



Too Hot To Test

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Creative Cooling Techniques for Package-Level Testing

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Development

Agenda

Thermal Management Challenges

Power Dissipation Roadmap

High Power Devices – Test Temp Management

MEMS/Sensors/Memory Device – Test Temp Control

Summary

Managing Power Dissipation – One Vector That Drives the Semiconductor Industry



HPC

- ▶ Artificial Intelligence
- ▶ Networking
- ▶ GPU/CPU

Large packages

56+ Cores

High power dissipation >100W



Mobility

- ▶ Smartphone
- ▶ Tablet

Memory

- ▶ PoP Stacking, UFS, HBM

Small packages/very large volumes

Low power dissipation <20W



IoT

- ▶ Wearables/Hearables
- ▶ Consumer
- ▶ Industrial



Automotive

- ▶ ADAS
- ▶ Infotainment
- ▶ Body Electronics

Power

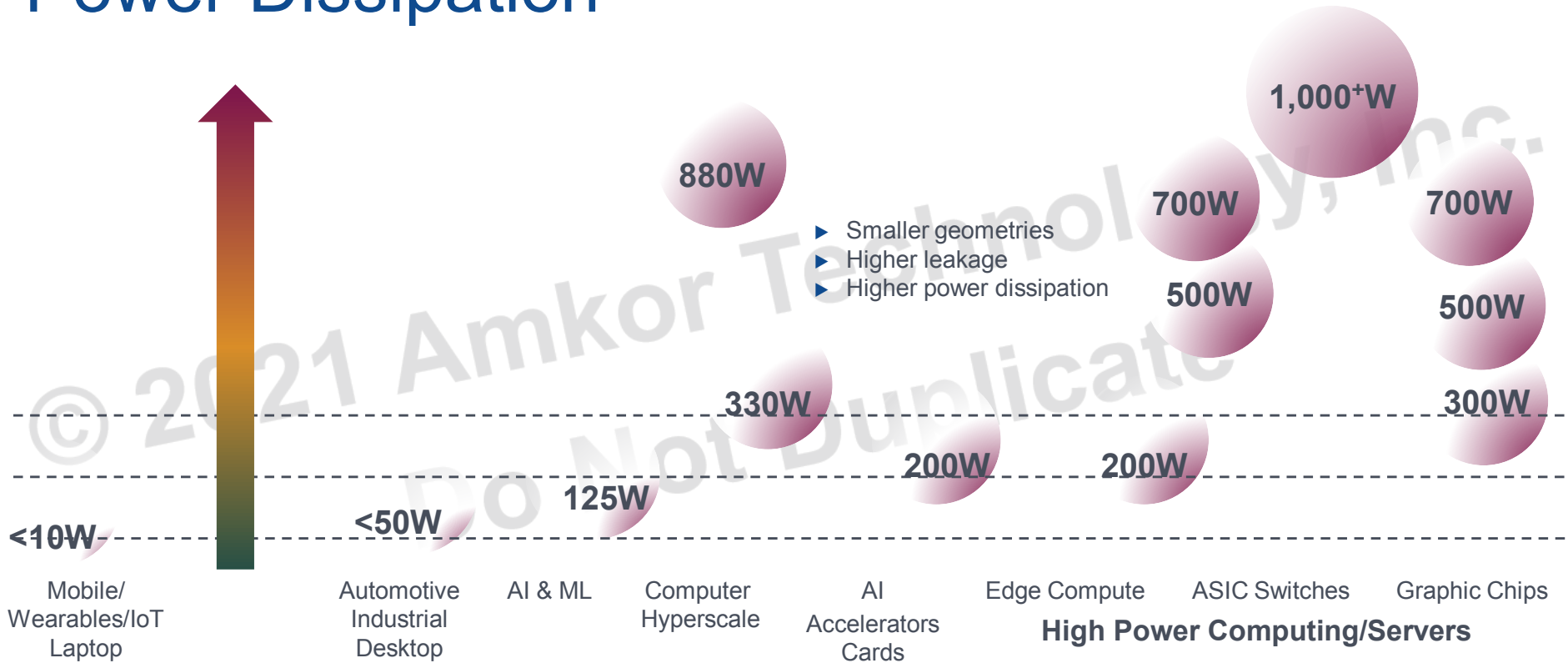
- ▶ Transmission, Industrial

Multitude of package sizes

Large volumes/stringent environmental

Medium power dissipation <50W

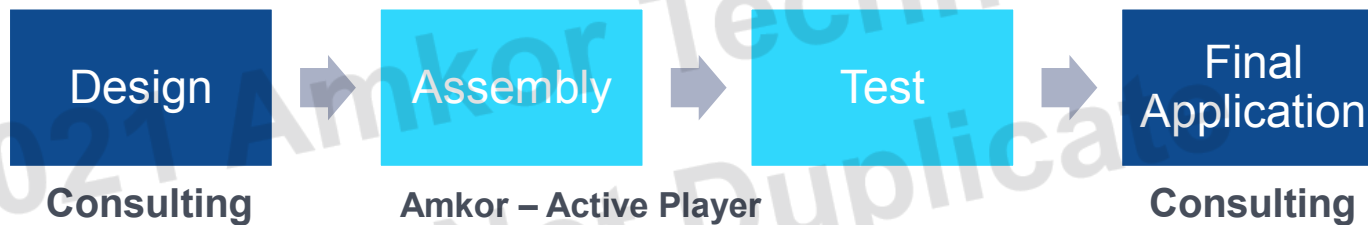
Power Dissipation



High power application packages are driving the need for creative thermal management solutions

Managing Power Dissipation – Stages

As a leading OSAT, Amkor provides complete turnkey solutions including assembly and test to support major market segments



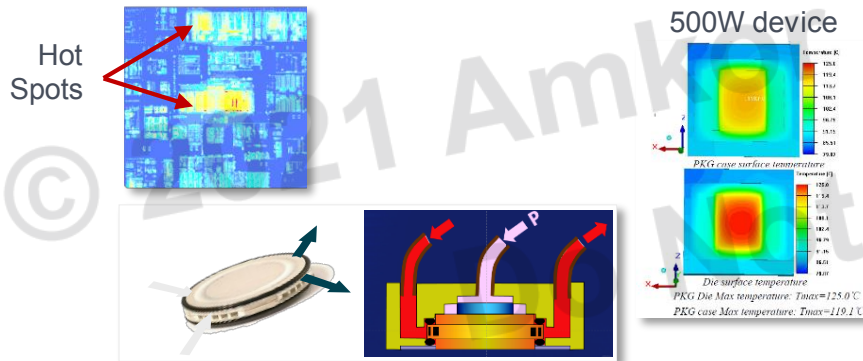
- ▶ Stringent package requirements
 - ▷ Heterogeneous integrations
- ▶ Most advanced testing technologies
 - ▷ Wafer sort
 - ▷ Final test
 - ▷ Burn-in
 - ▷ System level test

Thermal Management – Challenges

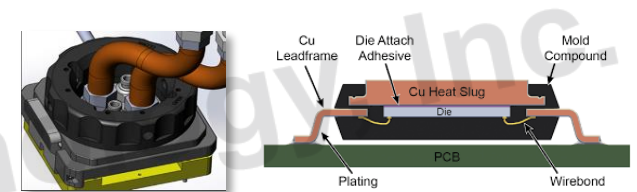
- ▶ High power devices – over ~150W power dissipation
 - ▷ Temperature control during test -55°C to 150°C
 - » Wafer sort
 - » Final test
 - » System level test
- ▶ MEMS/Sensors/Memory devices – multi sites
 - ▷ Site to site uniform temperature control
 - ▷ Rapid temperature cycles
 - » Final test
- ▶ Eliminate liquid nitrogen/reduce cost/minimize chiller footprint

High-Power Devices – Temperature Control

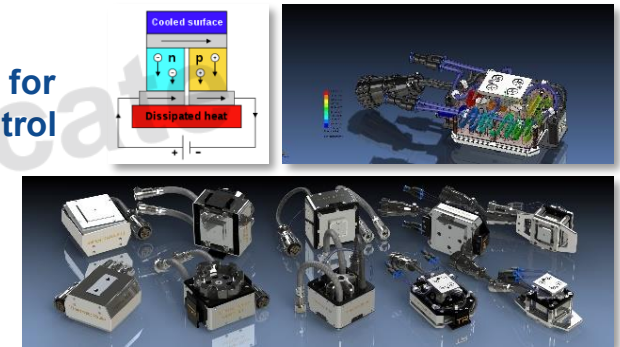
- ▶ Thermal management
 - ▷ Static power – continuous due to leakage
 - ▷ Dynamic power – during switching



Thermode compliant thermal contact – Courtesy Centipede



Advanced solution for active thermal control



Peltier thermal heads – Courtesy Thermal Rule

Amkor provides most advance thermal interface materials to optimize the thermal conductivity during production test

Active Thermal Control Solutions



Full Test –
Active Thermal Control
Tri-temp Handler
Hon Tech

100 W
25°-125°C ±3°C
-55°C Refrigerant

300 W
25°-125°C ±3°C
-55° to 175°C Refrigerant

450 W
25°-125°C ±5°C
-55°C Refrigerant



1,000 W
25°-125°C ±5 °C
-55° to 175°C Refrigerant

2,000 W – F2021
25°-150°C ±5°C
-55°C Refrigerant



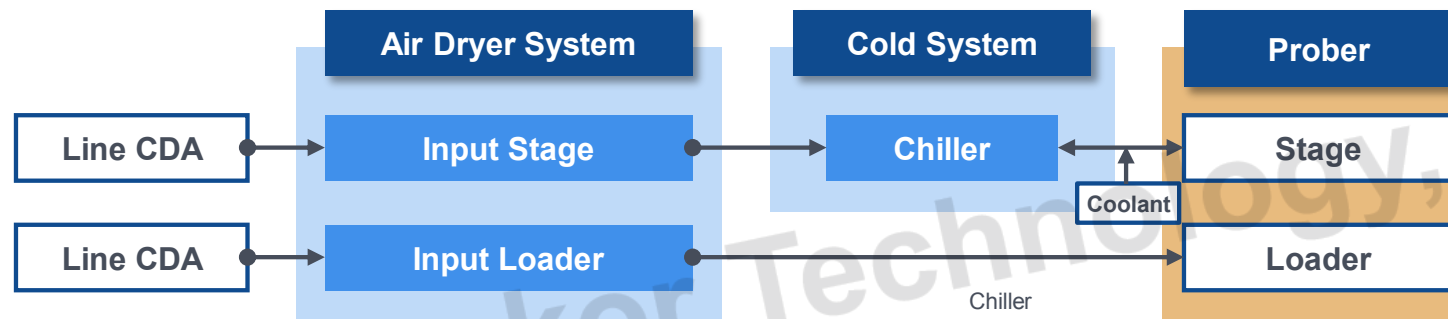
SLT –
Active Thermal Control
Tri-temp Handler
Hon Tech

2,500 W – F2023
25°-150°C ±5°C
Refrigerant



Heterogeneous packages require customized solution

Environmental Wafer Probe – Cold



Reference Temperature	Current Temperature
-45.0	-44.9
Current Dew Point	Chiller temperature
-49.6	-57.6

Dew point



Chiller



Air dryer system



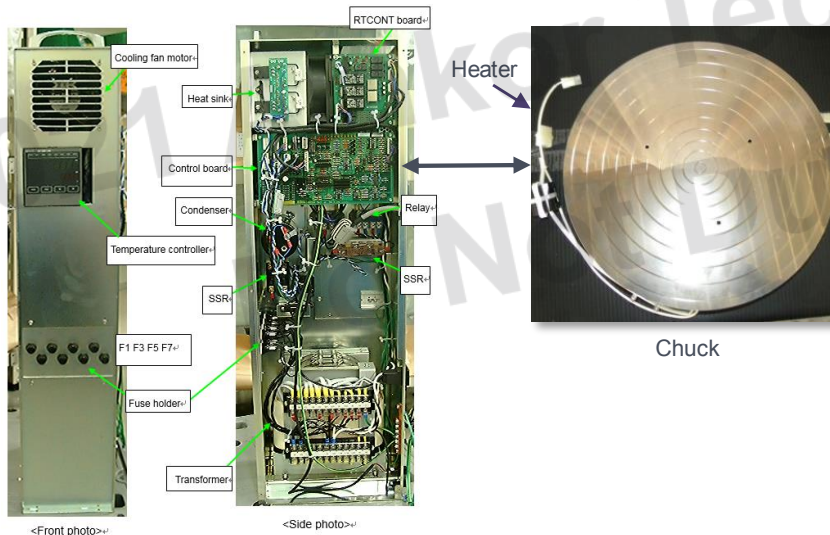
Prober

- ▶ Lowest temperature -55°C
- ▶ IDDQ testing at low temperature
 - ▷ Minimize burn-in
- ▶ Automotive environmental test

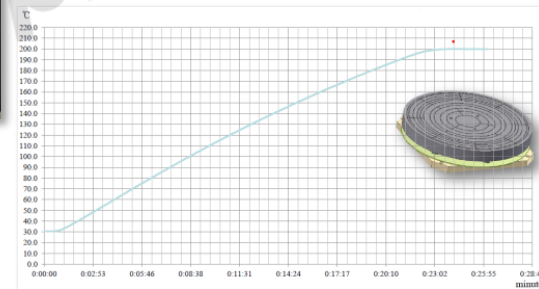
Environmental Wafer Probe – Hot



- ▶ Highest temperature 200°C
- ▶ Automotive environmental test
- ▶ -50°C to **200°C**



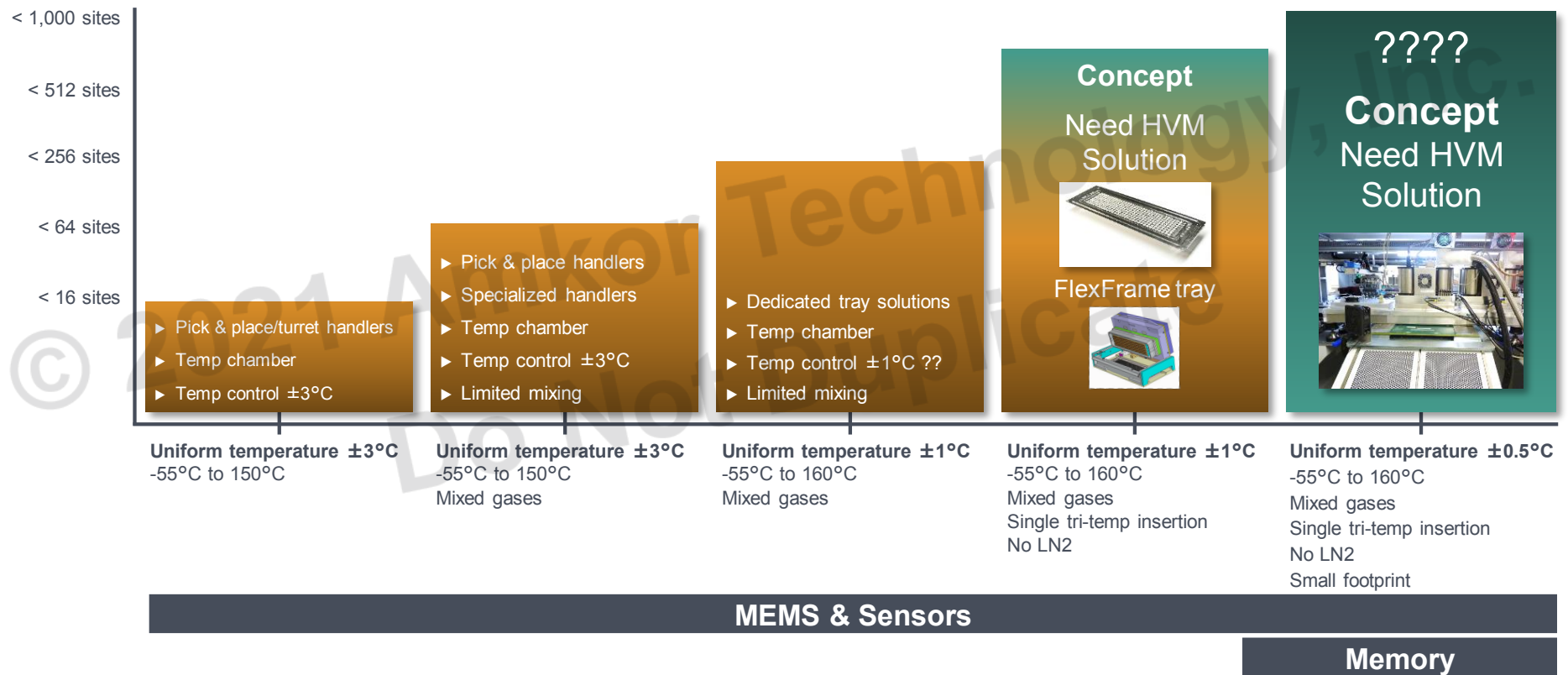
<Front photo>
<Side photo>
UF3000EX Hot chuck controller



Sensors/Memory – Test Temperature Control

- ▶ Controlling uniform temperature $\pm 1^{\circ}\text{C}$
 - ▷ Over a very large number of parts tested in parallel
 - » Over 500 parts in parallel
 - ▷ Large temperature range – possible in one insertion
 - » 55°C to $+160^{\circ}\text{C}$
 - ▷ Besides temperature, for sensors there are other stimulus, such as pressure and various gases

Sensors/Memory – Requirements



MEMS & Sensors

Memory

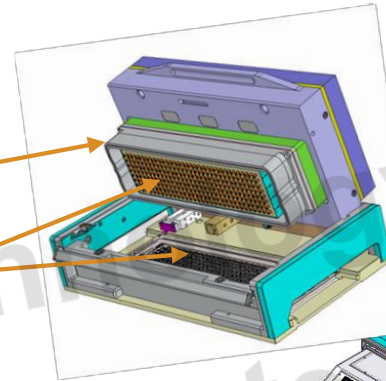
MEMS/Sensors – Test Environment Concept



256-512 MEMS sensor
FlexFrame tray

Test station components

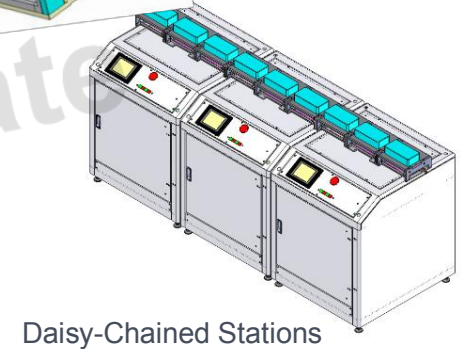
- ▶ Mini chamber
- ▶ Pusher with integrated gas manifold
- ▶ FlexFrame tray carrier



- ▶ Mini-chamber to enclose DUTs
- ▶ Opening for tray of DUTs
- ▶ Socket array

Compact environmentally controlled zone

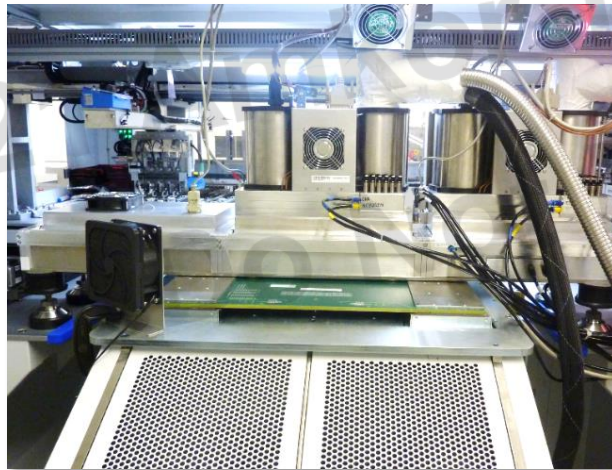
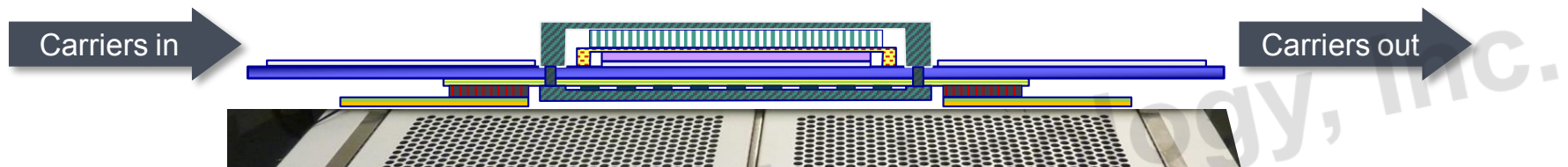
- ▶ Thermal zone limited to volume around the DUTs
- ▶ All temp/gas stimuli in one mini-chamber
- ▶ Fast, accurate temperature control $\pm 1^\circ\text{C}$



Daisy-Chained Stations

Source: Courtesy Centipede Systems

Memory Devices – Test Environment Concept

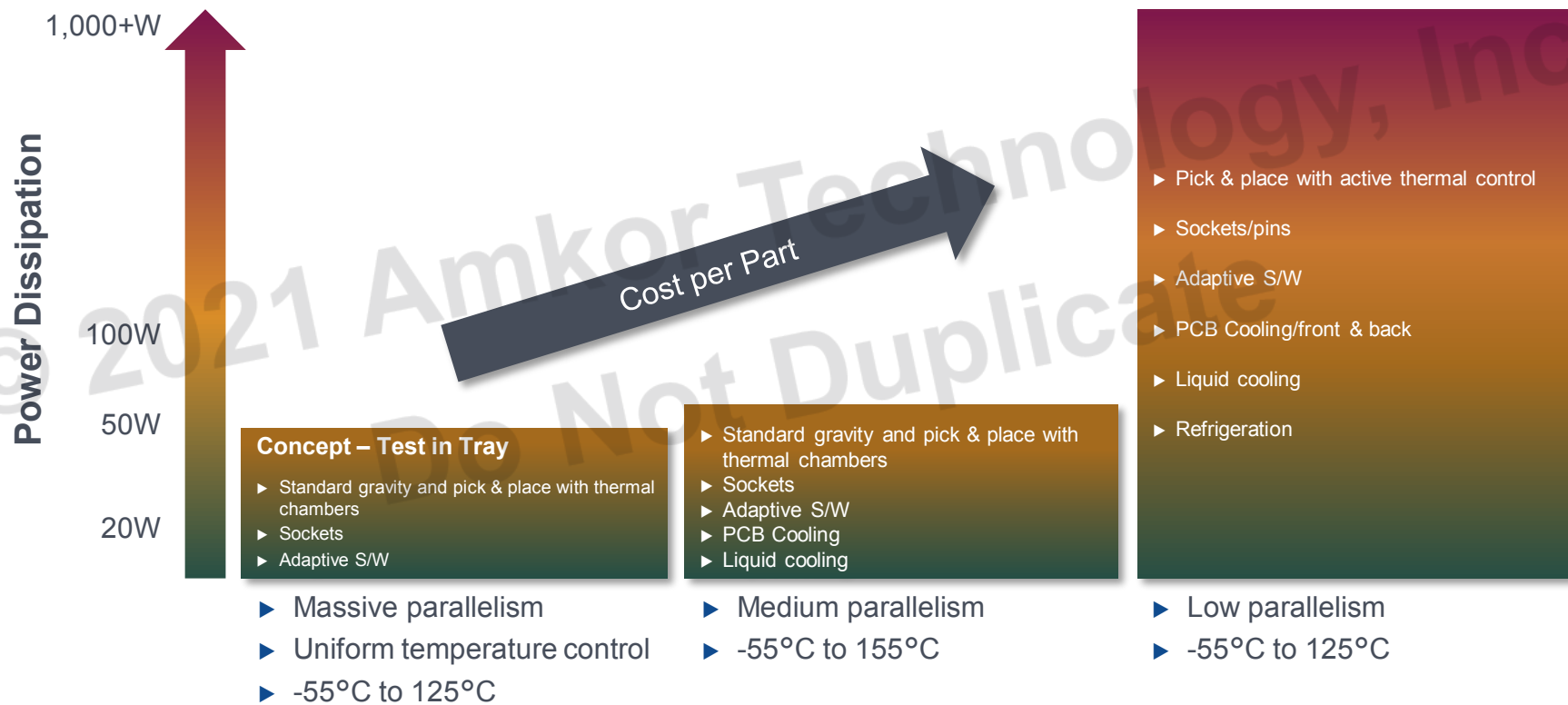


Micro-chamber thermal conditioning
FlexFrame tray carrier automation
Unlimited parallelism

Memory test module
In production, direct docked to
Commercial memory tester

Source: Courtesy Centipede Systems

Toolkit



Summary – Solutions & Concepts

- ▶ High power devices – low volumes, low parallelism high power dissipation
 - ▷ Wafer probe – tri-temp controlled probe chuck
 - ▷ Final test – active temp control solution
 - ▷ System level test – active temp control solution
- ▶ MEMS/Sensors – high volumes, very high parallelism uniform temperature control, mixture of sensors
- ▶ Memory devices – high volumes, very high parallelism, multiple temperatures, uniform temperature control, long test time
- ▶ **Amkor provides a large variety of packages for various products that require a complete portfolio of temp management solutions based on power dissipation and volumes**
- ▶ **Balance between thermal technology and test economics**



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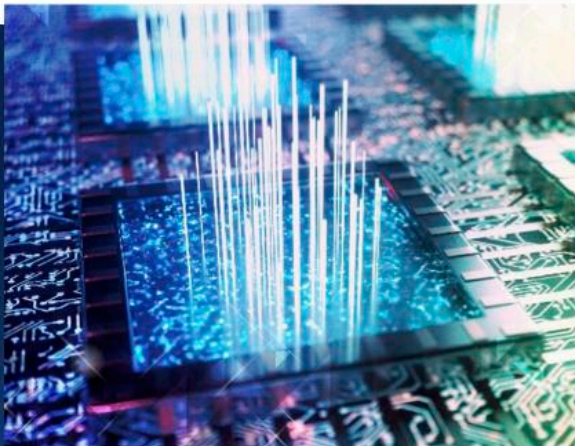
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Engineering Services
Broad Portfolio



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Execution
Automation



Service

Design & Test Through Drop Ship
Manufacturing Footprint
Local Sales & Support



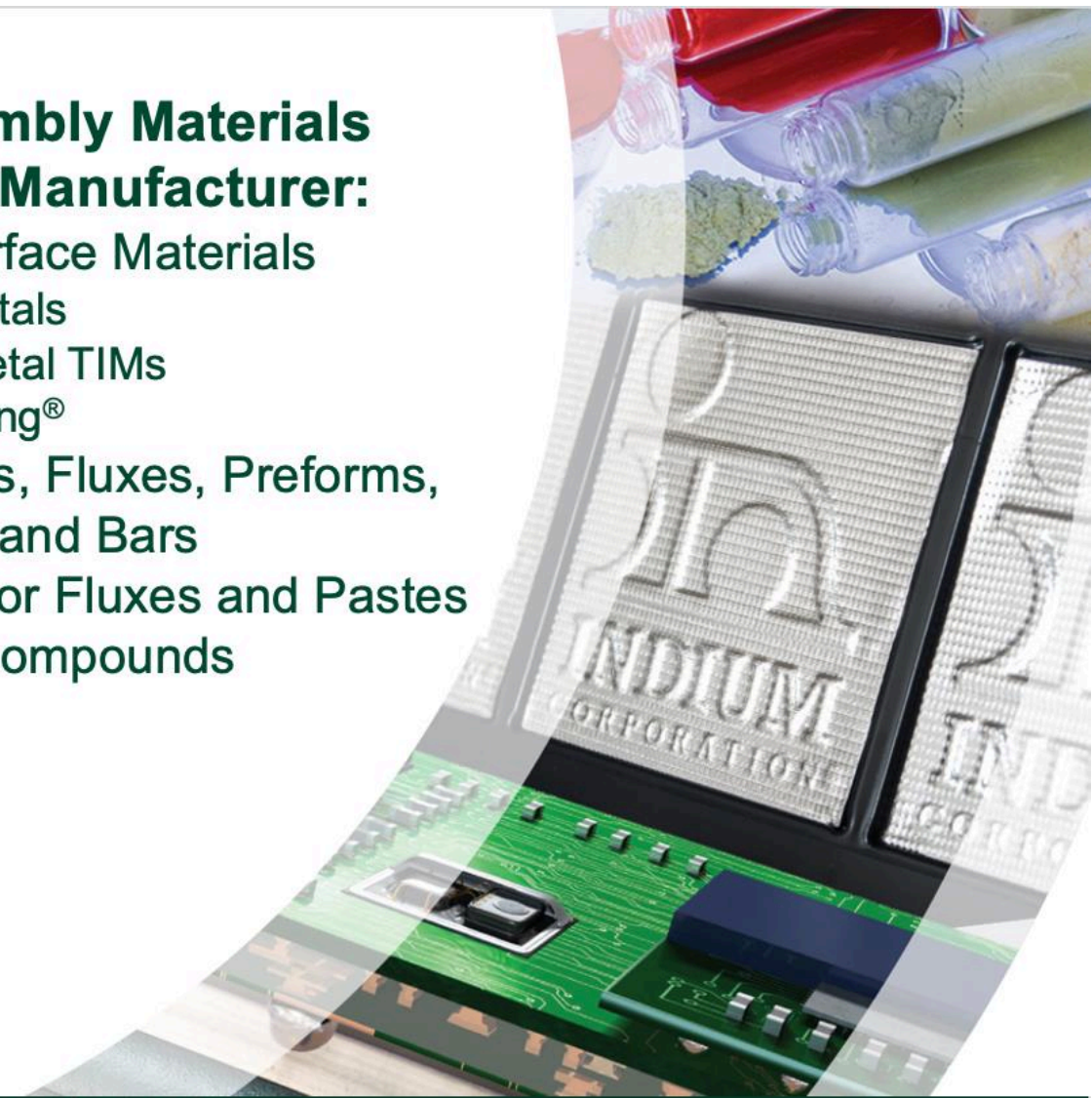
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