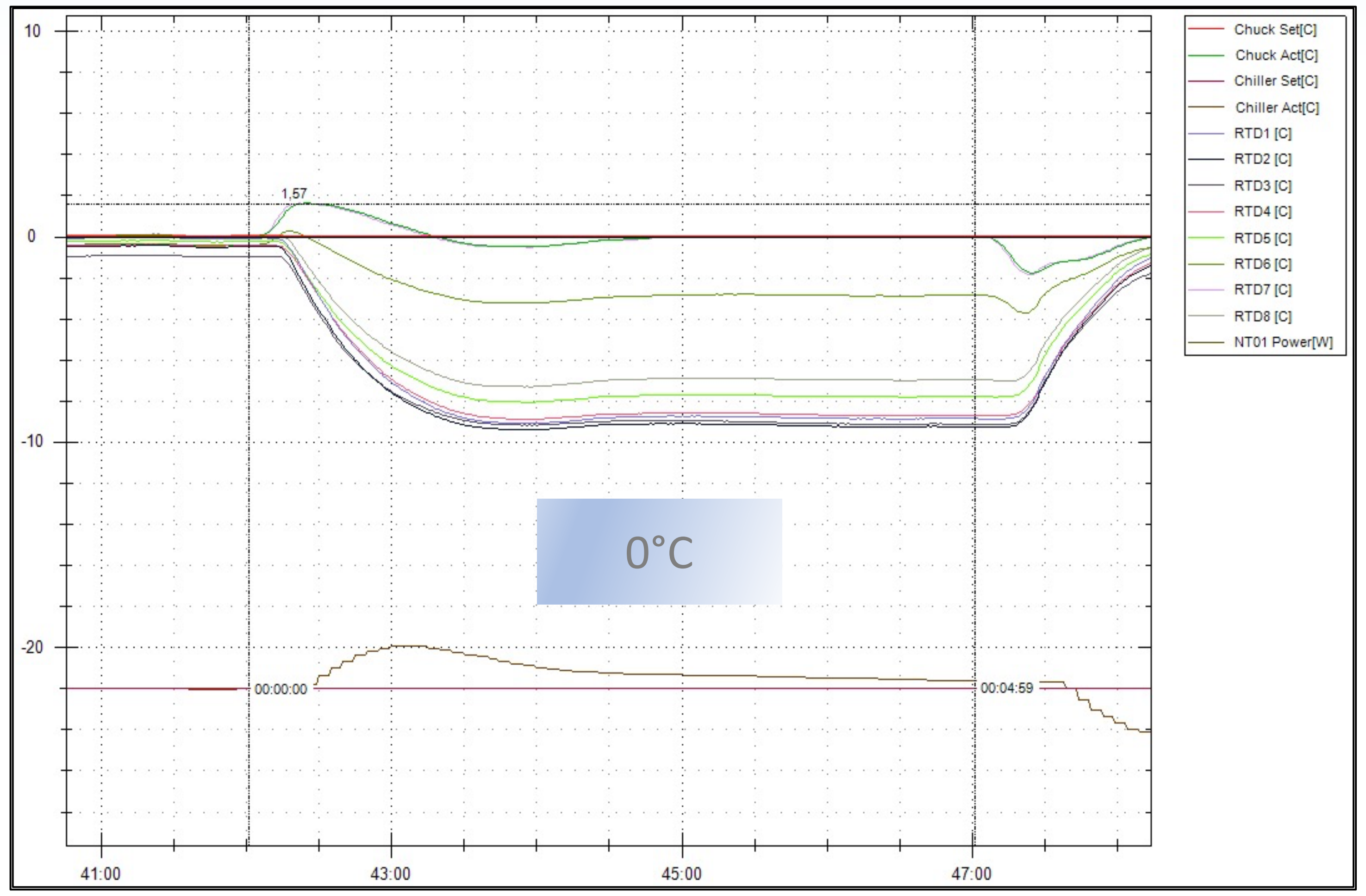
Applied power of 2000 Watts, uniformly distributed across the chuck

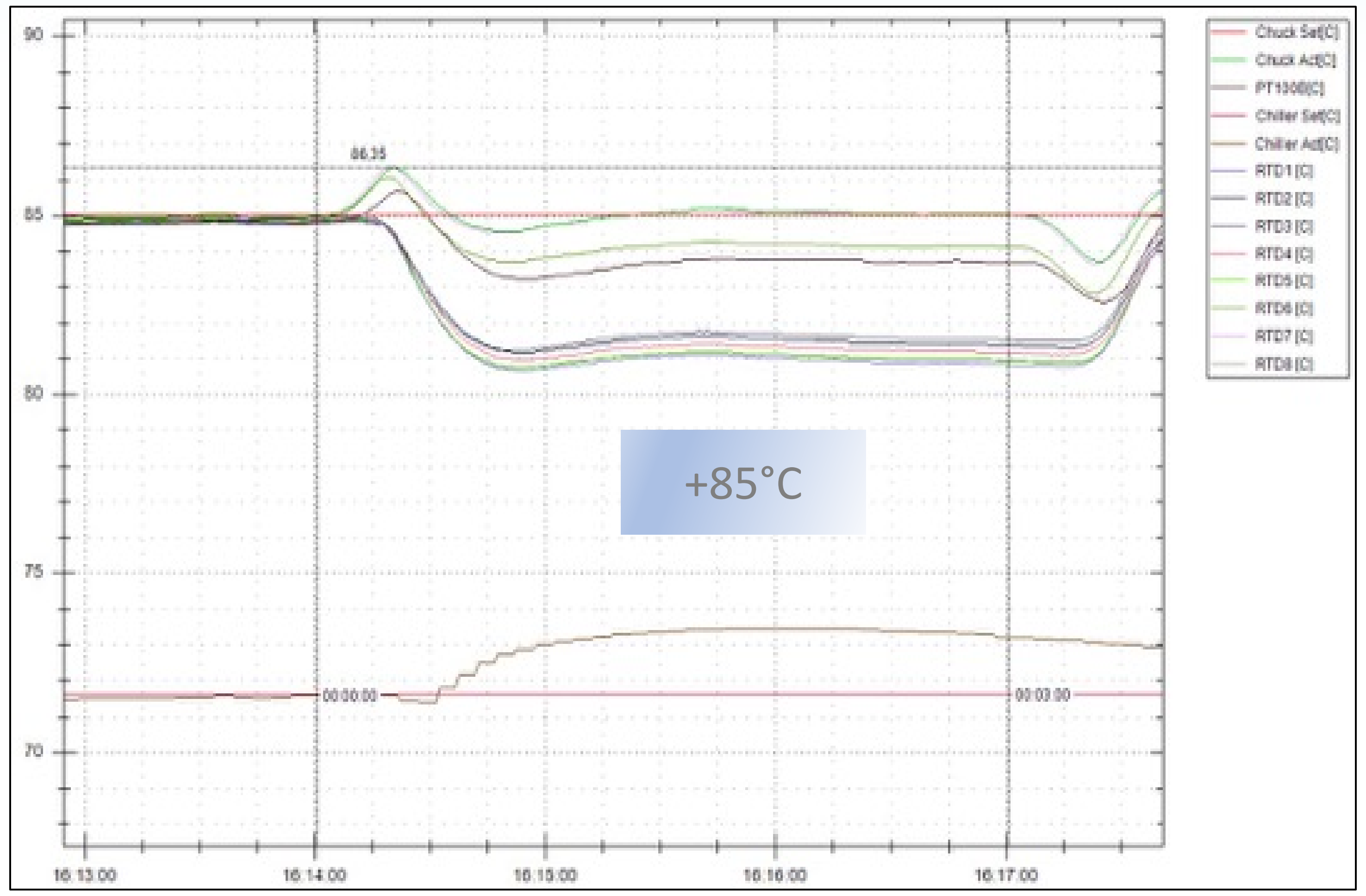
Liquid Chiller, -40°C, +25°C and +125°C

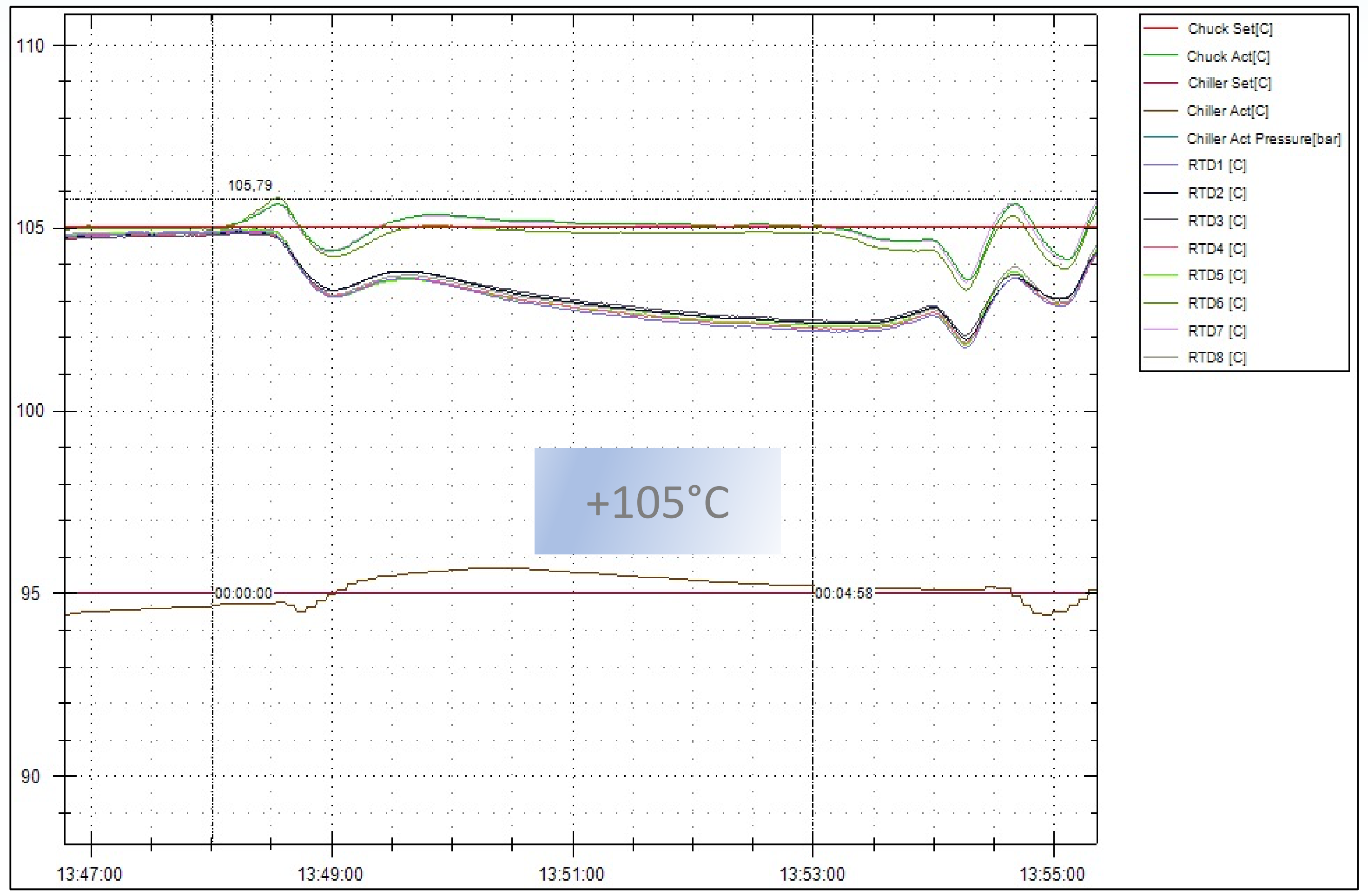
Chuck system is able to dissipate 2000W at all three temperatures



Customer Study – 100x100mm – 400W







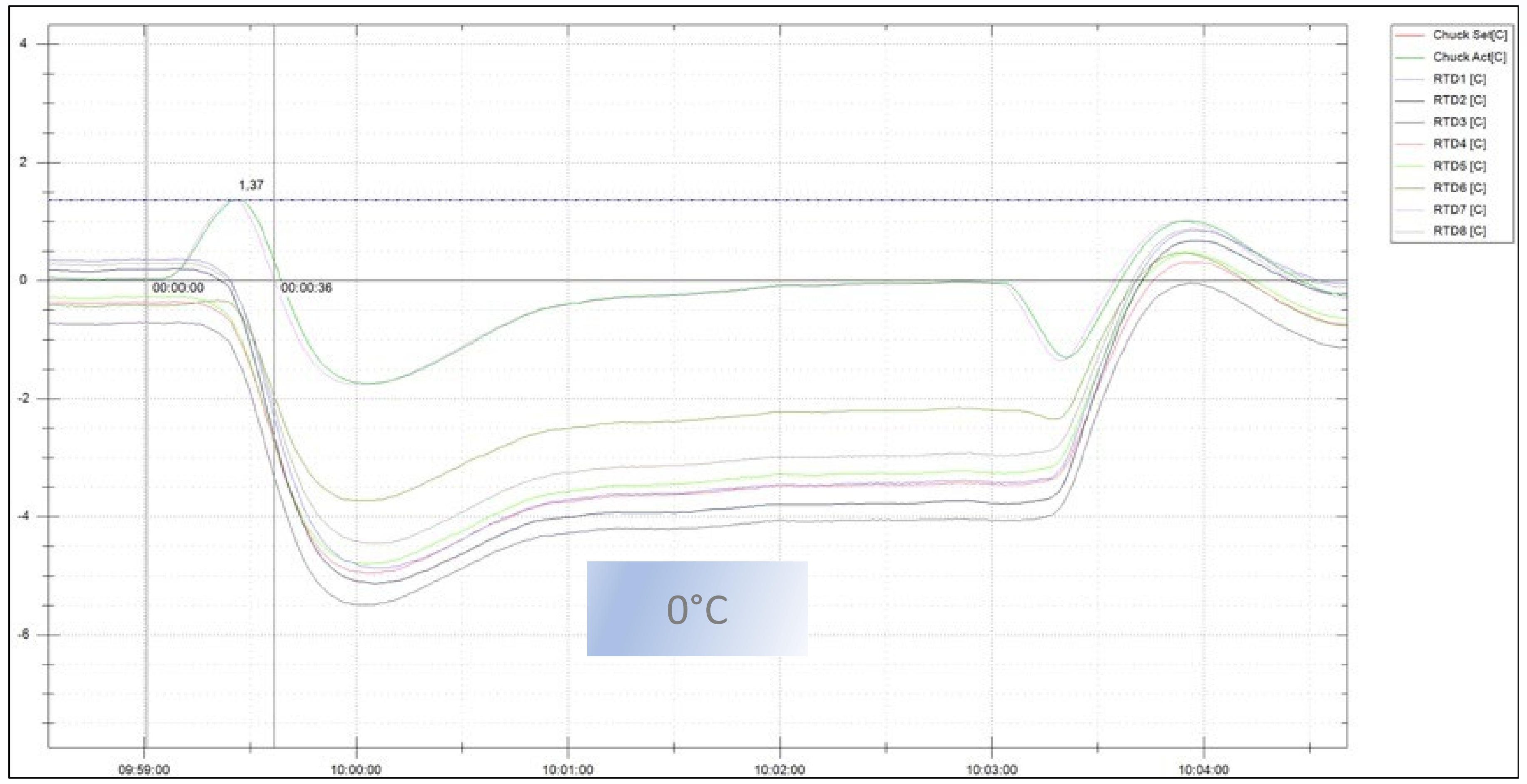
100x100mm contact area – Automotive microcontroller

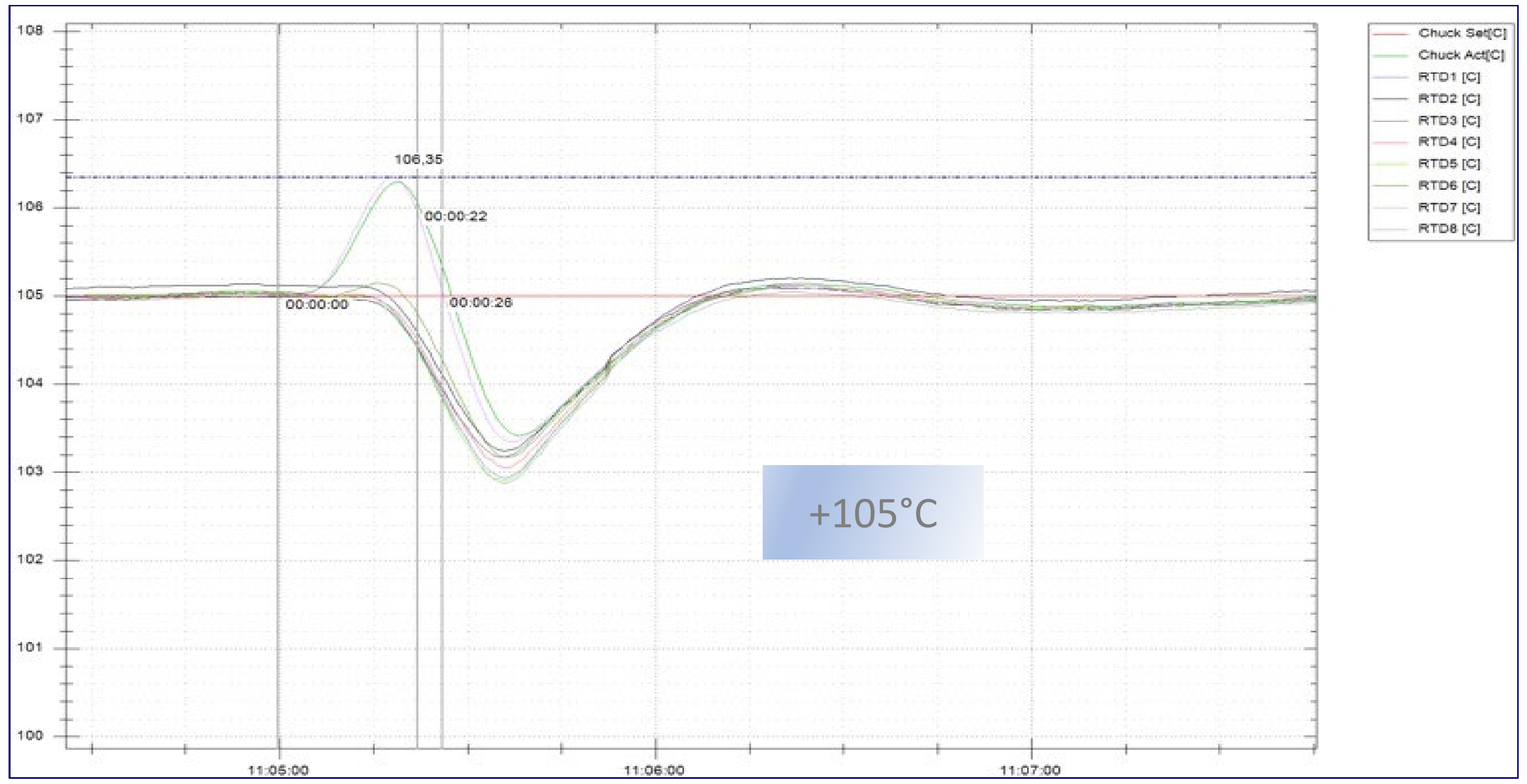
Applied power of 400 Watts

Liquid Chiller, 0°C, +85°C and +105°C

Chuck system is able to dissipate 400W within a +/- 2°C temperature range

Customer Study – 21x20mm – 160W





21x20mm contact area – 5G Device

Applied power of 160 Watts

Liquid Chiller, 0°C and +105°C

Chuck system is able to dissipate 400W within a +/- 2°C temperature range

Summary

High Power Dissipation requires Liquid Cooled Systems

Full Wafer Contact up to 2KW – doable

100x100mm up to 400W – doable (higher power possible with stronger chillers)

21x20mm up to 160W – doable (higher power possible with stronger chillers)

-40°C to +125°C covered with single fluid - Wider temp range requires new fluids (high BP and low viscosity) or

Dedicated test cells for certain temperature ranges (e.g. -60°C to +25°C; +25°C to +150°C)

Wafer test requirements are changing dynamically – Power densities, Parallelism, IC complexity

ATT is working on new chuck concepts addressing future requirements – Please contact us for more details

THANK YOU