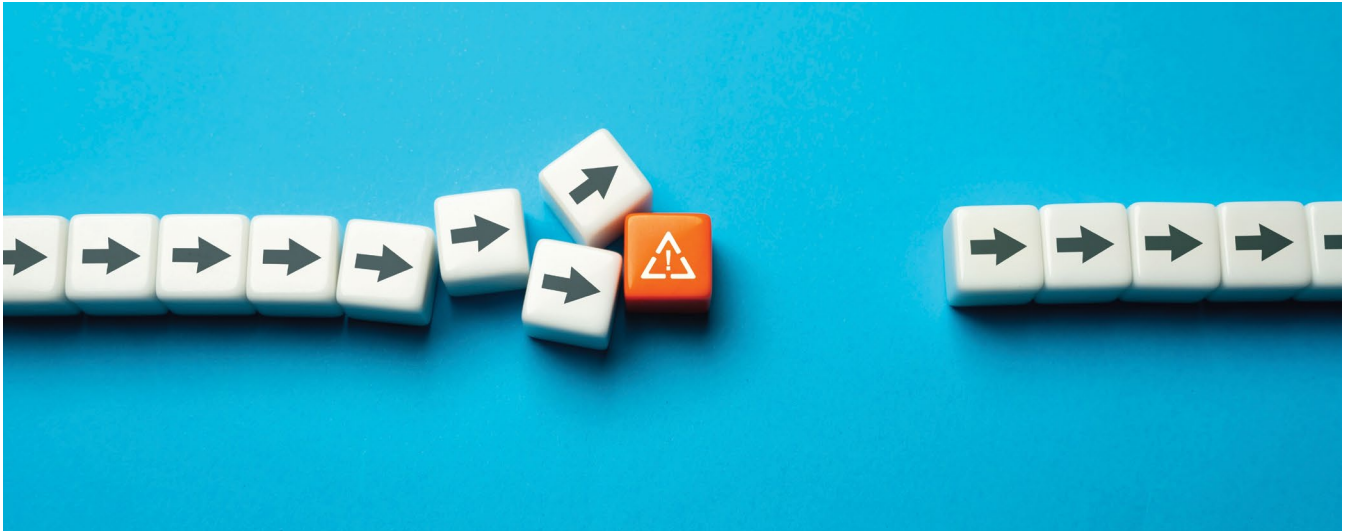


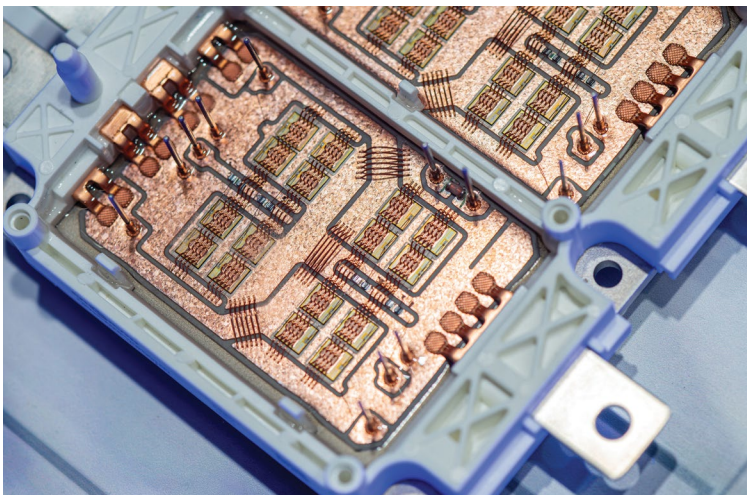


## Why KGD is the make-or-break gate for advanced packaging and power modules

Known Good Die testing helps manufacturers detect defects earlier, improve module yield and reliability, and reduce downstream packaging and production costs.

BY COSMIC

IN SEMICONDUCTOR manufacturing, the cost of a defect rises at every subsequent step downstream. Testing at Known Good Die (KGD) stage is not a premium option reserved for research labs, it is a production necessity for maximizing yield, reliability, and optimizing total cost of ownership in advanced packaging and power module production. For device makers, the question is no longer whether to test the die, but how to define and execute a KGD strategy that is fast enough for production, rigorous enough to protect module quality, and reproducible enough to scale from lab characterization to high-volume manufacturing.



### The industrial context: Smaller dies, denser modules, higher stakes

The relentless drive towards smaller, faster, and more powerful semiconductors makes process optimization a strategic imperative. As packaging becomes more advanced and modules integrate multiple dies, the penalty for shipping a defective die into assembly grows dramatically. A single faulty or underperforming die inside a multi-die package can compromise the entire module, triggering field failures, warranty costs, and brand damage that far exceed the cost of catching the defect earlier.

For power devices, the stakes are even higher. Modules for automotive, industrial, and energy applications must meet stringent reliability expectations under high voltage, high current, and harsh thermal cycling. In this context, KGD is not just about electrical functionality; it is about ensuring that only fully validated dies proceed to advanced packaging or module integration, minimizing downstream assembly costs and improving overall product reliability.

### What “Known Good Die” really means in practice

“Known Good Die” is often used as a shorthand for “tested die,” but in production-grade environments it carries a more precise meaning: a die that has passed a defined set of electrical, parametric, and stress tests under controlled conditions that are

representative of its intended application. This makes KGD testing a critical process step, not merely a quality assurance formality. Beyond defect screening, parametric KGD testing also enables die-to-die matching, ensuring that all elements of a finished module switch in harmony and share the load symmetrically.

From a decision-maker's perspective, KGD is a risk-management tool. It shifts defect detection upstream, where the cost per escaped defect is lowest, and it provides a clear quality gate between wafer-level operations and downstream assembly. From a technical perspective, KGD defines which tests are mandatory, under what conditions (temperature, stress profiles, timing), and with what coverage (number of sites, statistical sampling, correlation to final test).

This requirement spans all three principal power-semiconductor technologies used in modern modules: silicon (Si), silicon carbide (SiC) and gallium nitride (GaN). Mature Si devices require robust screening of leakage, breakdown, switching and ruggedness. SiC devices place additional importance on high-field leakage, gate-oxide integrity, dynamic behaviour and parametric consistency. GaN devices demand close control of leakage, threshold and on-resistance stability, together with dynamic effects associated with high-speed switching such as trapped charge screening.

### The risks of skipping or under-specifying KGD

When KGD is skipped or underappreciated, manufacturers effectively bet that wafer-level screening and final module testing will catch all critical defects. In mature, low-complexity products this may have been acceptable. In advanced packaging and high-reliability power modules, it is increasingly risky.

Typical failure modes that KGD aims to catch include:

- Dies with marginal breakdown voltage or leakage that may pass room-temperature tests but fail under thermal stress or high temperature operation.
- Devices with inconsistent avalanche or short-circuit behavior, which can lead to early failures in automotive or industrial applications.

If these dies reach module assembly, the cost of rework, scrap, and field returns can dwarf the investment in a robust KGD flow. Moreover, in safety-critical applications, an escaped defect can have consequences beyond economics, affecting system safety and regulatory compliance.

### What a production-grade KGD system must deliver

A KGD strategy is only as good as the hardware and methodology that implement it. For device makers evaluating or upgrading their KGD capability, several requirements stand out.

### Speed and throughput without compromising coverage

KGD sits between wafer test and final test in the value chain. If it is too slow, it becomes a bottleneck; if it is too light, it fails to protect downstream operations. A production-grade KGD test cell must therefore support high throughput while maintaining comprehensive test coverage. Platforms that enable ultra-fast AC and DC testing across multiple sites allow manufacturers to screen more dies per hour without sacrificing the depth of characterization needed to declare a die “known good.”

### Built-in stress and robustness tests

For power semiconductors, electrical functionality is not enough. KGD must include stress tests that probe robustness under realistic operating conditions. Avalanche testing, short-circuit testing, and dynamic reverse bias tests are essential to ensure that dies can survive transient overvoltages, fault currents, and harsh switching environments. A KGD flow that integrates these stress tests as standard provides a much stronger guarantee of field reliability.

### Reproducibility from lab to production

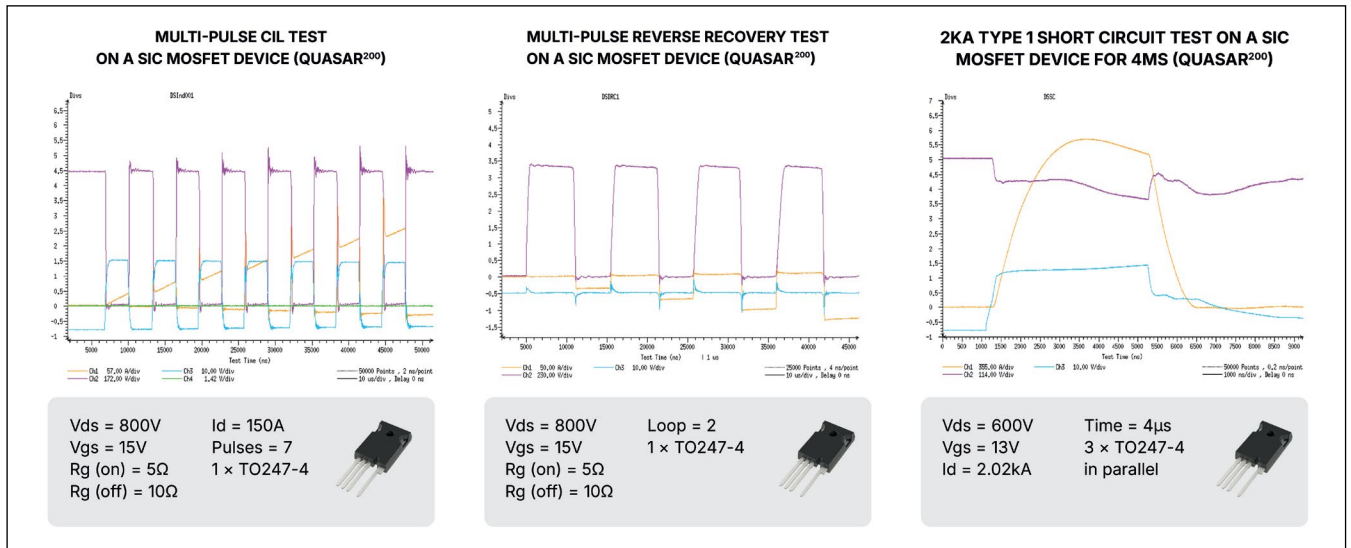
One of the most valuable aspects of a well-designed KGD platform is reproducibility. The same test architecture and loadboard philosophy used in lab characterization should scale to wafer-level KGD and final test with minimal re-engineering. This “lab-to-production” continuity reduces correlation issues, shortens qualification cycles, and ensures that the definition of “good” remains consistent across stages. For decision makers, this translates into faster time-to-quality, lower NRE costs, and more predictable yield ramps.

### Cosmic's approach: A flexible, high-power KGD platform

Cosmic's equipment portfolio illustrates how these requirements can be met in a single, flexible platform. The M2 Rotary Edition, for example is ideal for testing power devices on any rotary or conveyor handler from bare KGD through to packaged

➤ M2 Rotary Edition features modular test generators which can be installed next to each test site for highest performance and minimal footprint





discretes and modules. Designed to maximize units per hour (UPH) in high-volume production environments, M2 ensures precision, repeatability, and reliability without compromising test accuracy.

M2 supports ultra-fast AC and DC testing, enabling high-throughput screening without sacrificing test depth.

The index-parallel architecture assigns dedicated generators to specific sites on the Rotary handler. This enables the system to run at the handler's maximum mechanical speed: on typical Rotary handlers, this translates into throughputs on the order of 15,000 units per hour for packages such as DPAK and TO-220. From an operational standpoint, this approach aligns with the industrial imperative highlighted in KGD literature: process optimization is strategic, and testing must be both rigorous and scalable. By enabling the same test philosophy from lab characterization through wafer-level and KGD through to final test, Cosmic's approach ensures measurement correlation and comprehensive test at every stage of production.

## Implications for decision makers: TCO, yield, and risk

For R&D and operations leaders, the KGD decision is ultimately a total cost of ownership (TCO) calculation. Investing in a robust KGD flow entails capital expenditure, test development time, and ongoing operational costs. However, these must be weighed up by:

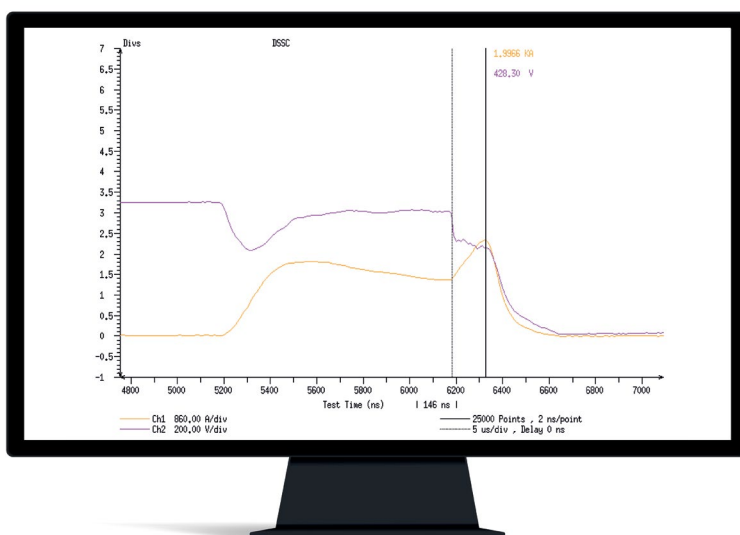
- Reduced scrap and rework in packaging and module assembly, as defective dies are filtered earlier.
- Higher effective yield at module level, since fewer bad dies enter the assembly line.
- Lower field failure rates and warranty costs, particularly in automotive and industrial applications where reliability is paramount.
- Faster qualification and ramp-up, thanks to reproducible test architectures that correlate from lab to production.

In high-mix environments, the flexibility of the KGD platform also matters. A system that can handle multiple device types and handler modes on the same architecture reduces the need for parallel lines and duplicate equipment, improving asset utilization and simplifying maintenance and training.

## From strategy to execution: Defining your KGD roadmap

Implementing or upgrading a KGD flow is not just a procurement decision; it is a process redesign. Device makers typically benefit from a phased approach:

- **Define the KGD specification:** Identify which electrical, parametric, and stress tests are mandatory for each product family, and under what conditions (temperature ranges, stress profiles, timing).
- **Map the test flow:** Align KGD tests with wafer-level screening and final test to avoid gaps or unnecessary duplication. Ensure that the definition of "good" is consistent across stages.
- **Select a flexible, production-grade platform:** Choose a KGD handler that supports the required



throughput, stress tests, and handler modes, and that can scale from engineering batches to high-volume production.

- **Validate correlation and reproducibility:** Run correlation studies between lab, wafer, KGD, and final test to ensure that results are consistent and that the KGD gate is effectively reducing downstream defects.
- **Monitor and iterate:** Use KGD data to refine test coverage, adjust stress profiles, and identify process drifts at wafer level, turning KGD into a continuous improvement loop rather than a static checkpoint.

### KGD as a strategic lever, not a cost center

In the current landscape of advanced packaging and high-reliability power modules, KGD is best viewed not as a cost center but as a strategic lever for yield, reliability, and brand protection. The industrial imperative is clear: process optimization is essential, and testing must be both rigorous and scalable. Platforms that combine speed, flexibility, and built-in stress testing—while maintaining reproducibility from lab to production—enable device makers to ensure that only fully validated dies proceed to advanced packaging or module integration.

For decision makers, the message is straightforward: a well-designed KGD strategy, supported by the right equipment and methodology, reduces downstream assembly costs, improves overall product reliability, and strengthens the foundation for next-generation semiconductor products.

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