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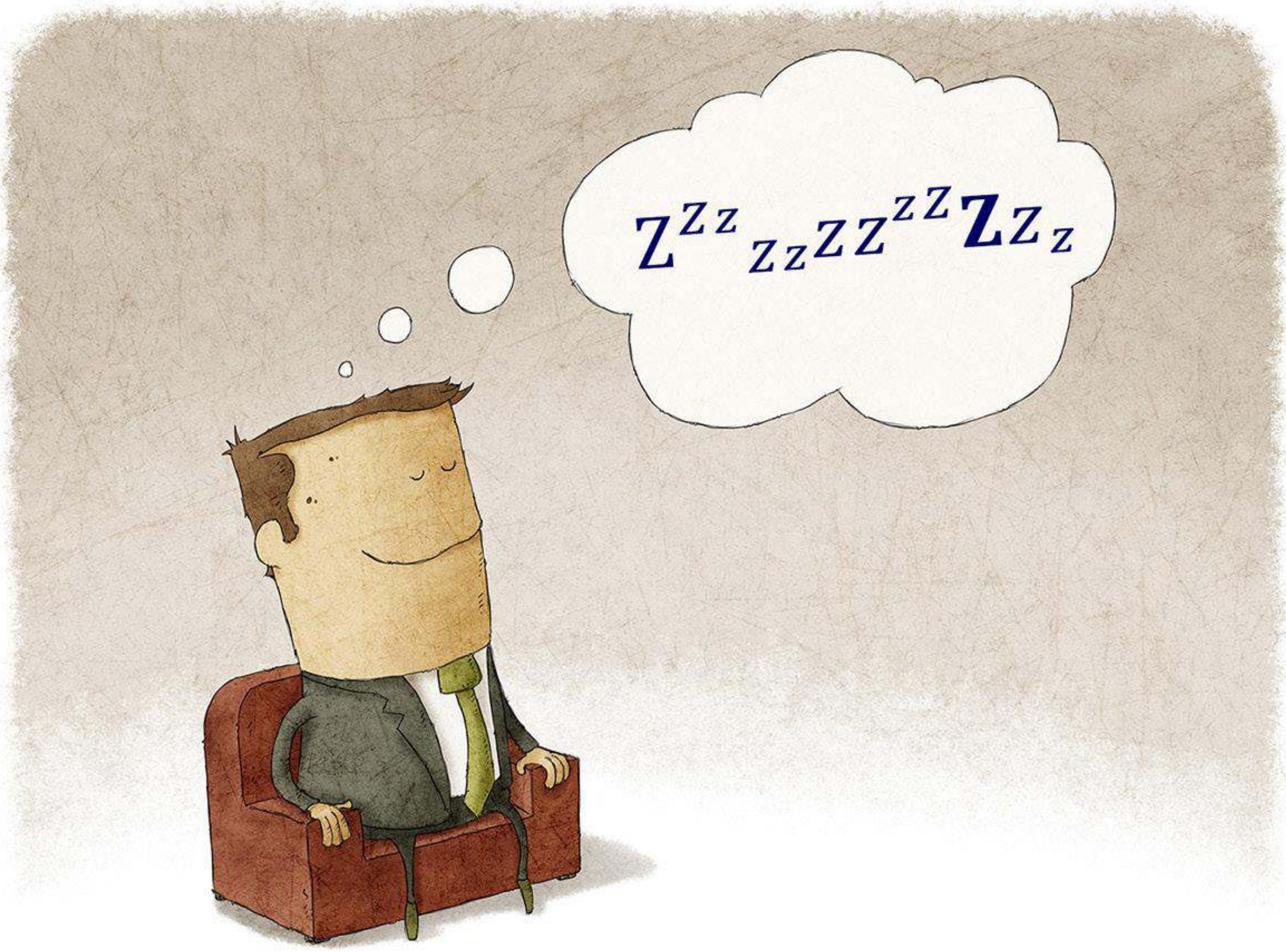

Did you know that two seemingly unrelated concepts are the foundation of a product's performance and reliability?

- Transmission line impedance and
- Power Distribution Network impedance

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ReRAM
The Industry's Next Game-Changer

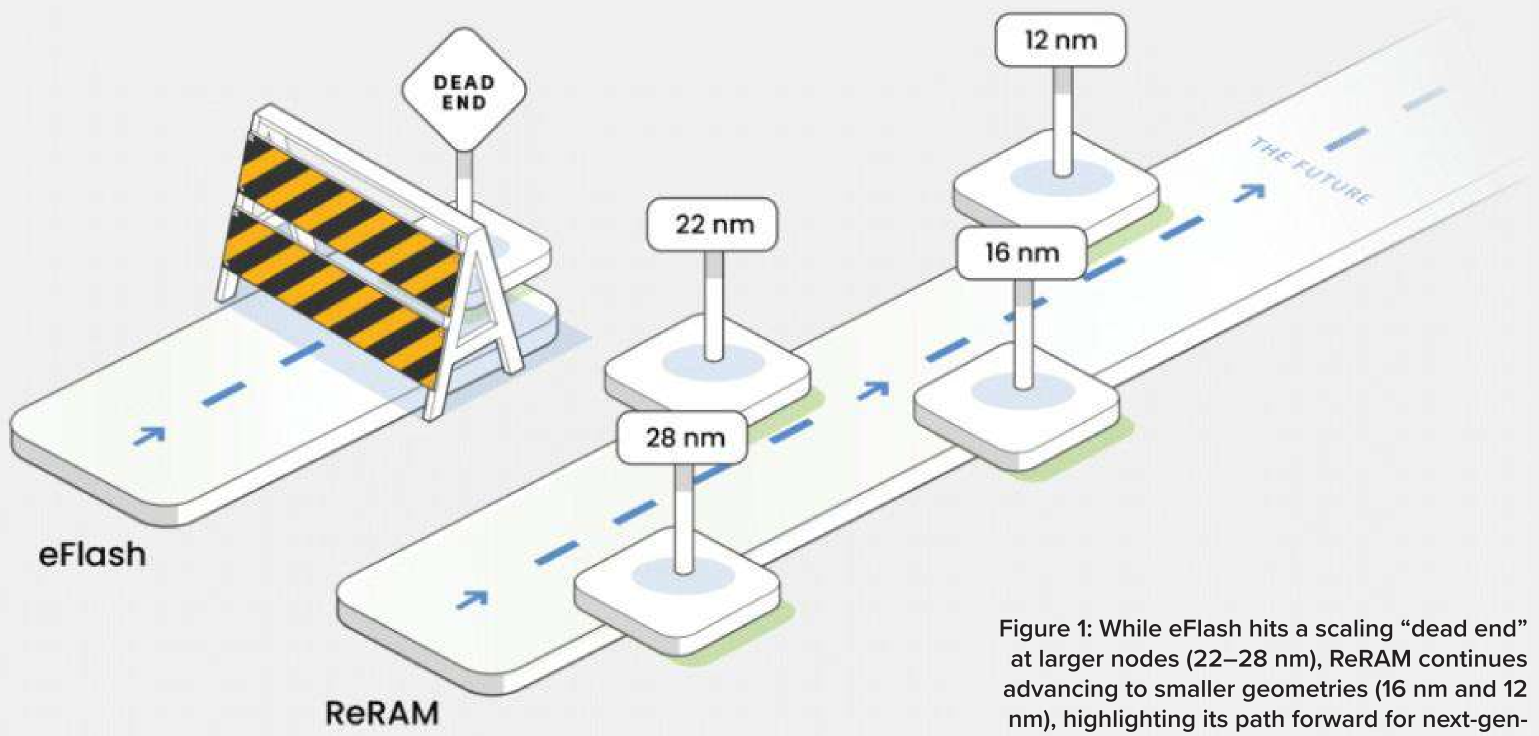

Figure 1: While eFlash hits a scaling "dead end" at larger nodes (22–28 nm), ReRAM continues advancing to smaller geometries (16 nm and 12 nm), highlighting its path forward for next-generation integration. (Source: Weebit Nano)

BY BARRY OLNEY, IN-CIRCUIT DESIGN PTY LTD | AUSTRALIA

Resistive RAM (ReRAM) is a nextgeneration nonvolatile memory technology that stores data by changing the resistance of a dielectric material layer rather than trapping electrical charge. That simple shift unlocks a surprising amount of power. ReRAM sits at the intersection of speed, efficiency, and scalability, exactly where the industry is hitting bottlenecks.

ReRAM addresses the growing need for higher-performance, lower-power non-volatile memory solutions across a range of new electronic products, including Internet of Things (IoT) devices, smartphones, robotics, autonomous vehicles, fifth-generation (5G) communications, and artificial intelligence. Plus, ReRAM technology is built on fab-friendly materials and integrates seamlessly into existing semiconductor flows. It delivers fast read/write performance and is ideal for applications that demand high-temperature operation and exceptional endurance. The result is a power-efficient, non-volatile memory that is easy to embed, highly reliable, and inherently tolerant to radiation and electromagnetic interference.

Random-access memory (RAM) can be classified as either volatile or non-volatile. Volatile memories lose their stored data when power is removed, as seen in dynamic RAM (DRAM) and static RAM (SRAM). Non-volatile memories, by contrast, retain their contents even without power; flash memory is a common example.

Modern memory technologies often balance trade-offs to achieve higher performance. DRAM offers high capacity and density, but its volatility requires constant refreshing every few milliseconds, increasing energy consumption. SRAM is faster but also volatile, and its relatively large cell size limits large-scale integration. Flash memory suffers from limited write endurance, slow erase cycles, scaling difficulties, and declining data retention as cells shrink.

All three (DRAM, SRAM, and flash) store data as electrical charge. As these technologies scale toward the 10-nm node, maintaining sufficient charge becomes difficult, leading to reliability issues, higher leakage, and shrinking noise margins. The refresh power required by DRAM, together with the inherent leakage in both DRAM and SRAM, further constrains their suitability for future memory architectures.

Why ReRAM is emerging as the better choice and the strengths behind it:

- **Speed:** Switching resistance states happens extremely fast, giving ReRAM the potential to outperform NAND flash and even approach DRAM-like speeds
- **Endurance:** It tolerates far more write cycles than flash, making it attractive for AI, edge devices, and high-duty workloads
- **Low power:** It writes at very low voltages, requires no stand-by power, and is ideal for mobile, IoT, and battery-sensitive systems
- **Density and scalability:** The cell structure is tiny and stackable, allowing much higher storage density as traditional flash approaches its physical limits
- **CMOS-friendly manufacturing:** It integrates cleanly with existing semiconductor processes, reducing cost and easing adoption.

Memory Type	Non-volatility	Write Speed	Read Speed	Endurance (cycles)	Retention	Scalability
ReRam	Yes	~10 ns	~10 ns	$10^6 - 10^{12}$	> 10 yrs	High
DRAM	No	~10 ns	~10 ns	∞	~64ms	Moderate
NAND flash	Yes	~100 µs	~25 µs	$10^4 - 10^5$	> 10 yrs	High
NOR Flash	Yes	~1 µs	~10 µs	$10^5 - 10^6$	> 10 yrs	Low

Table 1: ReRAM offers several advantages over existing memory

ReRAM stores data by modulating the electrical resistance of a thin metal-oxide layer sandwiched between two electrodes. Rather than holding charge like DRAM or trapping electrons like flash, it operates by forming and dissolving nanoscale conductive paths within the dielectric material.

At the device level, a ReRAM cell is a simple metal-insulator-metal (MIM) stack. When electrical pulses are applied, ions or oxygen vacancies migrate within the insulator, switching it between a low-resistance state (LRS) and a high-resistance state (HRS). These two stable resistance states represent binary data and remain intact even when power is removed. The application of an electrical field leads to the formation of conductive filaments through the insulator layer:

- **SET** (write a “1”): A conductive filament forms between the electrodes. This puts the cell into a low-resistance state.
- **RESET** (write a “0”): A reverse or lower-energy pulse ruptures or thins the filament. The cell moves into a high-resistance state.

Figure 2 illustrates the 3D structure of a ReRAM device. The top and bottom electrodes are connected by vertical pillars that can switch between

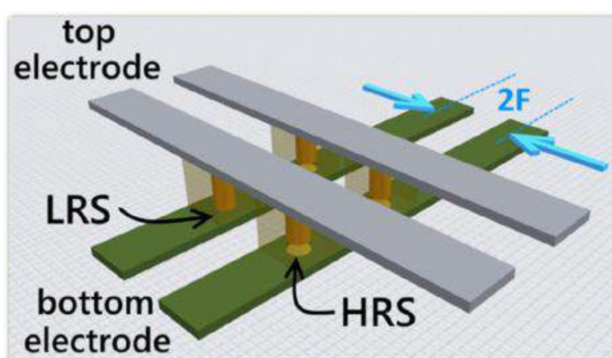

Figure 2: The 3D structure of a ReRAM device. (Source: Nanowerk.com)

low-resistance and high-resistance states to store data. The blue arrows labeled "2F" represent the electrical field applied to change the resistance of the material, which enables the storage of information.

The key advantage (for PCB designers) is that ReRAM drops onto a PCB with the same ease and familiarity as a traditional memory device. Although the underlying device physics are radically different, the board-level packaging and design rules remain comfortably conventional. For PCB designers, that means no exotic constraints, no unusual stackups, and no new routing paradigms to learn—just straightforward, well-understood bus routing with clean point-to-point tuned connections. In practice, ReRAM behaves like a modern, drop-in memory component that fits naturally into existing design flows, making integration fast, predictable, and refreshingly uncomplicated.

Although double data rate (DDR) operation has not yet been demonstrated in ReRAM, there is no fundamental barrier to adopting the protocol. In principle, the switching dynamics, interface timing, and bus architecture are fully compatible with DDR signaling, suggesting that future device generations could incorporate DDR support as the technology matures, effectively enabling a DDR-ReRAM implementation.

As the technology transitions into mass production, a notable milestone was achieved in December 2025 when Weebit Nano formalized a licensing agreement with Texas Instruments for its resistive ReRAM technology. ReRAM is built on fab-friendly materials and integrates seamlessly into existing semiconductor flows, making it an attractive option for deployment within TI's advanced process nodes for embedded processing devices.

The agreement encompasses intellectual property licensing, comprehensive technology transfer, and the design, integration, and qualification of Weebit's ReRAM within TI's established manufacturing technologies. With this collaboration now underway, we should expect to see early indications of ReRAM-enabled devices emerging in the market in the near future. Notably, this development coincides with a period in which DRAM prices have increased by roughly 170% over the past year, creating a profound impact across consumer and enterprise hardware segments.

Key Points

- Random-access memory (RAM) can be classified as either volatile or non-volatile. DRAM, SRAM, and flash store data as electrical charge.
- ReRAM stores data by modulating the electrical resistance of a thin metal-oxide layer sandwiched between two electrodes.
- ReRAM operates by forming and dissolving nanoscale conductive paths within the dielectric material.
- The application of an electrical field leads to the formation of conductive filaments through the insulator layer.
- The two stable resistance states represent binary data and remain intact even when power is removed.
- Switching resistance states happens extremely fast, giving ReRAM the potential to outperform NAND flash and even approach DRAM-like speeds.
- ReRAM writes at very low voltages, requires no stand-by power and is ideal for mobile, IoT, and battery-sensitive systems. It also retains memory when the power is removed.
- ReRAM drops onto a PCB with the same ease and familiarity as a traditional memory device. **I-CONNECT007**

Resources

Nano Werk: Resistive, Random-Access Memory (ReRAM): Principles, Materials, and Applications

Barry Olney is managing director of In-Circuit Design Pty Ltd (iCD), Australia, a PCB design service bureau that specializes in board-level simulation. The company developed the iCD Design Integrity software incorporating the iCD Stackup, PDN, and CPW Planner. The software can be downloaded at www.icd.com.au. To read past columns, click here.