



Applied Vantage Vulcan™ RTP

Optimizing Spike Anneals for 32nm and Beyond

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Sr. MTS

Front End Products

Silicon Systems Group

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Smartphones



Tablets



Mobile PCs

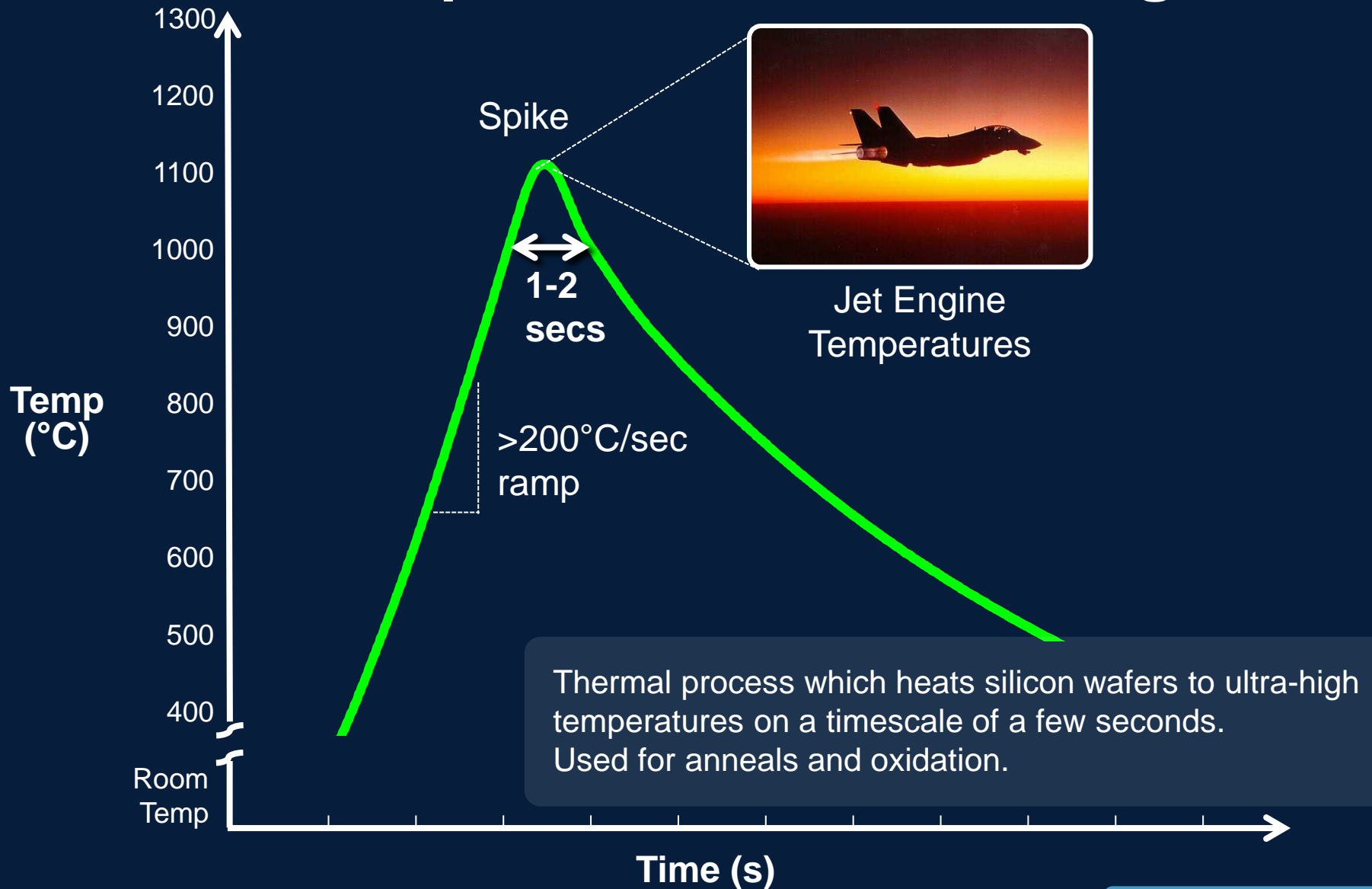


Servers

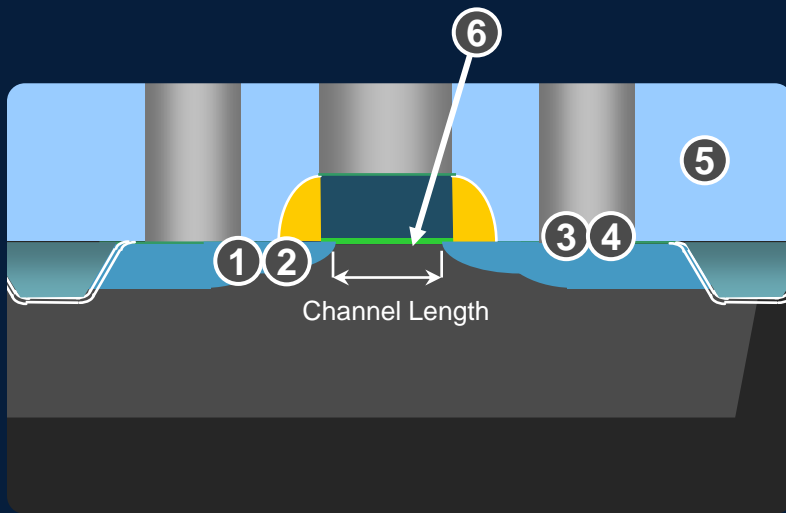


Mobility and Connectivity Driving Growth in Lower Power, High Performance Chips

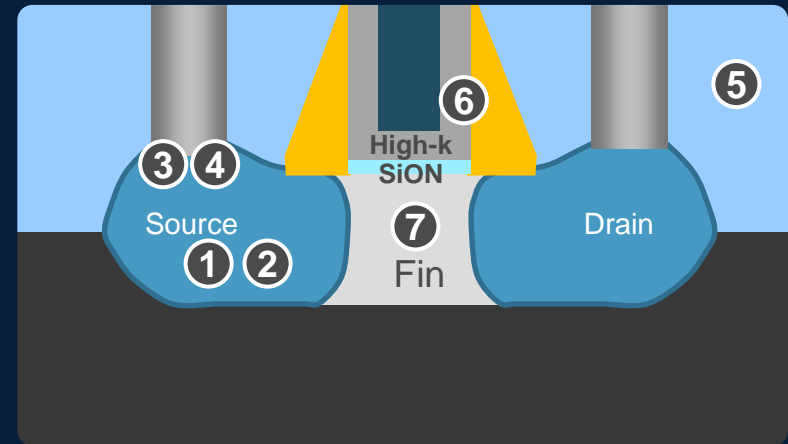
What is Rapid Thermal Processing?



Multiple RTP Steps in Advanced Transistors



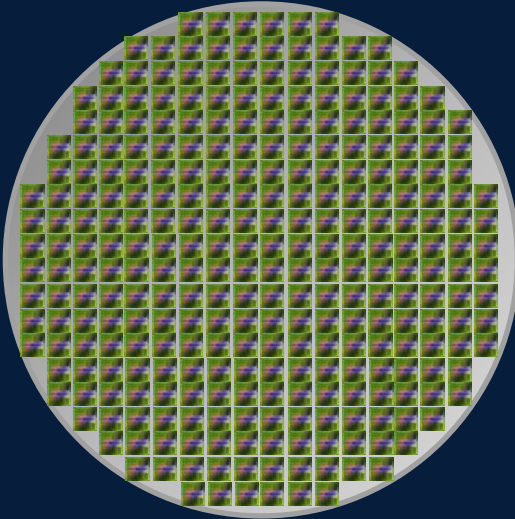
Advanced Planar Transistor



FinFET Transistor

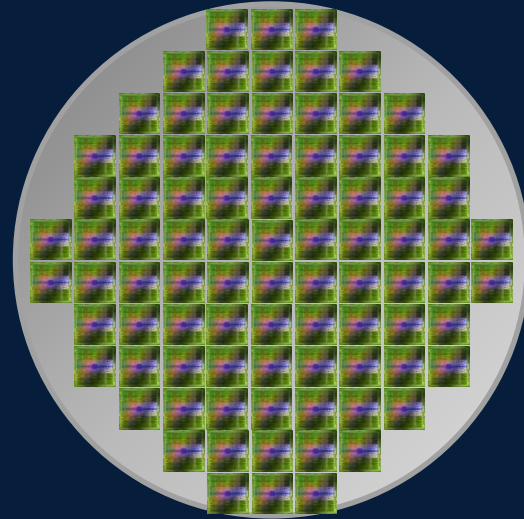
- ① ② Source/Drain Anneals
- ③ ④ Silicide Anneals
- ⑤ Inter-Layer Dielectric Anneal
- ⑥ High-k Densification Anneal
- ⑦ Fin Implant Anneal

Challenge #1: Bigger Die Increase the Within-Die Uniformity Challenge



~150 mm² die

130nm
technology node
graphics chip



~500 mm² die

40nm
technology node
graphics chip

Less Margin For Error

Challenge #2: Temperature Micro-Climates Add Within-Die Variation



Dense City

32°C

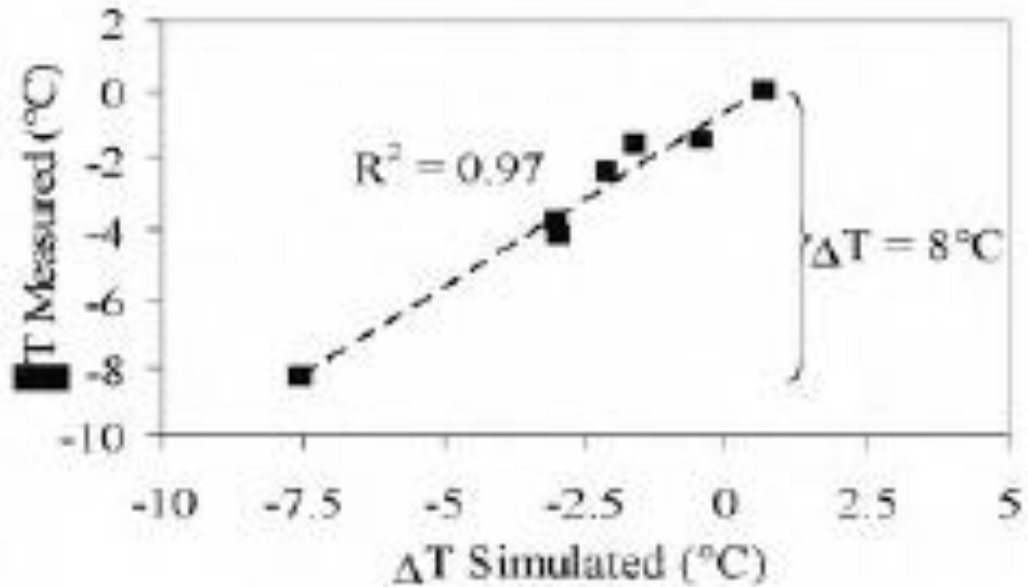
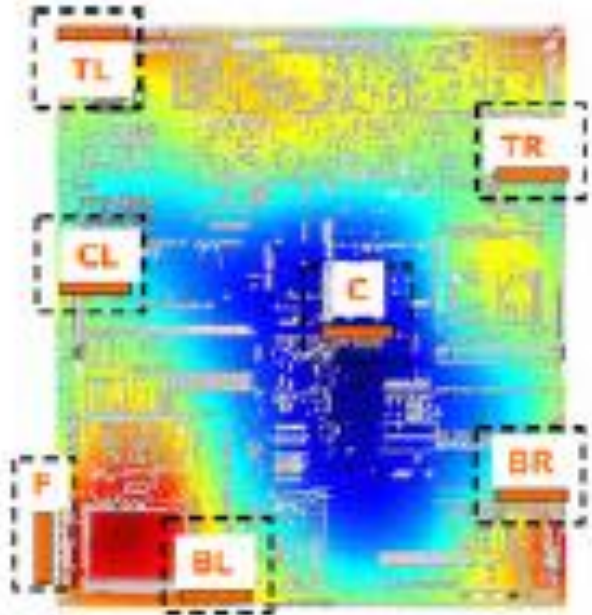


Open Field

25°C

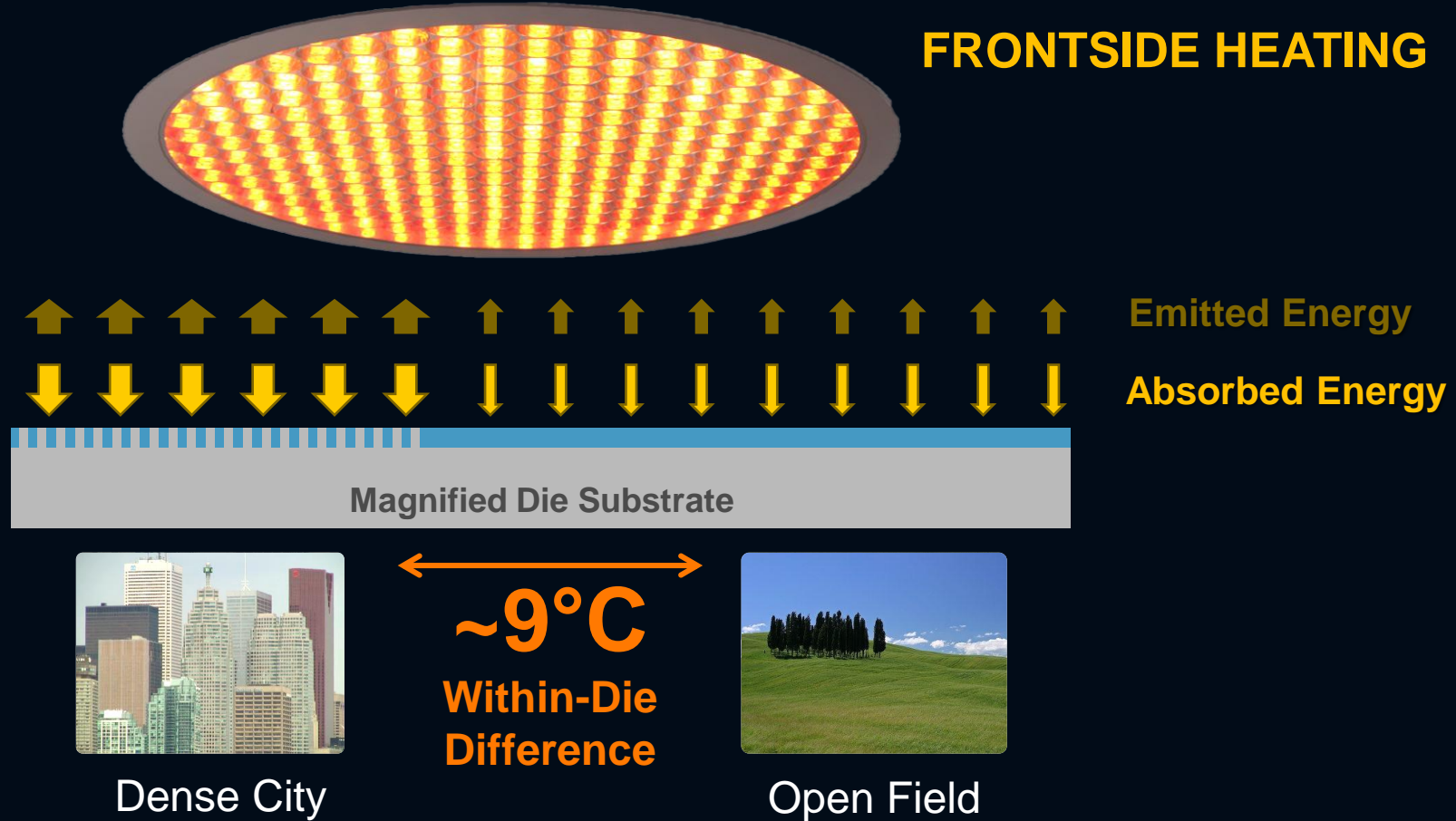
Customers Currently Change Design Rules to Combat This Effect

Production Data



Ring Oscillator test structures confirm temperature distribution based on design density

FRONTSIDE HEATING



Within-Die Spike Anneal Thermal Variability With Frontside Heating

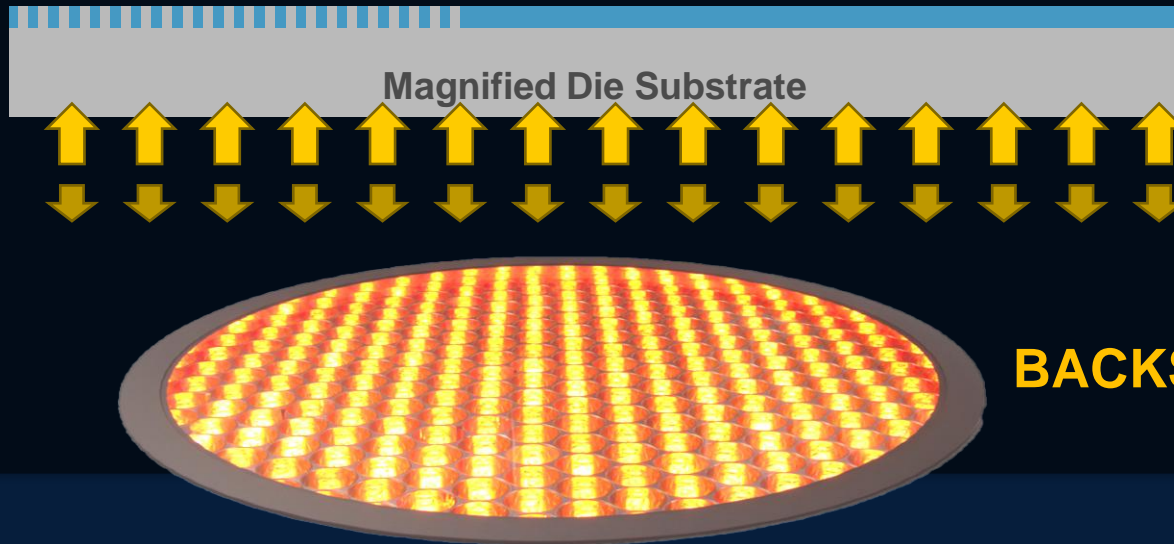


Dense City

←→
<3°C
**Within-Die
Difference**



Open Field

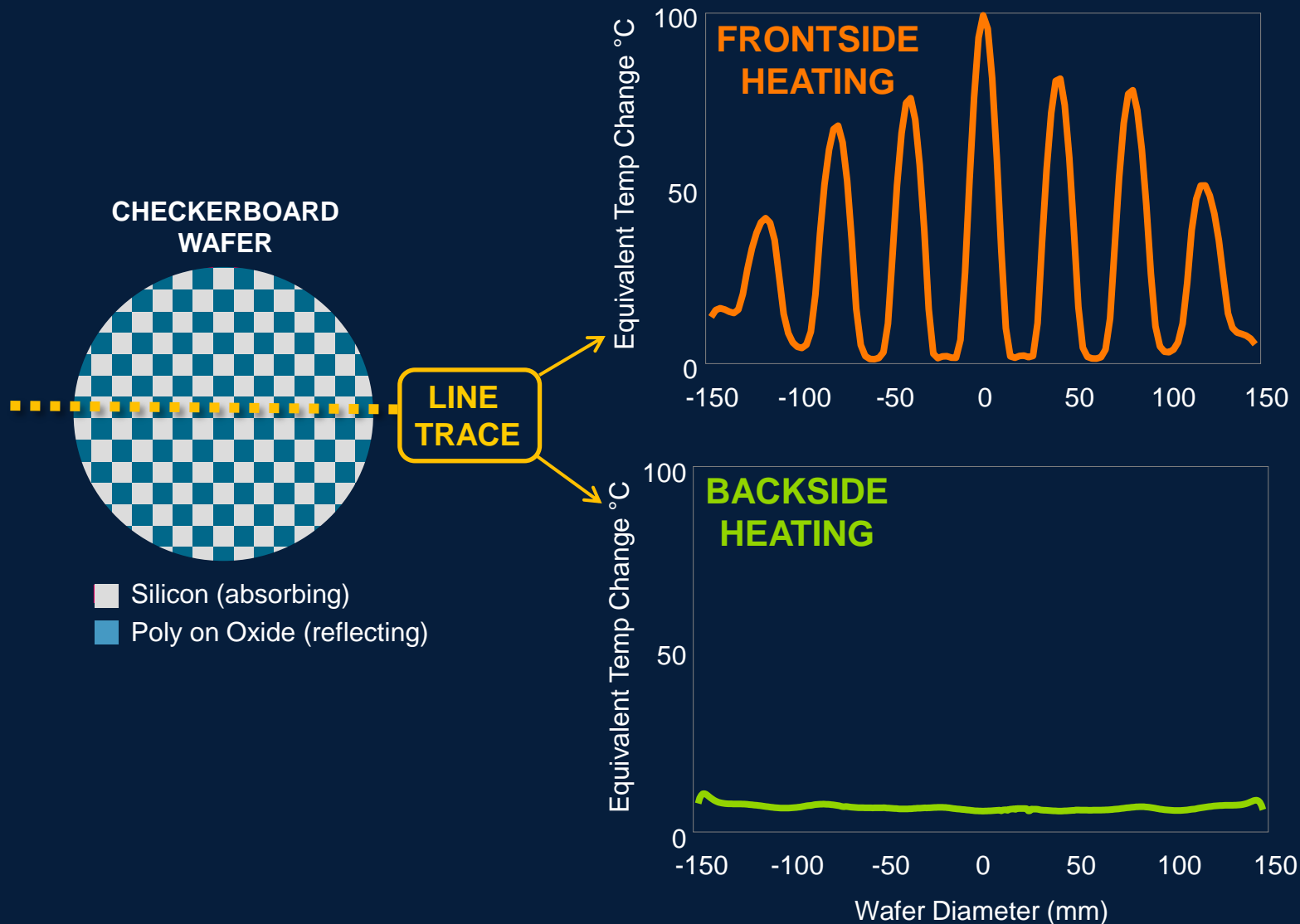


**Uniform
Absorbed
and Emitted
Energy**

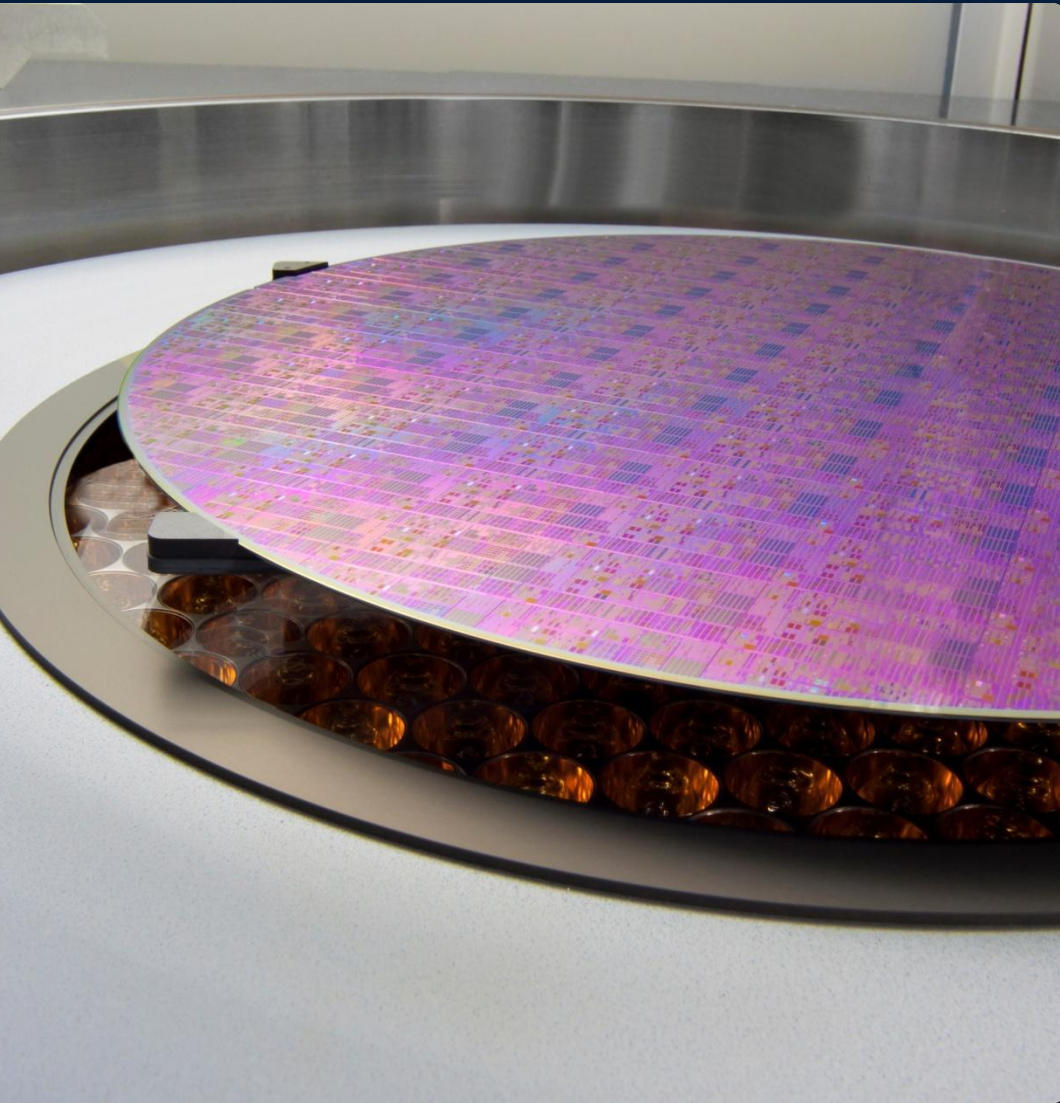
BACKSIDE HEATING

**3X Decrease in Within-Die Thermal Variability
With Vulcan System's Backside Heating**

Extreme Test For Within-Die Uniformity



Introducing Applied Vantage Vulcan RTP

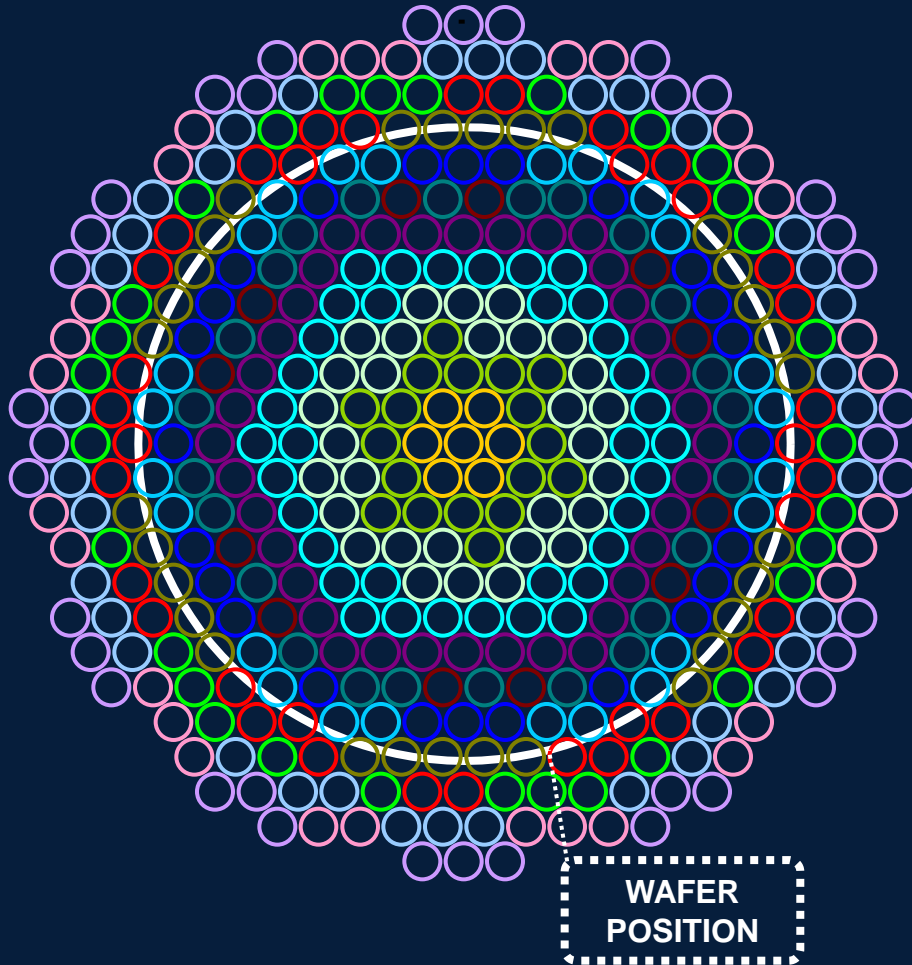


Revolutionary backside heating design

Extends Applied's technology leadership in ~\$500M market

Source: Gartner Dataquest April '11

Best-in-Class Dynamic Temperature Control



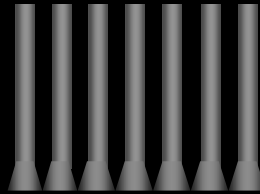
Proven honeycomb
design with 18 zones

0.1% control
of peak temperature

100 cycles-per-second
multi-zone control

Best-in-Class Dynamic Temperature Control

Pyrometers



*Wafer Levitation
and Rotation*



Honeycomb
Lamp Array

Proven honeycomb
design with 18 zones

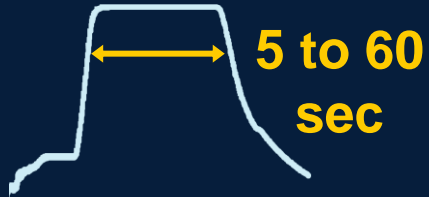
0.1% control
of peak temperature

100 cycles-per-second
multi-zone control

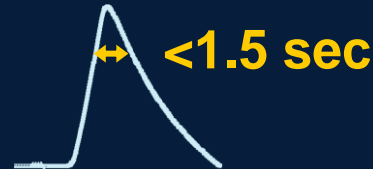
Thermal Processing Roadmap

Thermal Budget of Anneal

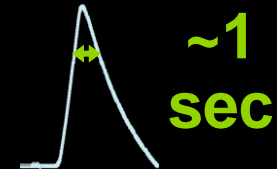
SOAK ANNEAL



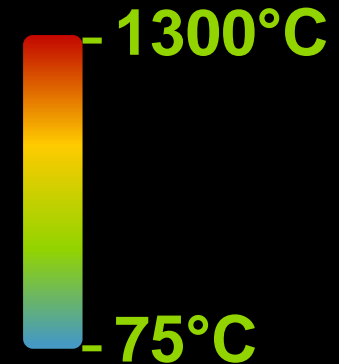
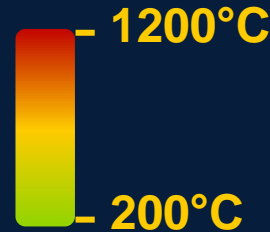
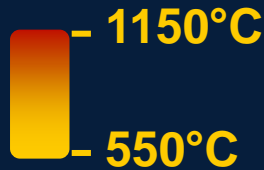
VANTAGE RADIANCE PLUS RTP



VANTAGE VULCAN RTP



Temperature Control Range



180

130

90

65

45

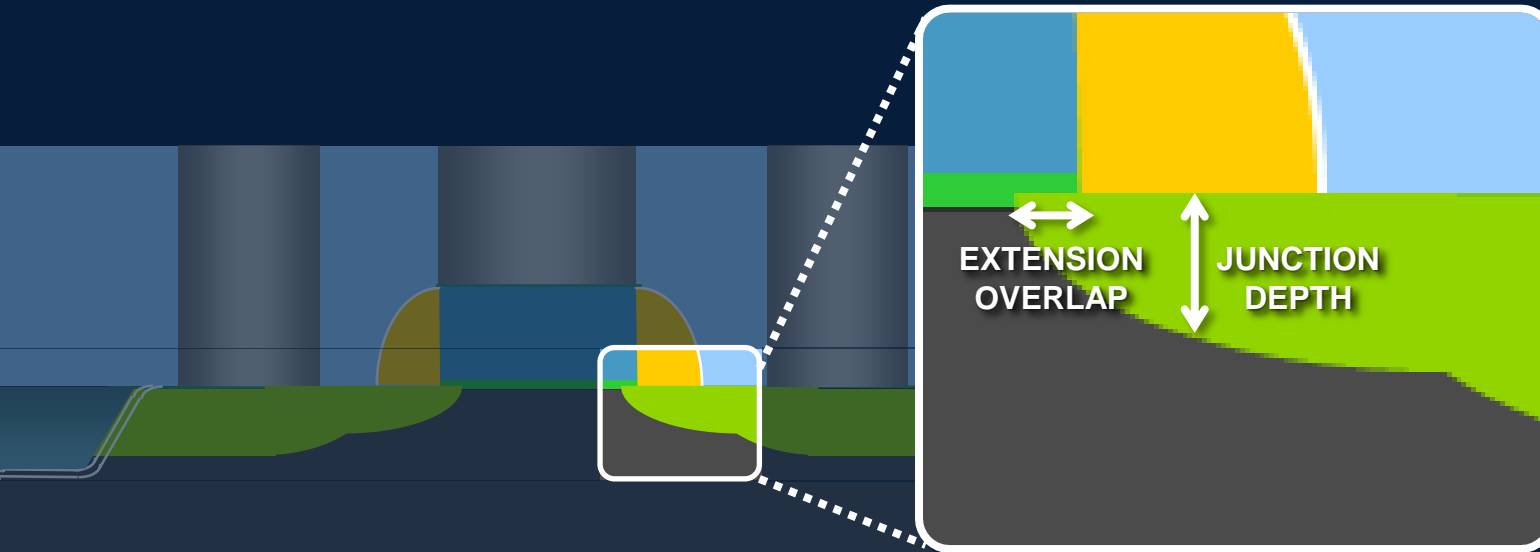
32

22

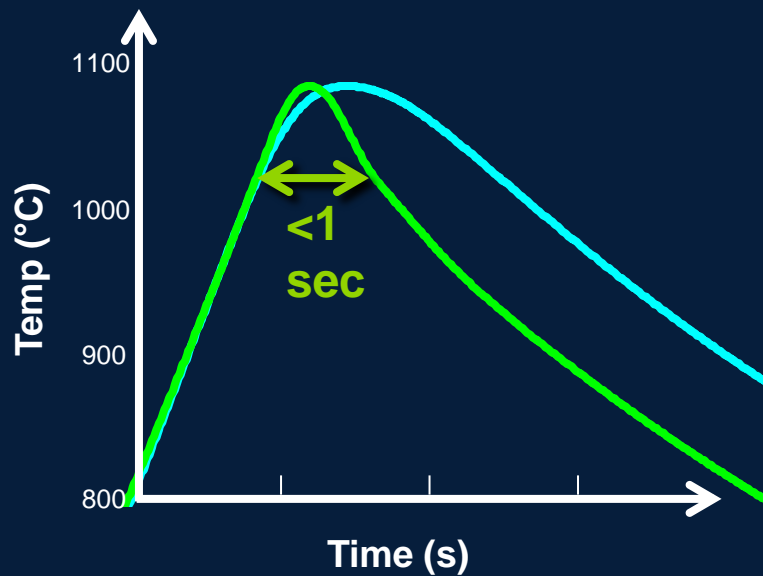
Technology Node (nm)

Enabling 28nm Node and Beyond With Sharper Spikes and Full-Range Temperature Control

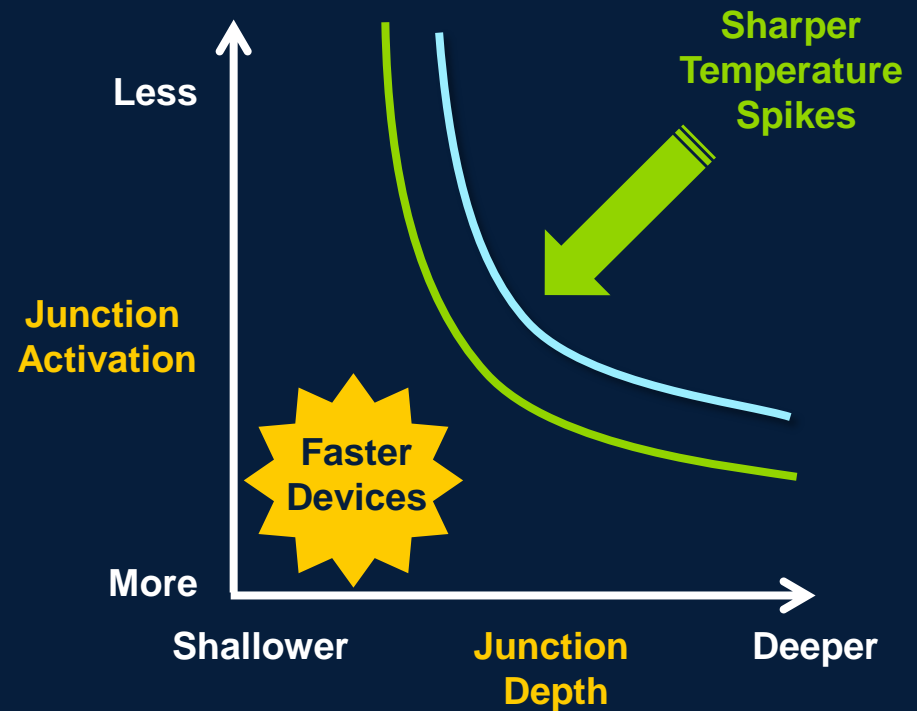
Atomic-Level Precision Required for Ultra-Shallow Junctions



Junction Diffusion Depth Must Be Reduced
Without Compromising Activation

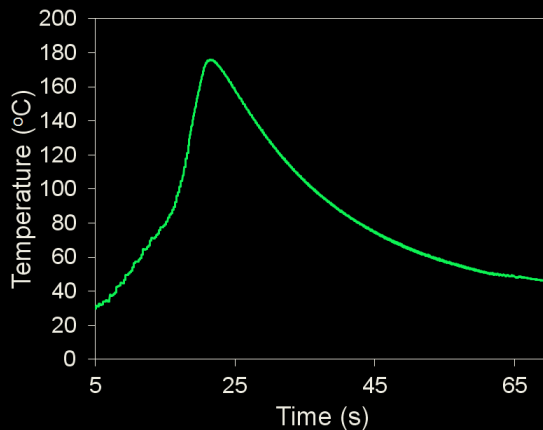
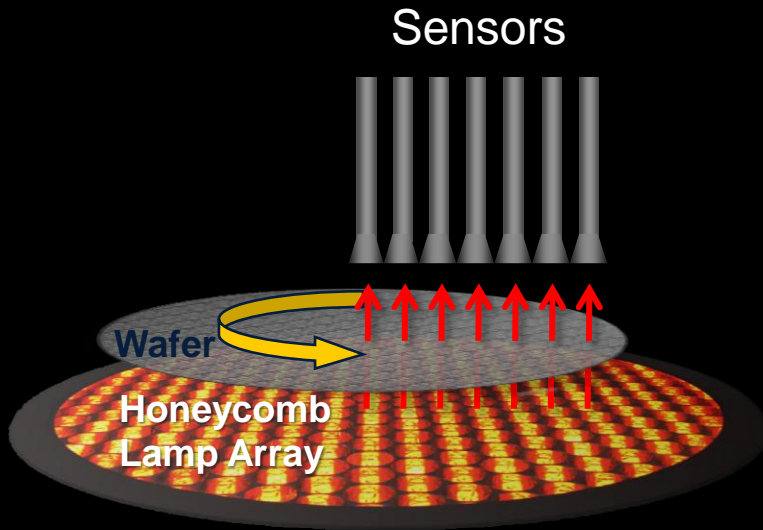


**Vantage Vulcan Nearly
Halves the Spike
Residence Time**



**Faster Devices Through
Sharper Temperature Ramp Profiles**

Enabling Low-Temperature Regime Control



Closed-loop control from
 $<75^{\circ}\text{C}$

Unique sensors for
accurate, low-temperature
measurement

New capability for
advanced low-temperature
applications

Industry's **Greenest** RTP Solution

CARBON
FOOTPRINT
REDUCTION* = 4 CARS OFF
THE ROAD

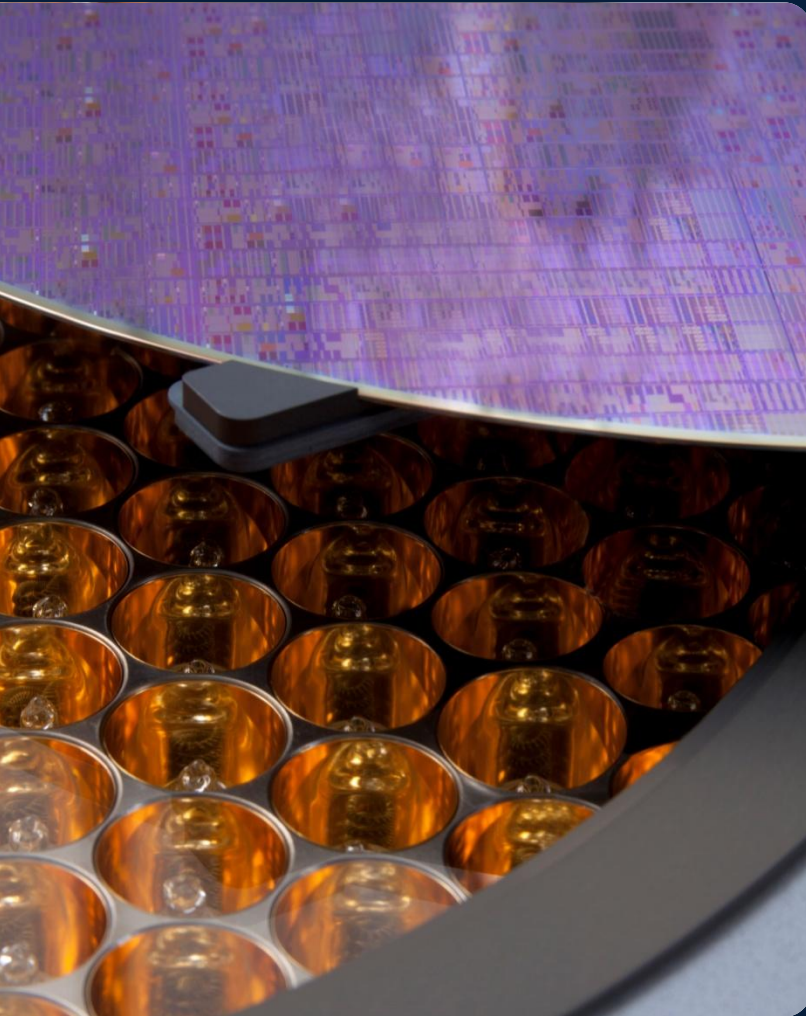


Advanced system
design improves
usage of
grid energy

* Per system; equivalent to 16 metric tons of CO₂/year

Applied Vantage Vulcan RTP

Continuing RTP Leadership for the Next Decade



Best-in-class temperature uniformity for higher yield

Sharper temperature spikes for faster chips

Low-temperature control for new applications

Efficient energy usage for lower carbon footprint



Turning innovations
into industries.™