Thermotest

Thermal test vehicle solutions by Nanotest





- **» Thermal Test Vehicle (TTV)** is a Thermal Twin of a package (e.g., CPU, GPU or NPU) to investigate thermal characteristics of these packages
- » Simulation of hot spots and power density variation and their impact on the package
- » Investigation of **Thermal Interface Materials** (TIM1, TIM1.5 and TIM2) under real applications
- » Development and investigation of **advance cooling solution** (Air cooling, liquid cooling, injection cooling etc.)
- » **Reliability** investigation of packages
- » Development and optimization of assembly process



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Design the TTV you need. No Compromise

We support our customers to verify their prospective package, TIMs and cooling solutions by offering TTV solution We offer:

- SN-TTV10-V1-23/1

Substrate

manufacturing

- » Thermal test chips wafer
- » Concept and feasibility
- » Interposer and test board
- » Assembly and quality assessment
- » Measurement hardware and software

Chip

configuration

Substrate

design

» Calibration and test





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TTV | Thermal Test Vehicle

Thermal test

chip wafer

Wafer

Thermal Test Chip Wafers by Nanotest



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Available Thermal Test Chip (as 8" wafer)



- » 2 heaters, one RDT and 4 monitoring bumps
- » 8" wafer / > 4000 cells per wafer
- » Power Density: 10 W/mm²
- » Wafer thickness: 500 µm undoped silicon
- » Flip-chip assembly
- » 300µm SAC bumps with 500µm pitch
- » BSM

»

- » Ti-NiV-Au (100nm-300nm-200nm)
- » NiV-Pt-Au (300nm-100nm-200nm)
- » Pure silicon
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- » 3.2 x 3.2 mm² unit cells
- » 10 heaters and one RDT
- » 8" wafer / > 2400 cells per wafer
- » Power Density: 10 W/mm²
- » Wafer thickness: 725 µm undoped silicon
- » Flip-chip assembly
- » 80 µm Cu-pillars with 300µm pitch
- » without BSM

» 3.2 x 3.2 mm² unit cells

- » 10 heaters and one RDT
- » 8" wafer / > 2400 cells per wafer
- » Power Density: 10 W/mm²
- » Wafer thickness: 400 µm undoped silicon
- » Wire-bond assembly
- » 150µm Aluminum pads
- » BSM: Ti-NiV-Au (100nm-300nm-200nm)



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* Available from August 2024

Custom TTV Design and Manufacturing

Substrate, heat spreader, test board



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TTV Types



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TTV System





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Available TTVs and tools



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In Shelf Thermal Test and Vehicles (small – large – larger)

0101010

TTV5

- » Based on the NT16-3k-FC
- » Chip size: 9.8 × 9.8 mm²
- » Substrate Size: 25 × 20 mm²
- » Blank silicon surface
- » 5 Temperature sensors (RTDs)
- » Uniform resistor heater
- » Total power: 140W



TTV10

- » Based on the NT20-3k-FC
- » Chip size: 24.9 × 24.9 mm²
- » Substrate size: 60 × 60 mm²
- » Chip BSM: NiV-Pt-Au
- » 16 Temperature sensors (RTDs)
- » 4 Independent heater zones
- » Total package power: 2000 W

TTV16 (coming soon)



- » Based on the NT20-3k-FC
- » Chip size: 39.9 × 39.9
- » Available as single die or 4-dies chiplet
- » Substrate Size: 78 × 57 mm²
- » Chip BSM: Ti-NiV-Au
- » 56 Temperature sensors (RTDs)
- » 24 Independent heater zones
- » Total package power: 4000 W



TTV10-NT20

General purpose compact TTV

- » Based on the NT20-3k-FC
- » Chip dimension: 10 × 10 matrix | 24.9 × 24.9 × 0.5 mm³
- » Substrate dimension: 60 × 60 × 1.56 mm³
- » Package dimension: 60 × 60 × 2.24 mm³
- » Assembly technology: Flip chip and underfill
- » Chip BSM: NiV 300 nm | Pt 100 nm | Au 200 nm
- » 16 Temperature sensors (3.3 k Ω with 10.0 Ω /K sensitivity)
- » 4 Independent heater zones (7 Ω each, 3.2 W/mm²)
- » Total package power: 2000 W







NT16-TTV5

» General purpose compact TTV



- » Based on the NT16-3k-FC
- » 3 × 3 matrix
- » FR4 substrate, flip-chipped, underfilled
- » Blank silicon surface
- » 25 × 20 × 2.38 mm³ package
- » Uniform resistor heater (15.5 Ω / 140 W max.)
- » 5 RTDs (3.3 kΩ / 9 Ω/K)



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Adhesive testing with TTV5

TIM1 characterization in TIMA[®] 5

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Control and measurement system for in Shelf TTVs

Control unit for TTV5

Control unit for TTV10

Control unit for TTV16



- » Hardware-software combination
- » Designed for NT16-TTV5
- » Features:
 - » Heater control (automatic / manual)
 - » Temperature monitoring
 - » Data Logging



- » Controlling of power suppliers
- » Measurement and visualisation of RTDs
- Scheduling for active power and temperature cycles
- » 19" case (stand-alone and integrable)
- » 4 Programmable PSU
- » DAQ with 8 Analog channels





Measurement and Control Unit for TTV10 (Hard- and Software)



Control and measurement Software

- » Controlling of power suppliers
- » Measurement and visualisation of RTDs
- » Configuration and measurement of MUX
- » Scheduling for active power and temperature cycles

Control and measurement Hardware

- » 19" case (stand-alone and integrable in a rack)
- » 4 Programmable PSU (expandable up to 6 PSU)
- » DAQ with 8 Analog channels for measurement of 56 RTDs
- » Integrated industrial computer (Win 11)

TTV10 assembly on ETB with

- » Constant current source for sense current
- » Multiplexer (NUX)



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Measurement and Controlling Hard- and Software for TTV5



- » TTV Stand-Alone Controller v3
- » Hardware-software combination
- » Designed for NT16-TTV5
- » Features:
 - > Heater control (automatic / manual)
 - > Temperature monitoring
 - > Logging
- » Built for NT16-TTV5
 - > Foundation for customization
 - > Adaptable to any small-scale TTV









Assembly

TTV, heat spreader, test board



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Process Flow I – Packaging and assembly capability



After chip placement

After soldering



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IZM

Process Flow II – Packaging and assembly capability





IZM

Calibration and test



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Temperature calibration

- » Memmert universal oven UFE 500 (with forced air circulation)
- » Resistance vs. temperature characteristics acquisition
 - > 100 1000 µA probe current
 - > 4-wire termination
 - > I/V measurement for resistance determination
- » Optional: TTV-specific multiplexers for process acceleration









Thermal Steady State Testing







- » Steady State Testing is simple way for:
 - » Determination of maximal power P=f(T)
 - » Investigation of cooling performance
 - » Investigation of TIM performance
 - » Determination of thermal resistance



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Thermal Transient Testing



Thermal Resistance Rth(x,y) for TIM 1



» Thermal transient Testing for deeper analysis

- » Junction to case thermal resistance
- » Junction to ambient thermal resistance
- » Structure function
- » Measurement of local thermal resistance Rth(x,y)





- » We support our customers to verify their prospective package, TIMs and cooling solutions by offering TTV solution
- » Three types of thermal test chip are available (bump, Cu-Pillar and wire-bond)
- » Our comprehensive TTV solution includes everything from die and substrate design to assembly, quality assessment, measurement hardware and software, calibration, and testing.
- » We provide a range of TTV options readily available, including measurement equipment, ensuring a seamless verification process for our customers.





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With more than a decade of hands-on experience, we've perfected the development, realization, and testing of thermal test vehicles.