KIOXIA

Q & A

The Future of Flash Memory Development – A New Normal is Here

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We're all familiar with the saying "Great challenges breed great opportunities." As we begin to emerge from the most severe downturn the NAND industry has ever faced, I feel that this quote captures the essence of our situation quite well.

The NAND flash market is constantly changing and fluctuating. In fact, over the last 5 quarters we've seen an industry-wide loss in demand to the tune of $28 billion[1]. While this may seem overwhelming, at KIOXIA we are embracing this challenge to streamline our business and thrive in a time of uncertainty and doubt. To this end, we've adopted a 'New Normal' focus and mindset which is driving our flash memory development into the future.

In my travels speaking with industry insiders, including customers and analysts, everyone is talking about what this 'new normal' looks like – so I've put together a few of my thoughts, Q&A style:

Q: With the industry rebounding from this challenging period, how might that change the way it operates in the future?

A: It's a given that each successive generation of 3D NAND flash technology brings intensive, increasing CapEx expense along with it. This is not only due to the increasingly complex and sophisticated manufacturing equipment required to produce smaller, faster, denser, more efficient NAND flash, but also the increasingly bigger footprint this equipment takes up on the fab floor. Today, the circumstances we find ourselves in mean that we need to think about technology migration in terms of CapEx.

We believe these accelerating CapEx costs will change the industry's capacity planning approach, and that leading-edge 3D NAND generations will be focused on those applications that are enabled by the newest technology. The implication is that there will be multiple generations of 3D NAND running in parallel with capacity, density and performance options that support the rest of the market.

This dynamic is reminiscent of Rock's Law, which states that the cost of semiconductor fabrication plants doubles every four years. As we push the boundaries of flash memory development, we must balance the relentless march of technological progress with the economic realities of skyrocketing costs.

Q: What does the New Normal look like?

A: KIOXIA will focus on multiple NAND flash generations existing at the same time. Let me explain.

Up to this point, the industry would 'tick-tock' the entire volume/capacity from one NAND generation to the next. A significant portion of the market doesn't need cutting-edge performance – which is why a 'legacy line' must exist. This approach enables KIOXIA to maintain multiple generations at a time and provide the latest generation to the portion of

the market that is enabled by leading-edge density and performance. By supporting multiple 3D generations at once and making efficient utilization of existing capacity, along with our leading-edge CBA architecture, KIOXIA will have a more competitive CapEx strategy.

Embracing the New Normal

Each NAND flash generation serves a purpose and the market is addressed based on application needs.

Note: Visual depiction. Actual capacity is subject to market demand.

We've built the New Normal at KIOXIA around our CMOS directly Bonded to Array (CBA) technology.

Last year, we introduced the 8th generation of our BiCS FLASH™ 3D flash memory, which brought an entirely new architecture designed to meet the needs of a diverse range of applications. It's all about the design efficiencies and optimization that comes with separating the flash array from the CMOS circuit chip. We then optimize the flash array's vertical and lateral scaling. Separately, we optimize the performance of the CMOS circuit chip, then bond the two together using CBA technology. Fabrication of the flash array and CMOS circuit separately enables optimization of each, eliminating the trade-off between cell reliability and I/O speed – and delivering a major leap in power efficiency, performance, density, cost-effectiveness, and sustainability.

Q: How does all of this affect NAND leadership?

A: Addressing application needs in a cost-sensitive environment introduces new challenges that are difficult or impossible to overcome when the focus is on achieving x amount of layers.

At KIOXIA, we have a longstanding belief that technology leadership is determined not by how high you go, but by delivering the most cost-effective solution that meets performance and density requirements.

Economic times are challenging us to be creative in order to thrive. The need for high performance, high density is stronger than ever due to the growing demand for AI solutions and data-centric applications driving edge computing. Advanced smart phones, PCs, SSDs and data centers are being pushed to their limits with more and more data every day.

KIOXIA is committed to bringing high density, high performance and cost-effective solutions to market. While competitive solutions seem to be in a constant scramble to go higher, we view it differently. Our combination of vertical and lateral scaling produces greater capacity with fewer layers. We believe that offering a major leap in performance, density and cost through vertical and lateral scaling and wafer bonding is the best solution for our customers.

By embracing the New Normal – where each NAND flash generation serves a purpose and the market is addressed based on application needs – we can forge a path forward with a competitive CAPEX strategy that not only mitigates the impact of market volatility but also fosters sustained growth and innovation.

[1] Reported by Clearview Memory Research, January 2024

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