Going Beyond a Qualification Report: Power Cycling and Lifetime Modeling

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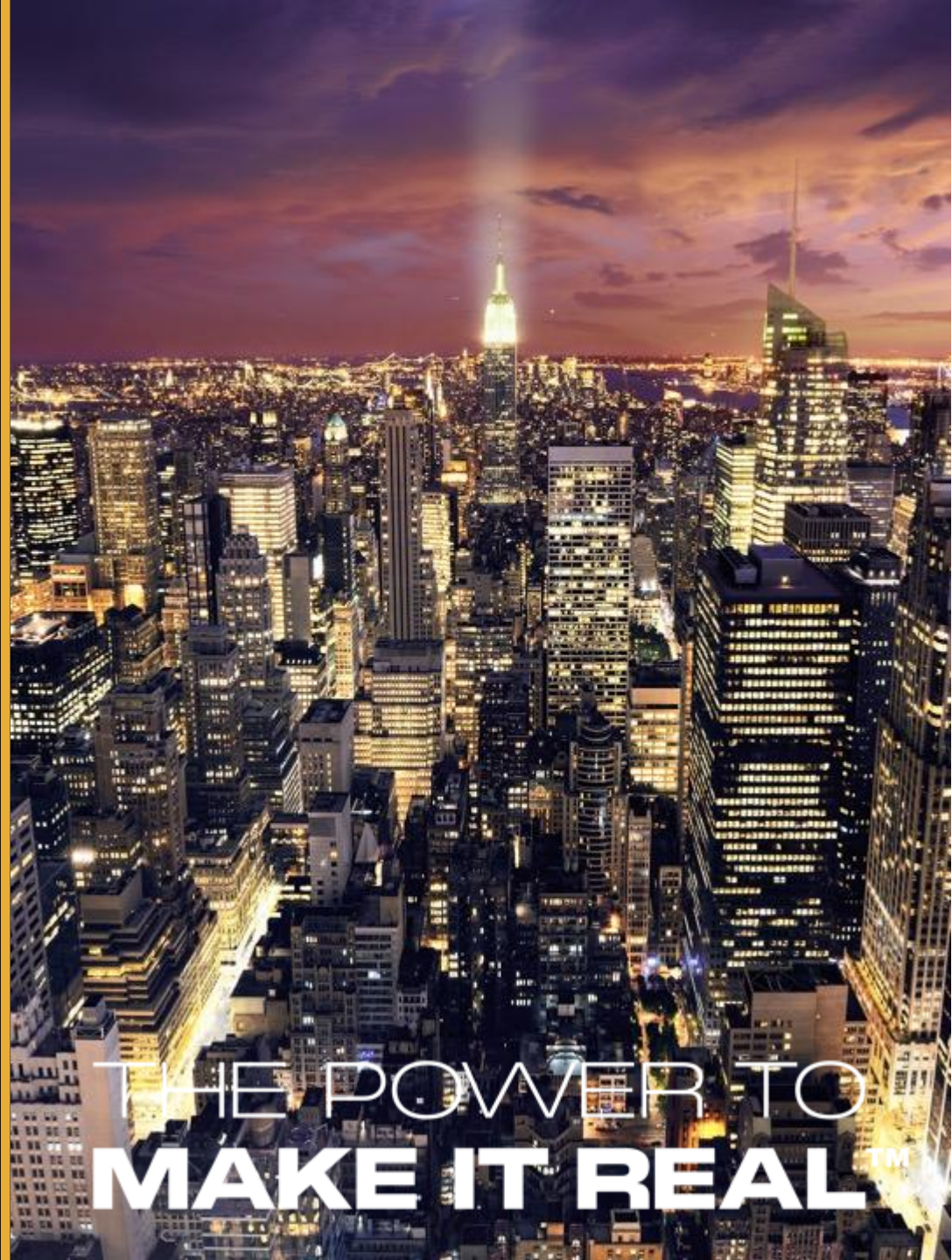
Bodo's Wide Bandgap Event 2025

Making WBG Designs Happen

SiC

ELECTRIFICATION, DIGITALIZATION & AI ARE GLOBAL TRENDS THAT ARE SHAPING OUR TODAY AND TOMORROW

High-voltage applications are NOT created equal and require application-optimized solutions.



Each application has a different mission profile

Maximize the useful life is our mission

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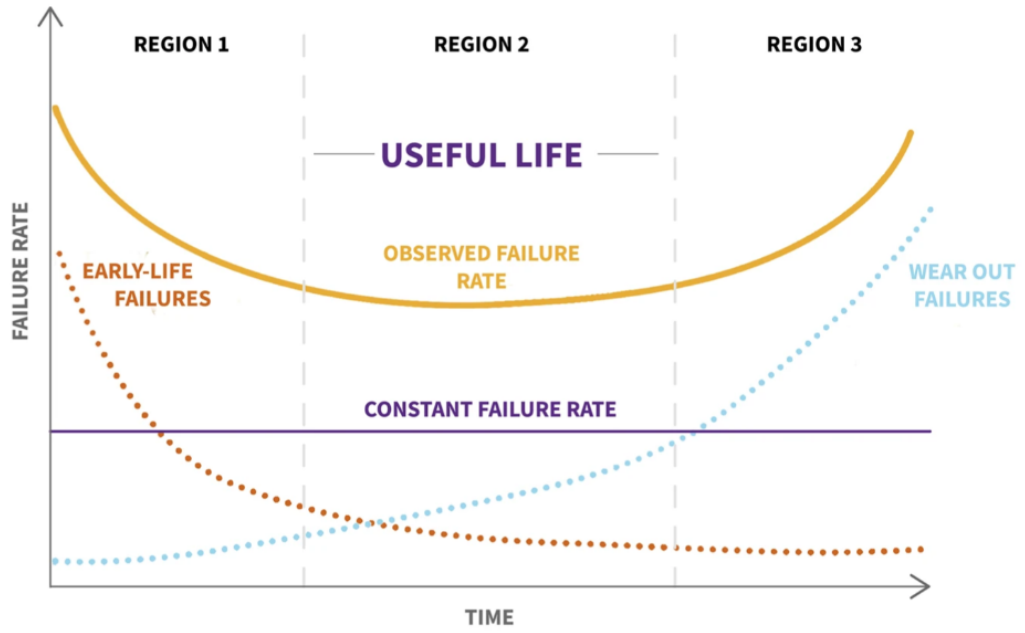
End systems enabled by SiC are now vast and entrenched, covering a multitude of voltage and power levels, many different package types and many differing mission profiles and long-term reliability requirements.

So much more than a qualification report, today's Silicon Carbide has to have proven application specific end system durability and ruggedness.

Delivering the next level of ruggedness at every stage of product life cycle



The lifecycle of reliability and failure rates of products

- **Early Failure:** Excellence in material defectivity an manufacturing imperfections control. Extended qualification test are further reducing the early failures
- **Constant (Random) Failures:** Enhanced MOSFET device structure and optimized Gate Oxide design are improving by orders of magnitude the constant failures.
- **Wear Out Failures:** Application optimized and easy to control devices are reducing the lifetime stress. Material and interconnection improvements are increasing the number of power cycles for a better durability

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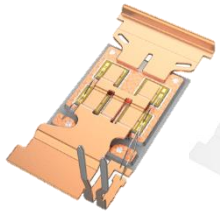
ΔT

$Tj = Ta + (Rth * P)$

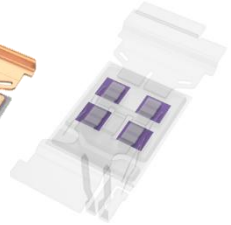
Rth

- Packaging Thermals
- Die attach technology

Pin Fin



Clip Topside Interconnection

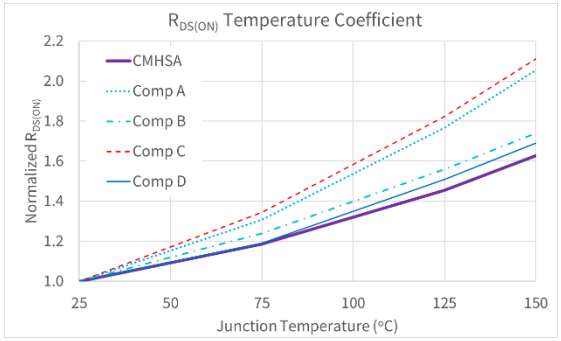


Device & Package Sintering

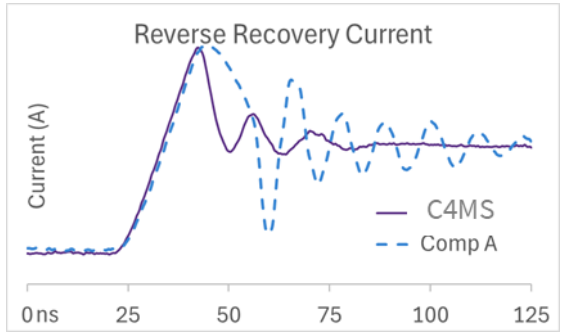
Total Losses

Die Performance

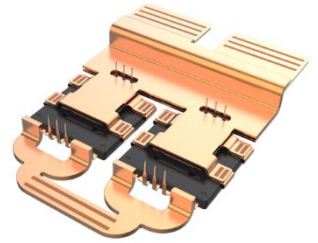
Conduction Losses



Switching Losses



Packaging Parasitic



Low Loop Inductance

Power cycling analysis has emerged as one of the most relevant figures of merit for system lifetime in real-world applications

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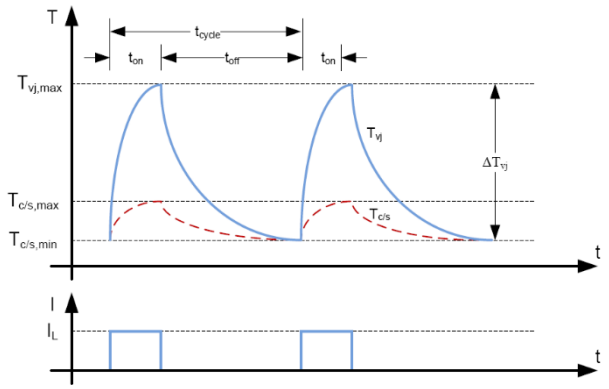
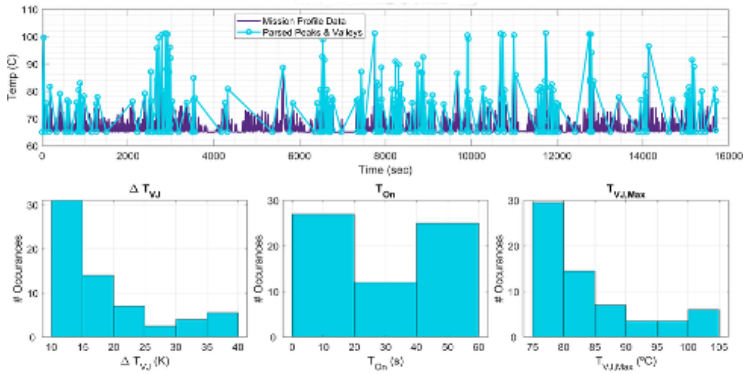
Lifetime model derived from power cycling can predict device lifetime in customer-specific applications

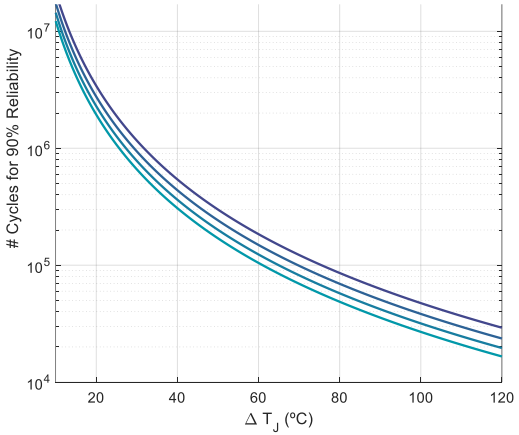
Power Cycling Testing
Model Definition



Mission Profile Analysis

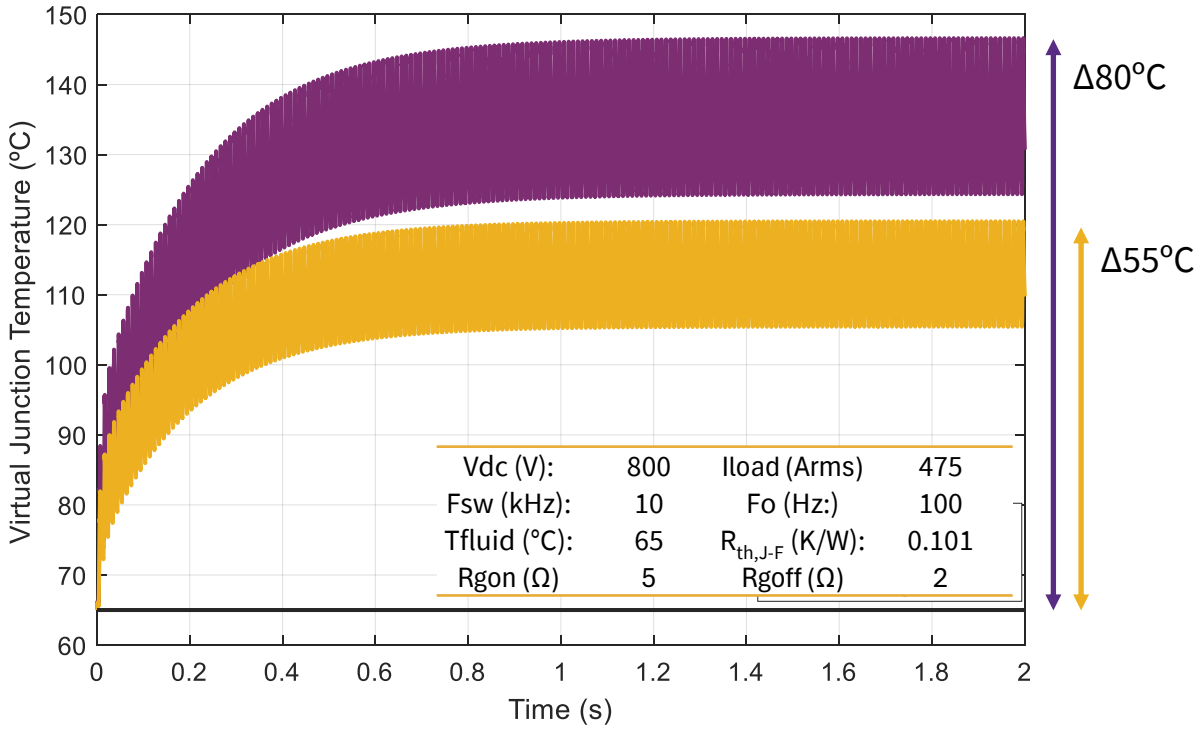


Lifetime Estimation

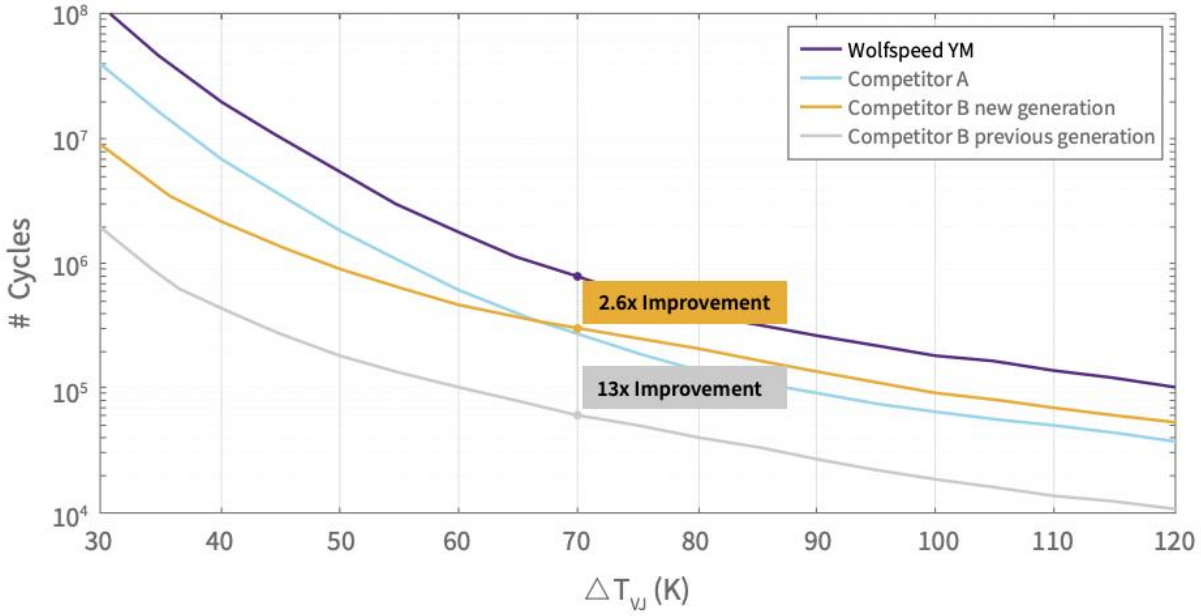


POWER MODULE LIFETIME ESTIMATION

The practical implementation of power cycling analysis extends far beyond laboratory characterization, providing system designers with quantitative tools **for optimizing application's lifetime, predicting maintenance requirements, and minimizing total cost of ownership**.



Combination of improved package materials and die attachment together with Wolfspeed Gen 4 die superior capabilities, the ΔT is reduced **from 80°C to 55°C** for the same application



Using cutting-edge packaging technology including sintered die attach and epoxy encapsulant material and copper clip interconnect enabling **3 times more power cycles**

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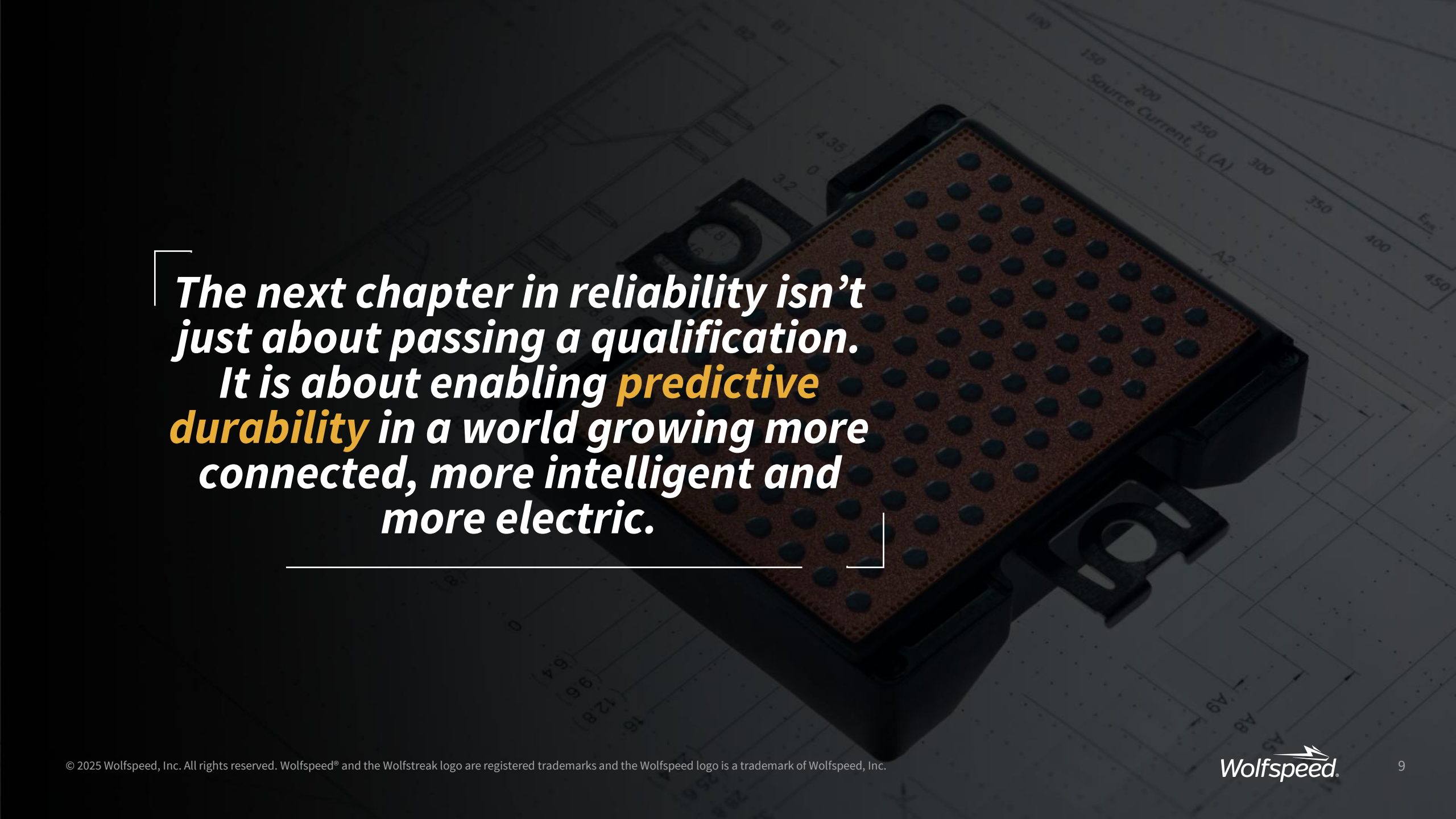

The next chapter in reliability isn't just about passing a qualification. It is about enabling predictive durability in a world growing more connected, more intelligent and more electric.