

NAND Memory Market Tracker – Q2 2020

Craig Stice

Chief Analyst, NAND Intelligence

askananalyst@omdia.com

© 2020 Omdia

Brought to you by Informa Tech



Contents

• Executive summary	3
• Market overview	6
• Market share	15
• Demand environment	18
• Supply environment	32
• Cost/financial update	46
• Appendix	49

Executive summary

Executive summary (1/2)

- In the second half of 2020 (2H20), the impact from the coronavirus (COVID-19) has been easing within certain regions across the world, while other regions continue to deal with the effects of the virus. Concerns as to whether the virus will return during the winter months ahead remain and keep the semiconductor industry on edge in preparation for any significant impacts. A cautionary approach is likely to continue within the NAND industry until a point when COVID-19 is under control across the world.
- Server and storage demand in the 2H20 is expected to soften following strong demand, four quarters in a row, with the latter half of that timeframe fueled by stay-at-home environments from COVID-19.
- The mobile markets are anticipated to rebound in 2H20 following a significant downfall in the first half of 2020 (1H20) from COVID-19. Omdia currently estimates 2H20 smartphone unit shipments to outpace 1H20 shipments by approximately 10%. However, total year-over-year (YoY) smartphone shipments for 2020 are expected to decline by 13% when compared with 2019.
- Hopes for 5G technology to fuel the smartphone market still hold, and the smartphone market is expected to bounce back in 2021 with smartphone unit shipments forecast with a 12% YoY growth rate.
- It is analyzed that NAND manufacturers as well as end markets are dealing with inventory buildup in the third quarter of 2020 (3Q20). As a result, average selling prices (ASP) have declined at the beginning of 3Q20. How long it will take the industry to bring inventory back to appropriate levels remains the question; Omdia analyzed that this atmosphere will last into the first half of 2021 (1H21) before the market tightens again in mid-2021.
- The US sanctions on Huawei continue to disrupt the market. It is analyzed that Huawei has been stocking up on its inventory over the last months, with both Samsung and SK hynix to support. However, both companies have recently announced that they will halt support for Huawei, leaving Huawei with a difficult challenge ahead. Huawei's buying spree has impacted NAND pricing, but this will likely be short-lived.

Executive summary (2/2)

- NAND's YoY bit growth for the year is now expected to be approximately 24% for 2020, down from the previous forecast of 27%. While SK hynix and the Kioxia/Western Digital (WD) camps remain aggressive with their bit growth plans, Micron and Samsung have been taking a much more conservative approach.
- Barring any significant impacts from COVID-19 or any other external impacts, NAND's bit growth is expected to improve in 2021, with a 34% YoY growth.
- NAND pricing for 2H20 is expected to decline as the market deals with softening demand from the enterprise/data center markets and inventory issues. Omdia currently expects ASPs to decline to low/mid-single digits in both 3Q20 and the fourth quarter of 2020 (4Q20), with this trend continuing into 1H21.

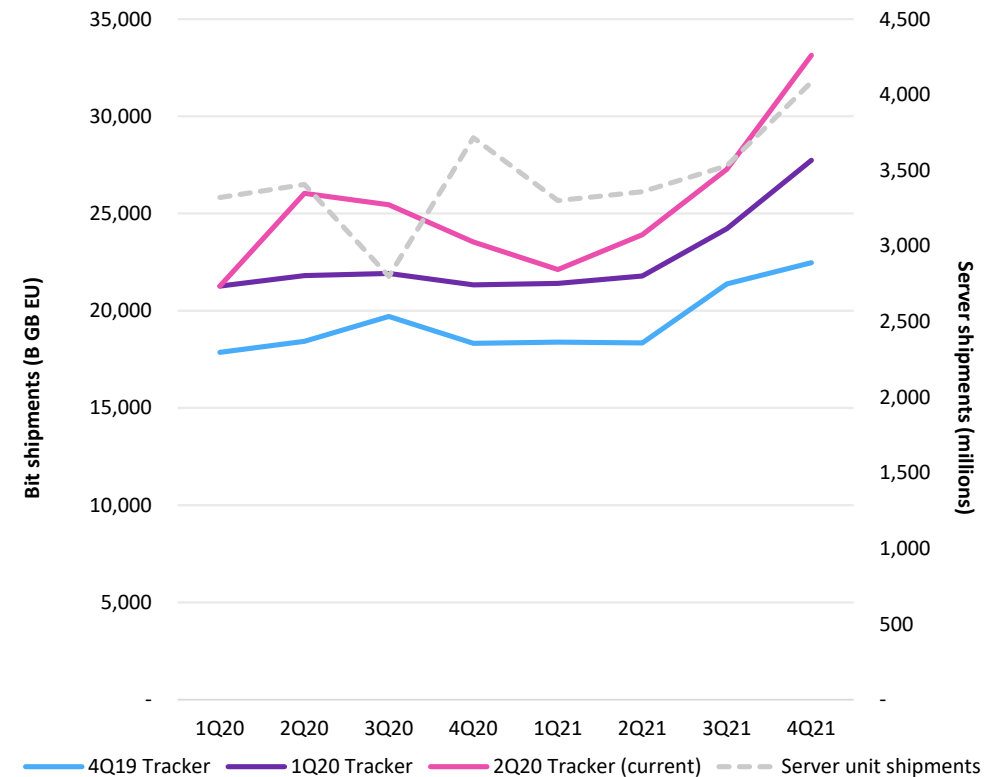
Market overview

NAND bit demand under constant change (1/3)

Enterprise

- **In 1H20**, there is an exceptional strong demand because of work-from-home (WFH), educate-from-home, and entertain-from-home mandates. Demand for storage from hyperscale data centers flourished, leading to the short supply of NAND and increasing prices.
- **In 2H20**, as anticipated, following several quarters of strong demand and buying by the enterprise/data center markets, a softening has taken place, including server shipment expectations. The softening has resulted in pricing declines, as well as inventory buildup. Despite server shipments are expected to return in 4Q20, the inventory management is expected to still be in place through the rest of 2020.
- **In 1H21**, following a server spike in 4Q20, another softening period is projected in 1H21. Enterprise demand and buying trends have shown more cyclical patterns in just the last couple of years. With only a small handful of the large hyperscalers driving a considerable percentage of demand, it only takes one of these giants to adjust its buying pattern to affect the market.

Figure 1: NAND enterprise bit demand forecast adjustments



Source: Omdia

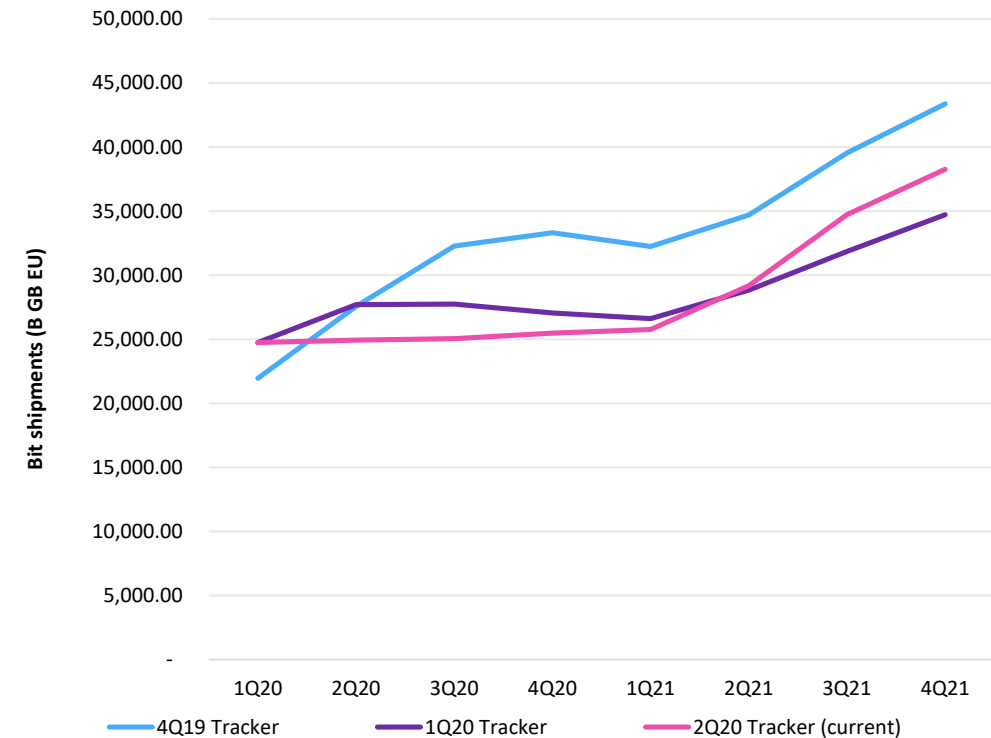
© 2020 Omdia

NAND bit demand under constant change(2/3)

Client

- **In 1H20**, demand was significantly strong in the client market early in the year; PC OEMs looked to keep up with the surging demand for PCs in conjunction with the stay-at-home environment.
 - It is analyzed that there was buy-ahead activities to build up inventory and to get ahead of any potential supply issues.
- **In 2H20**, decent signs for strong demand are shown but will not be compared to traditional seasonality that in the third and fourth calendar quarters.
- Notebook and Chromebook continue to show demand for the ongoing WFH and educate-from-home but is expected to fade by 4Q20.
 - However, Chromebooks do not bring large capacity storage so bit demand will not have a huge impact.
- **In 1H21**, the typical seasonal softening is expected but held up slightly by Chinese New Year demand. A more traditional demand scenario is then in place, with a strong second half of 2021 (2H21).
 - Should COVID-19 return in 2021, there could be buy-ahead activities in the market, similar in 2020, to try and get ahead of any potential supply-chain shortages.

Figure 2: NAND client bit demand forecast adjustments



Source: Omdia

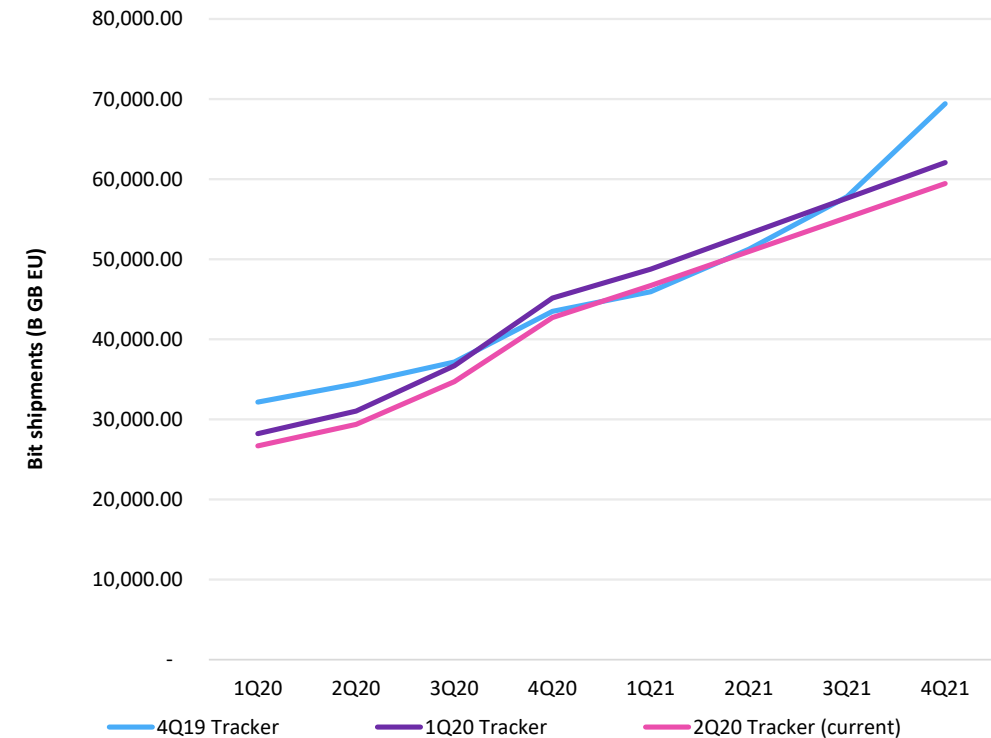
© 2020 Omdia

NAND bit demand under constant change (3/3)

Smartphone

- In **1H20**, the smartphone demand was adjusted downward as COVID-19 pandemic and lockdowns impacted the mobile markets. By 2Q20, there were some signs of strong demand in China as government subsidies continued to push 5G adoption, but these were not enough to change the impact worldwide. As a result, the inventory began to build up in **1H20**.
- In **2H20**, there was an expectation that new midrange priced and low-range priced 5G chipsets will be launched to help fuel demand. Additionally, government subsidies in China continue to push this market positively within the region. However, given the COVID-19 pandemic is still highly volatile, the overall strength of smartphone demand is a concern as struggling economies typically point toward low consumer confidence and lower consumer spending.
 - Huawei sanctions as well as potential inventory digestion could mute demand.
 - The overall mobile pricing is expected to decline in 2H20, though not as sharp previously expected.
- In **1H21**, the growth of 5G is expected to continue. Omdia expects that 5G smartphones will maintain a higher average storage capacity and will help to boost demand. With the pent-up demand from COVID-19, demand is expected to remain steady, with mobile pricing flat to down during this time period.

Figure 3: NAND smartphone bit demand forecast adjustments



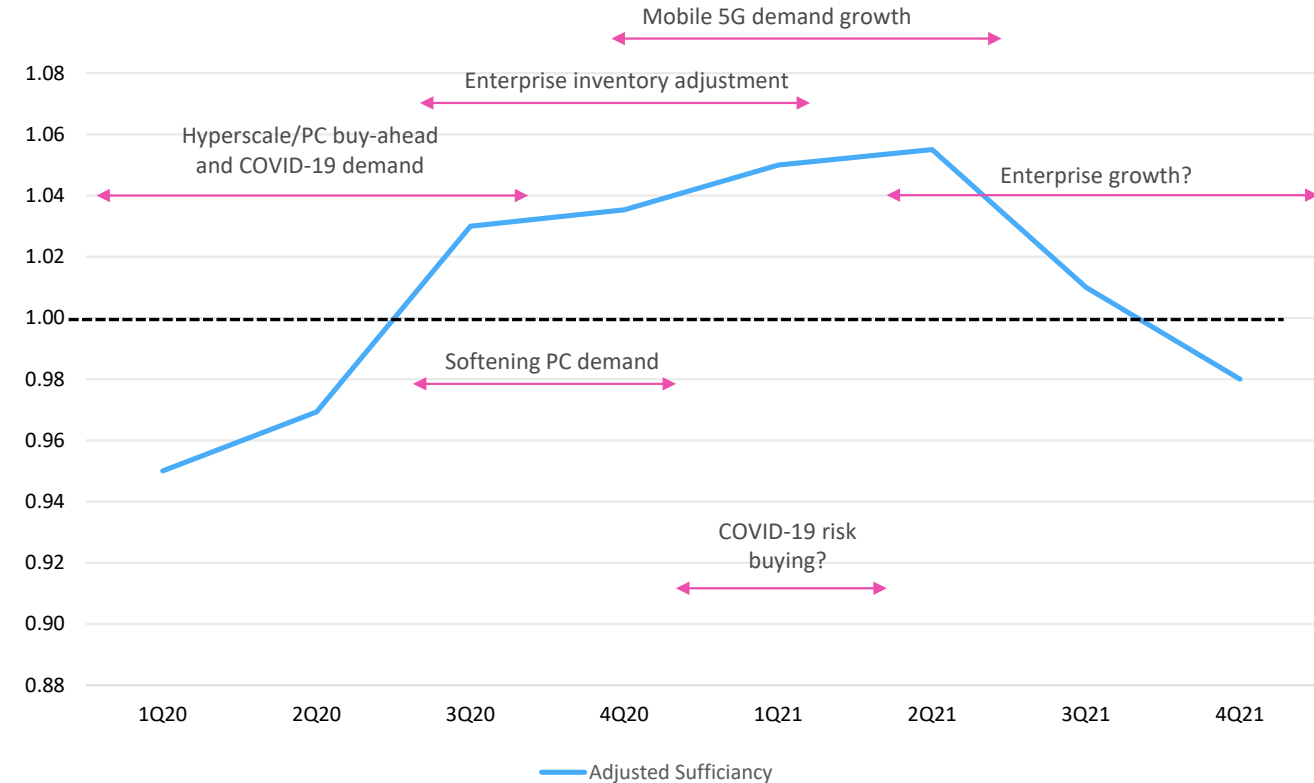
Source: Omdia

© 2020 Omdia

NAND sufficiency

- COVID-19 has brought extreme nontraditional buying activities in 2020, and this is expected to continue in 2021.
- The three major markets (enterprise, client, and mobile) remain very volatile, and any adjusted activity within any of these markets can and will impact the supply/demand balance.
- Following the undersupply market in 1H20, a positive outcome of COVID-19, with the softening of both client and enterprise markets as well as the mobile market that appears unsteady, an oversupply is projected to take place for the remainder of 2020 and continue into 2021 before the expected market correction in 2H21.
- Risk:
 - Hyperscale demand has become cyclical over the last two years. The timing and longevity of these cycles are difficult to anticipate.
 - Will there be a risk of buy-ahead activity, preparing for a possible return of COVID-19 in 2021?

Figure 4: NAND supply/demand sufficiency



Notes: Sufficiency - Shipments/ship-in demand (includes OEM inventory adjustments and build-ahead demand)

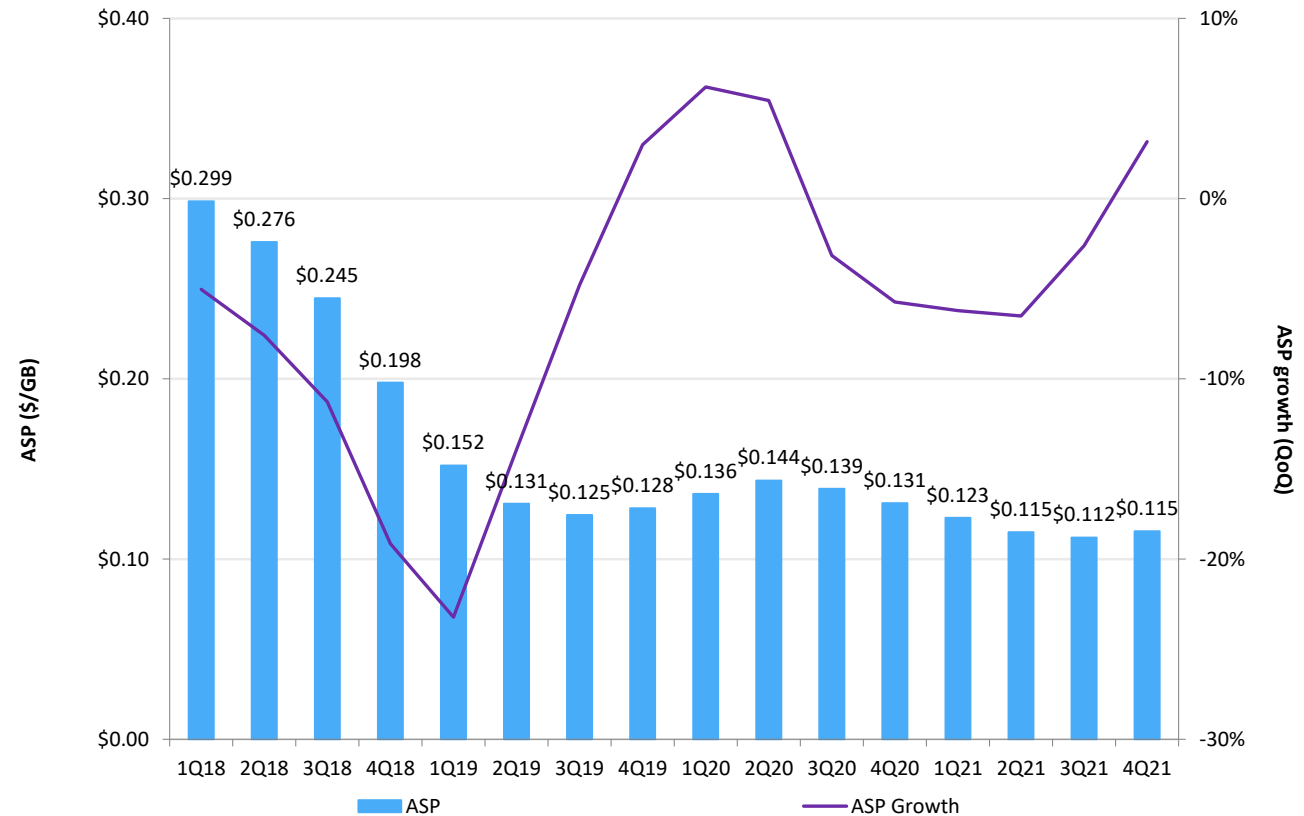
Source: Omdia

© 2020 Omdia

NAND pricing (price/gigabyte)

- NAND blended ASPs increased by 5.4% quarter-over-quarter (QoQ) in 2Q20, slightly down from the 6.2% QoQ increase in 1Q20. While COVID-19 has hurt many markets, the NAND industry did prosper during these peaks of high demand for PCs and data center storage.
- As expected, ASPs began to weaken in 3Q20 because of sluggish mobile markets, softening enterprise demand, and inventory corrections. This appears to have been slightly muted because of Huawei's buy-ahead activity to build its inventory in proportion of the US sanctions.
- ASPs are expected to continue to decline in the low-to-mid-single digit percentages in 3Q20 through 1H21. The market is then expected to have a correction in 2H21 with improving ASPs.
- Given the status of COVID-19, ASP changes will remain very volatile for the next several quarters.
- NAND ASPs are expected to decline at a 13.2% CAGR over the 2019–24 period.

Figure 5: NAND pricing



Source: Omdia

© 2020 Omdia

NAND annual revenue and ASP

- The year 2020 is currently projected to have a revenue of more than \$59 billion, down from the previous forecast projections of \$62 billion. This resulting from the unfavorable ASP conditions in 2H20, as well as a slight reduction in the bit growth for the year.
- On the other hand, considering the devastation COVID-19 has had on the world, the NAND market is still expected to show a positive YoY revenue growth of approximately 29%.
- NAND revenue for 2021 was also adjusted downward in this forecast cycle, with ASPs expected to decline in 1H21 as well as NAND manufacturers' cautious bit growth plans because of the uncertainties of COVID-19 and the impact to the markets. However, the overall NAND revenue is still expected to have a modest YoY growth of nearly 14%.
- With the anticipation that COVID-19 will be under control and vaccinations available worldwide by 2022, it is hopeful that "normal" market behavior will resume. With two strong years of revenue growth, 2022 is forecast to have strong capex investment, as well as YMTC reaching its full capacity of 100,000 wafers per month (WPM), resulting in a sharp bit growth. With enterprise demand expected to remain stable and 5G smartphones occupying the unit shipment volume, 2022 is forecast to be the peak revenue year of this cycle.
- As with any memory cycle, following a very strong 2022, a market correction is forecast to occur in 2023 before stabilizing once again in 2024.

Figure 6: NAND industry revenue and ASP

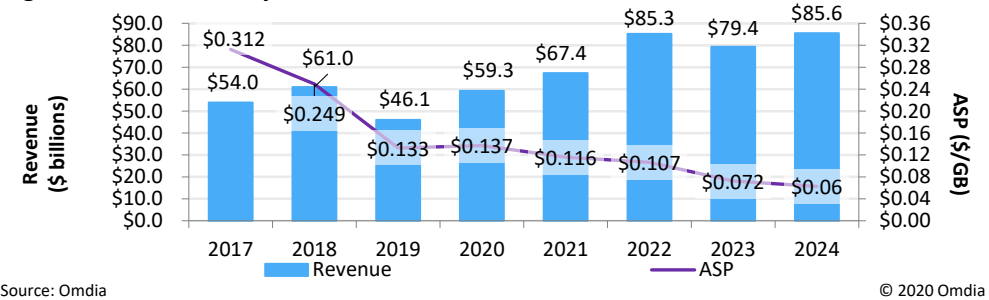
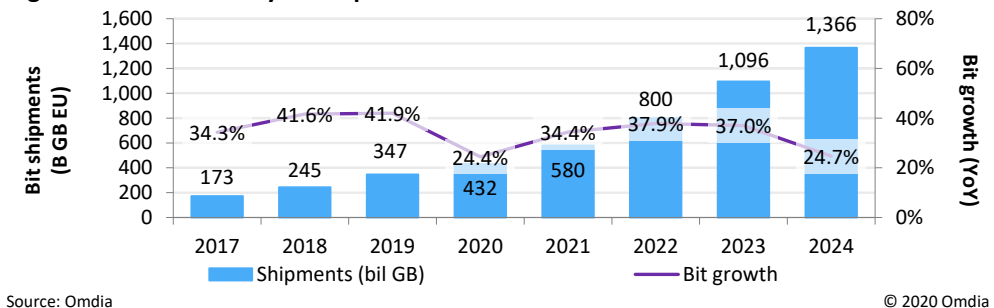
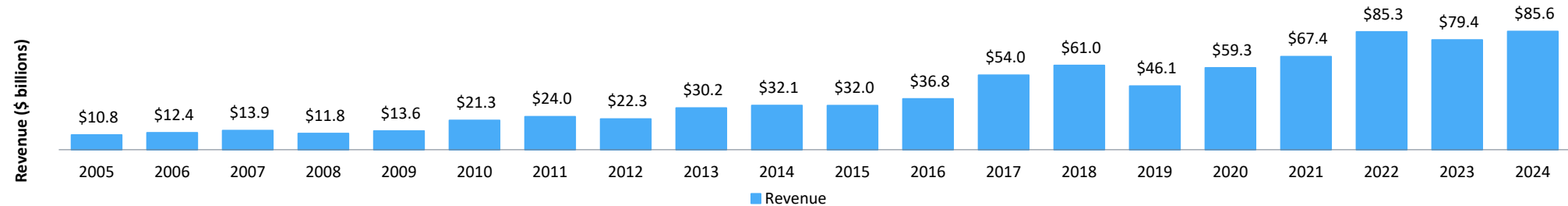


Figure 7: NAND industry bit shipments



NAND long-term market summary

Figure 8: NAND industry revenue



Source: Omdia

© 2020 Omdia

Table 1: NAND annual forecast
(millions of dollars, millions of GB EU)

	2019	2020	2021	2022	2023	2024	CAGR (2019–24)
Revenue	\$46,062	\$59,269	\$67,355	\$85,292	\$79,415	\$85,559	13.2%
% change	-24.5%	28.7%	13.6%	26.6%	-6.9%	7.7%	
1GB equiv unit shipment	347,110	431,829	580,191	799,894	1,095,532	1,366,214	31.5%
% change	41.9%	24.4%	34.4%	37.9%	37.0%	24.7%	
1GB equiv ASP	\$0.13	\$0.14	\$0.12	\$0.11	\$0.07	\$0.06	-13.9%
% change	-46.8%	3.4%	-15.4%	-8.2%	-32.0%	-13.6%	

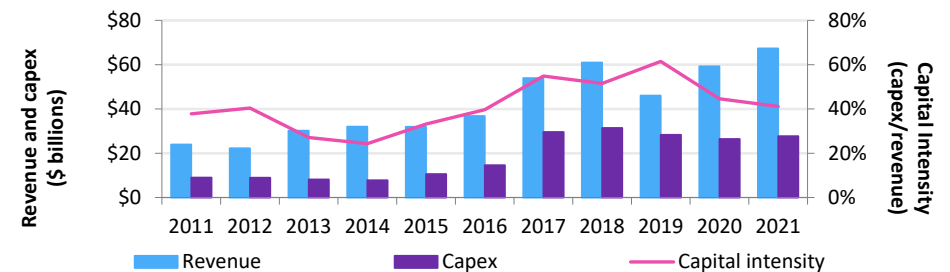
Source: Omdia

© 2020 Omdia

NAND capital intensity

- The 2020 capex is projected to fall in 2020 by 6.7% when compared with the previous year. Many NAND manufacturers started the year with a conservative approach to capex, and COVID-19 has then maintained this view.
- Although NAND manufacturers have not publicly communicated its capex plans for 2021 with COVID-19 still impacting many parts of the world, Omdia analyzes that NAND manufacturers may once again take a conservative approach to capex. Omdia is currently forecasting 2021 capex at \$27.7 billion, or an approximately of 4.9% YoY increase, and a similar conservative approach may be taken in 2021.
- All NAND manufacturers have some level of new capacity ready for wafer expansion and are expected to do so based on market conditions.
 - These fabs include Samsung's at Pyeongtaek, South Korea and Xi'an, China.
 - Kioxia and WD are ramping up their new facility Fab 6, in Yokkaichi, Japan as well as their new facility in Kitakami, Japan.
 - Micron has been expanding its Singapore-based manufacturing facility adjacent to its current fabs 10N and 10X.
 - SK hynix is expected to begin a meaningful ramp-up of its fab in Cheongju, South Korea.
 - YMTC is ramping up its new facility in Wuhan, China.
- The NAND industry will also need to continue to invest in next-generation technologies such as the 128-layer.

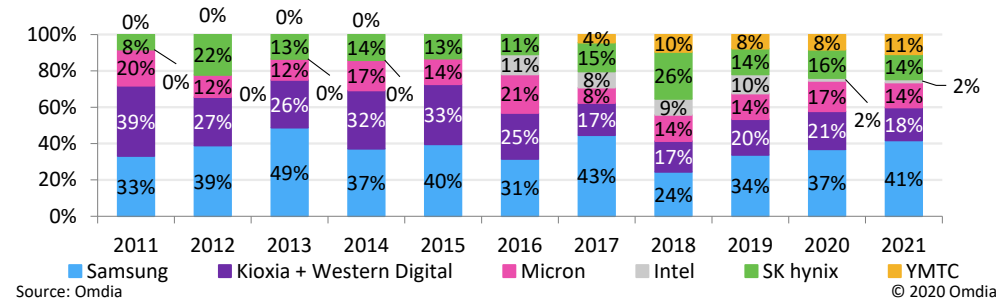
Figure 9: NAND capex, revenue, and capital intensity



Source: Omdia

© 2020 Omdia

Figure 10: NAND capex % spend by supplier



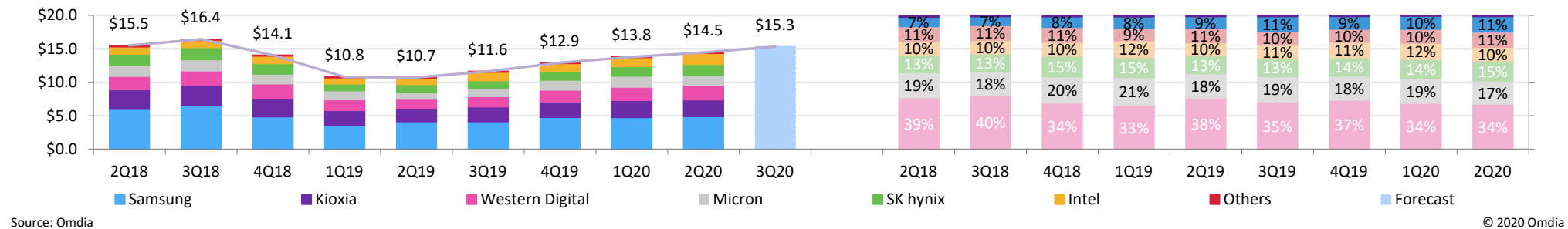
Source: Omdia

© 2020 Omdia

Market share

NAND quarterly revenue

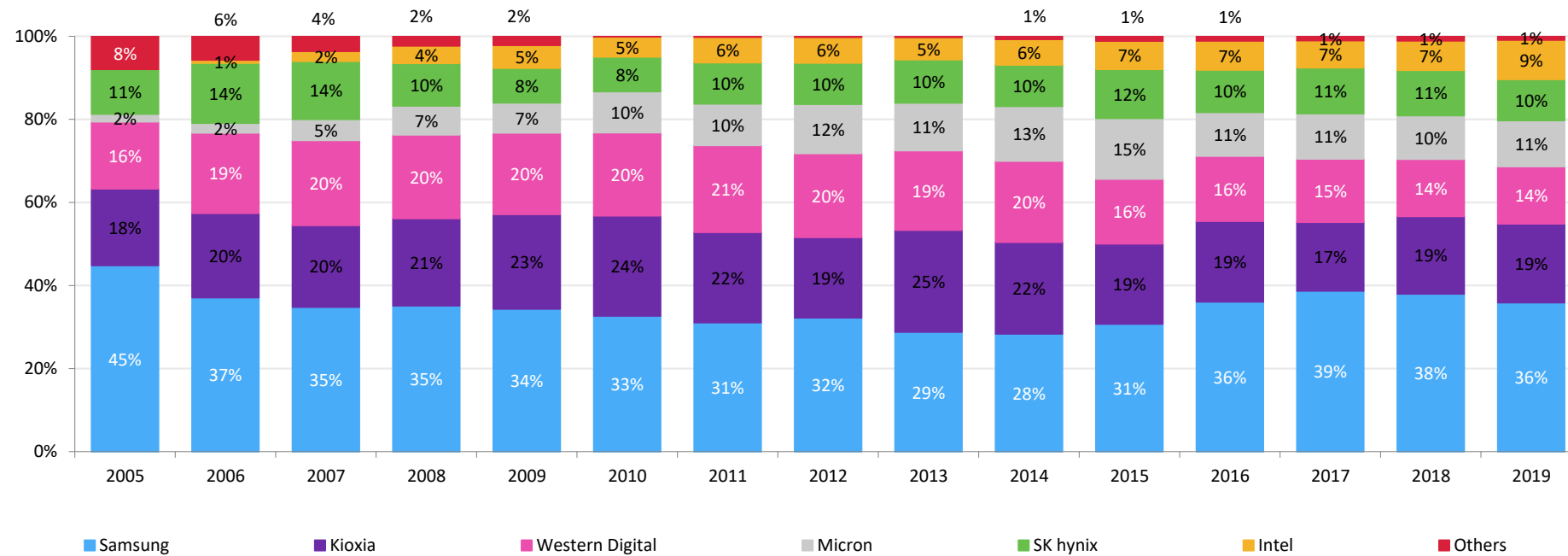
Figure 11: NAND revenue in billions of dollars



- NAND revenue increased by 4.9% QoQ in 2Q20, to less than \$14.5 billion.
 - Looking ahead to 3Q20, it is projected NAND revenue will continue to improve and reach \$15.3 billion.
- Samsung remained in the top position for the revenue market share in 2Q20, with 33.8%. Samsung has a three-percentage point decline since the beginning of 2020. While it has increased its ASPs during this period, Samsung's bit growth has been muted.
- Kioxia finished 2Q20 second in the revenue market share at 17.3%, also down from its 1Q20 mark of 18.6%. WD was third with a 15.0%, a slight improvement from its previous quarter's mark of 14.4%.
- Micron and SK hynix rounded out the top 5 for the NAND revenue share. Micron's revenue share slipped nearly two percentage points with a declining QoQ bit growth, while SK hynix's revenue share improved by a full percentage point with an aggressive QoQ bit shipment growth.

NAND historical revenue market share

Figure 12: NAND annual revenue market shares



Source: Omdia

© 2020 Omdia

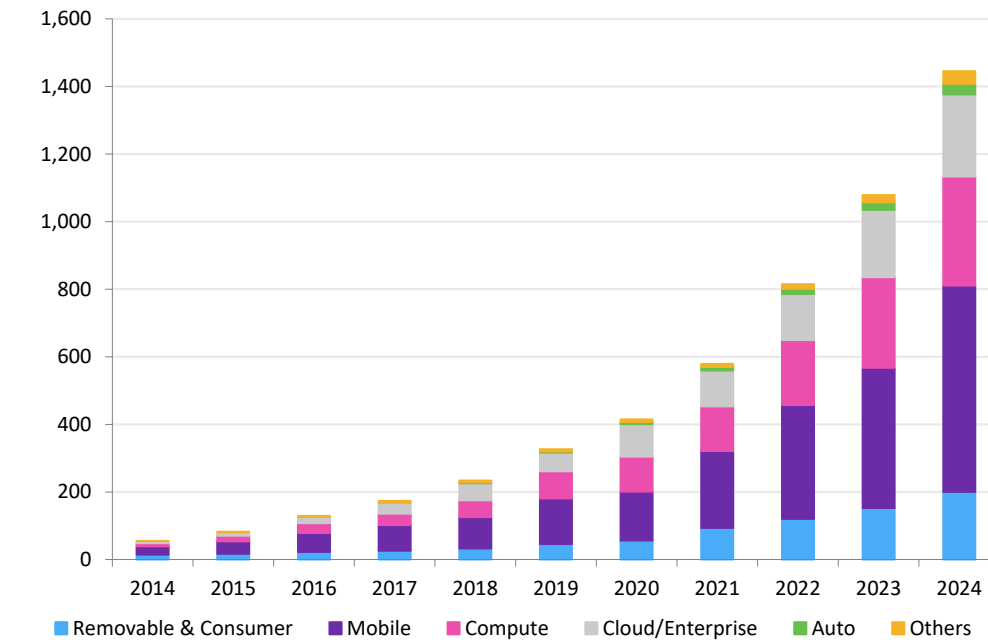
Demand environment

NAND demand summary (1/2)

- NAND bit demand is expected to grow at a 34.6% CAGR over the 2019–24 period, slightly ahead of the projected NAND bit production CAGR of 31.5%.
- The three major markets—enterprise solid state drive (SSD), client SSD, and mobiles—which make up more than 80% of worldwide bit demand, are expected to have robust demand throughout the forecast period. However, these markets will fluctuate in the years to come, moving in and out of unique cycles of demand.
 - The mobile market is and will continue to be the largest consumer of NAND flash with approximately 40% of total bit demand. Because of 5G, there will be a strong demand in the coming years, with higher average storage capacity than its 4G predecessor. Omdia adjusted the smartphone average capacities down this cycle, in line with the new market forecasts and ASP trends now.
 - The compute markets, which consist of the PC and tablet markets, make up the second-largest demand. While the market is shrinking in terms of system shipments, SSD capacity growth capabilities along with expected long-term NAND price reductions will help drive higher capacity drives. SSDs are still replacing traditional hard disk drives (HDD) in PCs, and SSD upgrades will continue.
 - Today, these two categories alone represent approximately 60% of total NAND demand. This is projected to grow to approximately 65% by the end of the forecast period.
 - Cloud/enterprise is expected to account for 23% of total NAND bit demand in 2020, thanks to the strong year. Going forward, it is projected that this market will drive less than 20% of total bit demand. While the overall percentage is not as large as the mobile and compute markets, the market itself is of high priority to NAND manufacturers; based on its market performance in the last couple of years, it can be very cyclical in nature and drive industry-wide supply/demand imbalances.
- The gaming console industry in 4Q20 is also expected to boost the NAND industry, as both Sony's PlayStation and Microsoft's Xbox are releasing their latest gaming systems. Both are moving away from the traditional hard drive storage to the high-capacity SSD. Both systems are expected to be launched over the 2020 holiday season.

NAND demand summary (2/2)

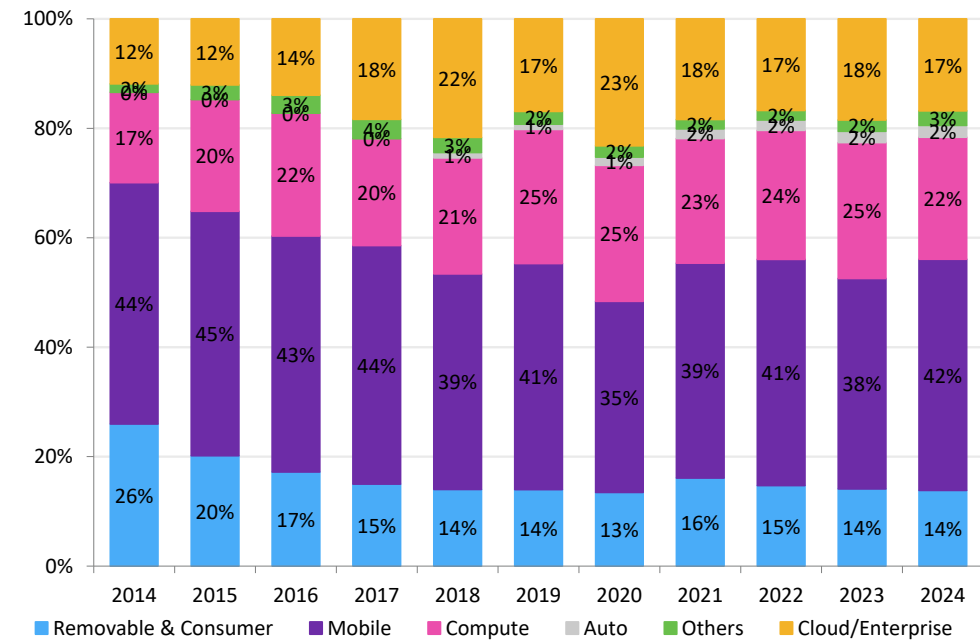
Figure 13: NAND flash application demand – 1GB equivalent units (billions)



Source: Omdia

© 2020 Omdia

Figure 14: NAND flash application demand – % of bits



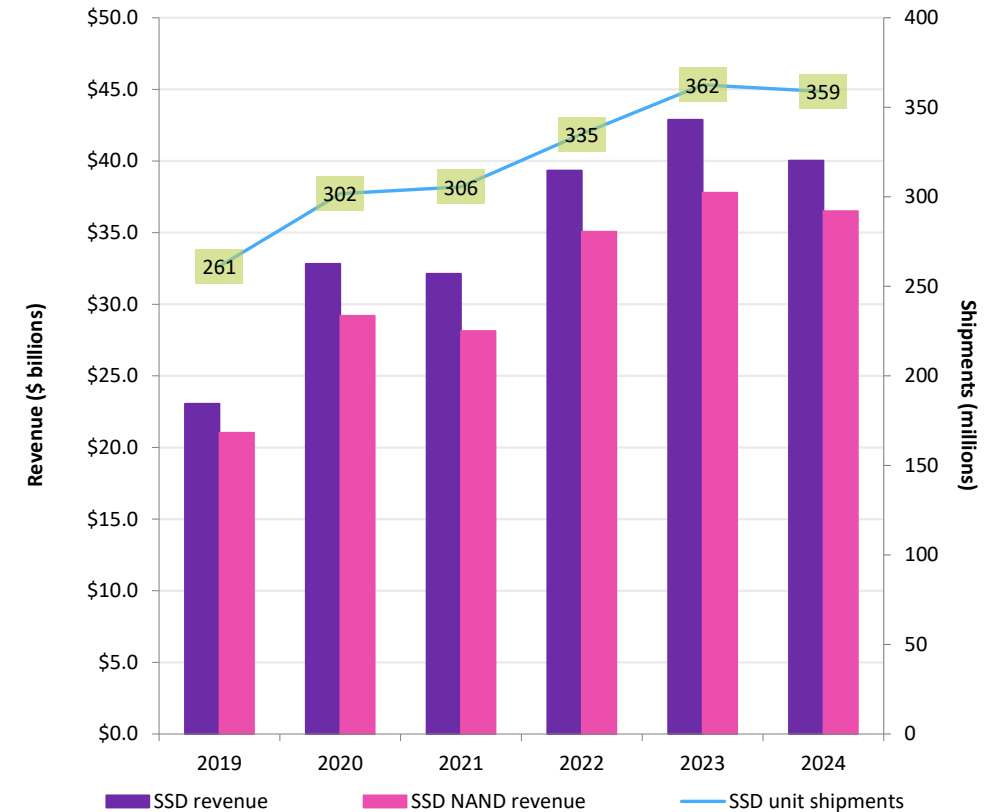
Source: Omdia

© 2020 Omdia

SSDs – Summary

- The total revenue from SSDs increased by 13.7% QoQ in 2Q20 to approximately \$8.9 billion. SSD unit shipments increased by 4.4% QoQ in 2Q20 to 77.7 million units.
 - Momentum for the client SSD markets continued into the second quarter, with strong demand because of stay-at-home environments during this period. Revenue for the client SSD market increased by 4.0% QoQ to \$3.5 billion, while unit shipments increased by 1.8% QoQ.
 - While the client SSD market is expected to soften in 2H20, the overall client SSD unit shipments for 2020 are projected to increase by 9.5% YoY.
 - Enterprise SSD demand continued to be strong in 2Q20, with shipments increasing an impressive 20.6% QoQ. To put this into perspective, in comparison with a year earlier in the second quarter of 2019 (2Q19), enterprise SSD units have grown more than 125% YoY.
 - Revenue for enterprise SSDs also increased by 22.2% QoQ to more than \$5.1 billion.
- The enterprise SSD market increased by 1.5% QoQ in average capacity during 2Q20, while client SSDs declined 1.1% QoQ. This was likely an effect of more Chromebooks/educational notebooks that shipped during the quarter because of educate-from-home situations.
- SSD unit shipments and revenue are forecast to grow at CAGRs of 3.5% and 4.0%, respectively, through the 2019–24 period.

Figure 15: SSD revenue and shipment



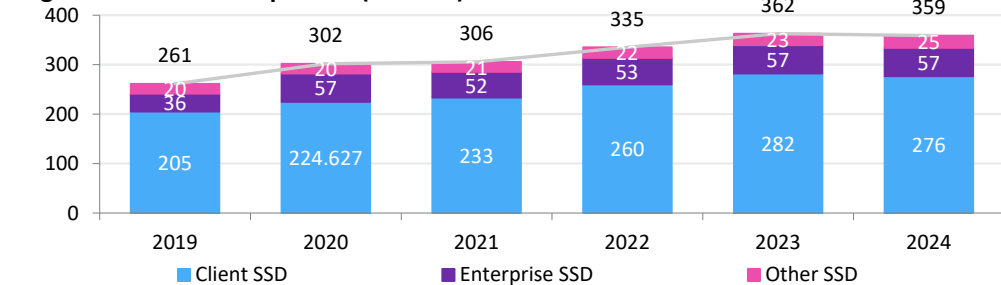
Source: Omdia

© 2020 Omdia

SSDs – Client and enterprise

- In 2020, client SSD shipments rise 9.5% YoY to approximately 225 million units. Client SSDs are projected to be 74% of all SSD unit shipments in 2020.
 - With a mix of virtual education and in-classroom education in 2H20 still taking place around the world because of COVID-19, demand for educational notebooks such as Chromebooks, will still be robust. However, this demand will not drive significant NAND bit demand as these systems typically have much smaller storage average capacities. By 4Q20, the client SSD market is projected to soften further as traditional seasonal demand is muted because of the strong demand throughout the year.
 - Thanks to the tremendous strong demand in 1H20, enterprise SSD shipments are now expected to increase substantially by 58.8% YoY to more than 57 million units in 2020. COVID-19, WFH, and educate-from-home mandates have driven this growth.
- The enterprise SSD average capacity is expected to reach nearly 1.7 terabyte (TB) in 2020, while the client SSD average capacity is projected to be 446 gigabyte (GB) in 2020.
 - As a result of the much-higher-capacity drives, enterprise SSDs are forecast to account for 48% of the total SSD bit demand in 2020.
 - Demand for peripheral component interconnect express (PCIe) nonvolatile memory express (NVMe) drives exploded in 2Q20 and has now pushed the projection to show PCIe occupying the volume of the interface shipments in 2020 for enterprise SSDs. By 2024, PCIe NVMe SSD drives will be more than 60% of all enterprise SSD units shipped, while SATA drives are projected to decline to 30% of the market.

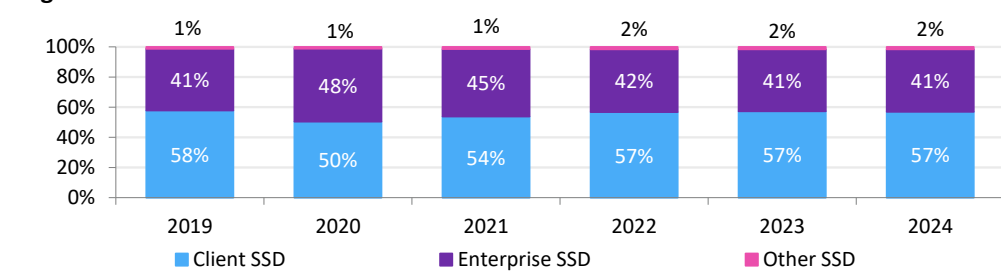
Figure 16: SSD unit shipments (millions)



Source: Omdia

© 2020 Omdia

Figure 17: SSD NAND bit mix



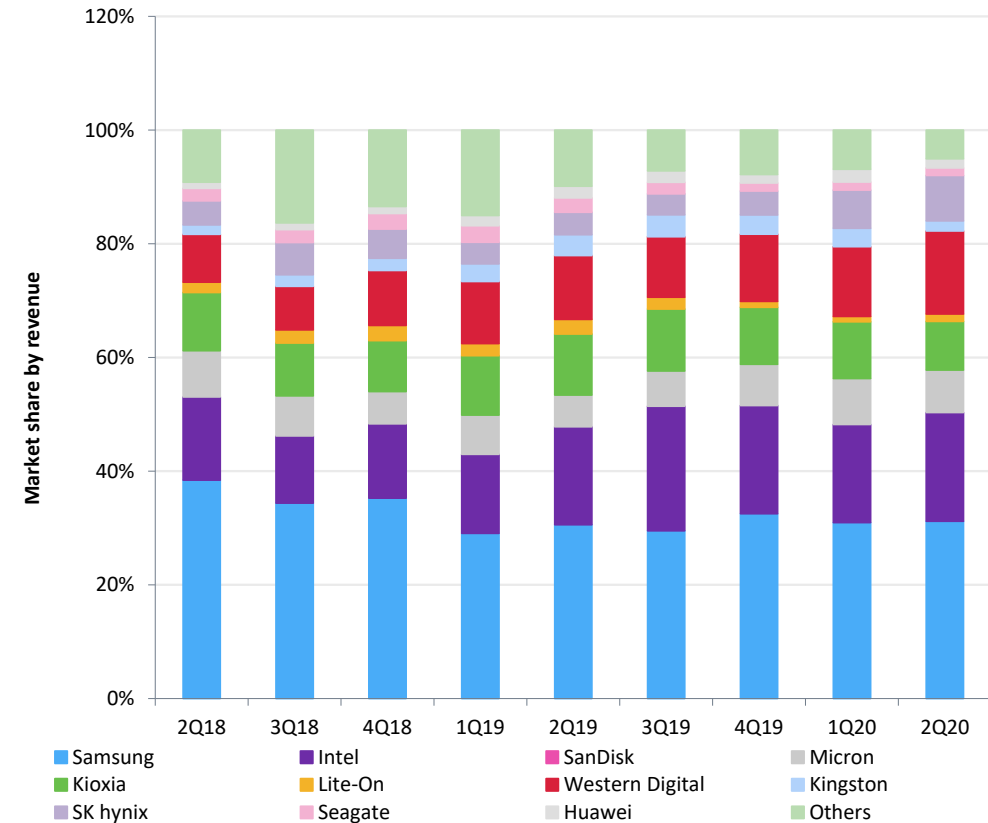
Source: Omdia

© 2020 Omdia

SSD revenue market share

- In 2Q20, Samsung had approximately \$2.8 billion in total SSD revenue, resulting in a 31.0% market share. Its QoQ revenue increased by 14.6% but relatively unchanged in terms of revenue market share from the previous quarter.
- Intel continued to hold the second position in the total SSD revenue market share, with \$1.7 billion in the total SSD revenue during 2Q20. This resulted in a QoQ increase of 26.1%. Intel focused heavily on the higher-value enterprise SSD markets, which resulted in the company's higher overall SSD revenue market share of 19.1%.
- WD recorded \$1.3 billion of the total SSD revenue during 2Q20, another impressive QoQ improvement of 35.3%, bumping the company's revenue market share by two-percentage points, landing at 14.6%.
- Only one percentage point separates the third, fourth, and fifth companies in revenue market share.
 - Kioxia landed in the third spot with \$760 million and an 8.6% share.
 - SK hynix finished the quarter at \$711 million and with an 8.0% share.
 - Micron had \$633 million in SSD revenue, with a 7.5% share.

Figure 18: SSD revenue market share



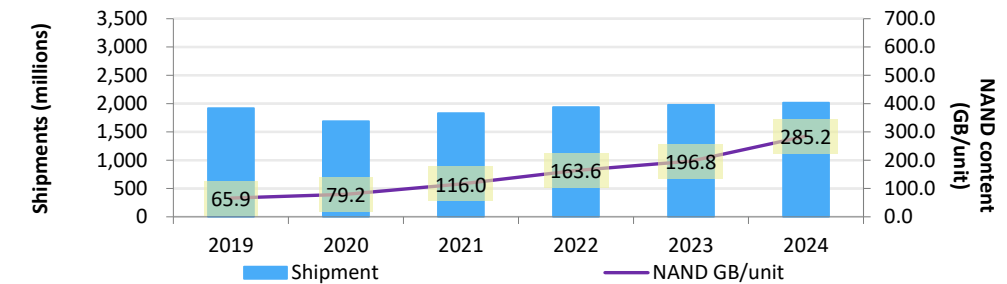
Source: Omdia

© 2020 Omdia

Mobile handsets – Summary

- Expectations have been that smartphone shipments will improve in 2H20 compared with 1H20. Omdia's mobile research is now showing that 2H20 will improve by 10% over 1H20; however, when comparing 2H20 with 2H19, shipments in 2H20 will decline by 13% YoY.
 - The overall NAND bit demand growth for the smartphone market is expected to be 5.2% YoY in 2020.
- The impact from COVID-19 on the smartphone market remains at play, and while there are positive signs in 2H20, economic impacts around the world have reduced consumers' immediate need to upgrade. Additionally, consumers have been opting for lower-priced handsets, which have slowed the average gigabyte per unit to a 21% YoY growth. This compared with the previous year's growth of approximately 48%.
- It is expected that low-tier and mid-tier 5G chipsets will be launched in 2H20 to boost consumer demand. There remains a cautious optimism that the smartphone market will rebound in 2H20; however, recent activities suggest this may not come to fruition.
 - Positively speaking, the smartphone market will rebound; it is just a matter of when and how fast. The growth of 5G will be rapid; governments will push 5G technology deployment, and the overall NAND bit demand growth will resume.
 - Omdia predicts that the markets will have a much stronger year in 2021, with the NAND bit demand growth to improve dramatically to 59% YoY.
- Shipments of 5G in 2020 are projected to be 18% of all smartphone shipments in 2020.

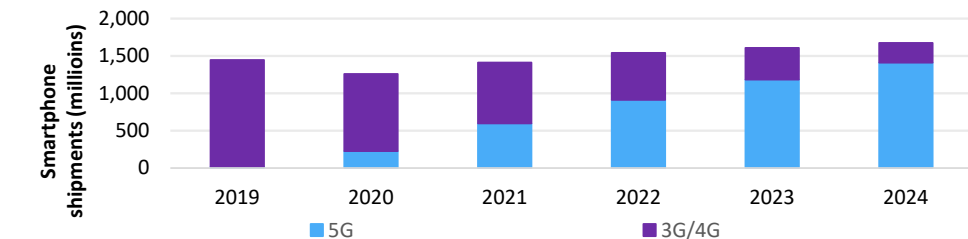
Figure 19: Mobile handset forecast



Source: Omdia

© 2020 Omdia

Figure 20: Rise of 5G smartphones - unit shipment forecast



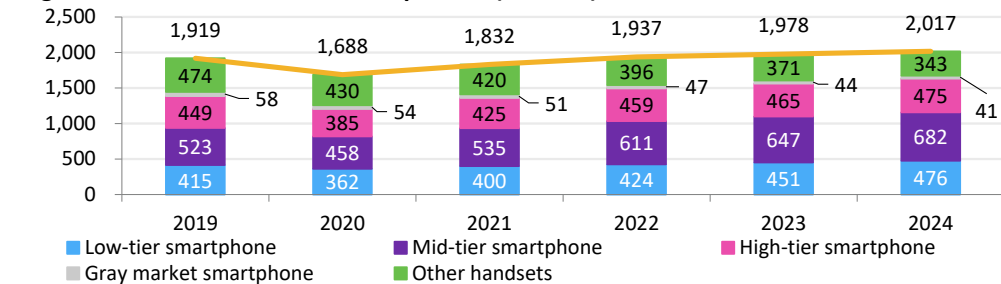
Source: Omdia

© 2020 Omdia

Mobile handsets – Smartphone breakout

- The impact from the early introduction of 5G smartphones was real, with many high-tier models having 256GB of NAND storage.
 - The overall capacity average of a 5G smartphone in 2019 was 247GB, considerably higher than the 153GB of non-5G high-tier smartphones.
- With new low-cost 5G solutions coming into the market in 2H20, the overall 5G smartphone average will fall considerably, especially as these volumes pick up.
- It is not expected that 5G smartphones will enter in the capacity of less than 64GB, and it is analyzed that 128GBs will likely be more of the sweet spot, even for the low-/mid-tier smartphones. Thus, the overall impact of 5G smartphones will certainly still be relevant.
- Despite the usage of cloud storage for many smartphone users, onboard storage will still be a critical and differentiating factor to many smartphone companies. As NAND manufacturers move to the next NAND layer-count roadmap and reduce price per gigabyte, this will only enable smartphone manufacturers to continue to push for higher and higher onboard storage capacities.
- Overall, smartphone average capacity is expected to grow by 21.3% YoY in 2020, climbing to 106GB per smartphone unit. In 2021, this is expected to accelerate, climbing to a 150GB average smartphone, resulting in a YoY average capacity growth of 41.8%

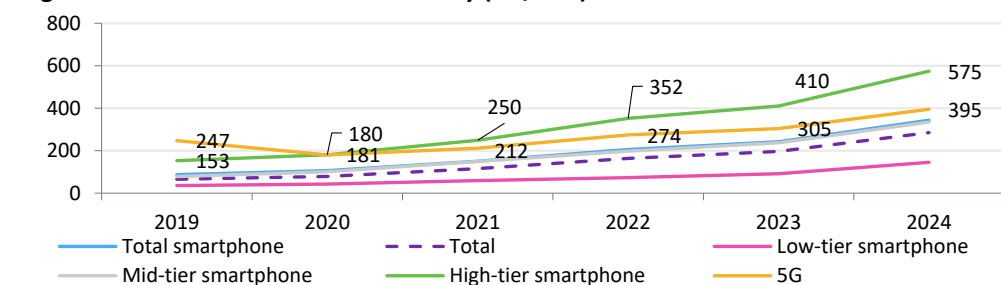
Figure 21: Mobile handset unit shipments (millions)



Source: Omdia

© 2020 Omdia

Figure 22: Mobile handset NAND density (GB/unit)



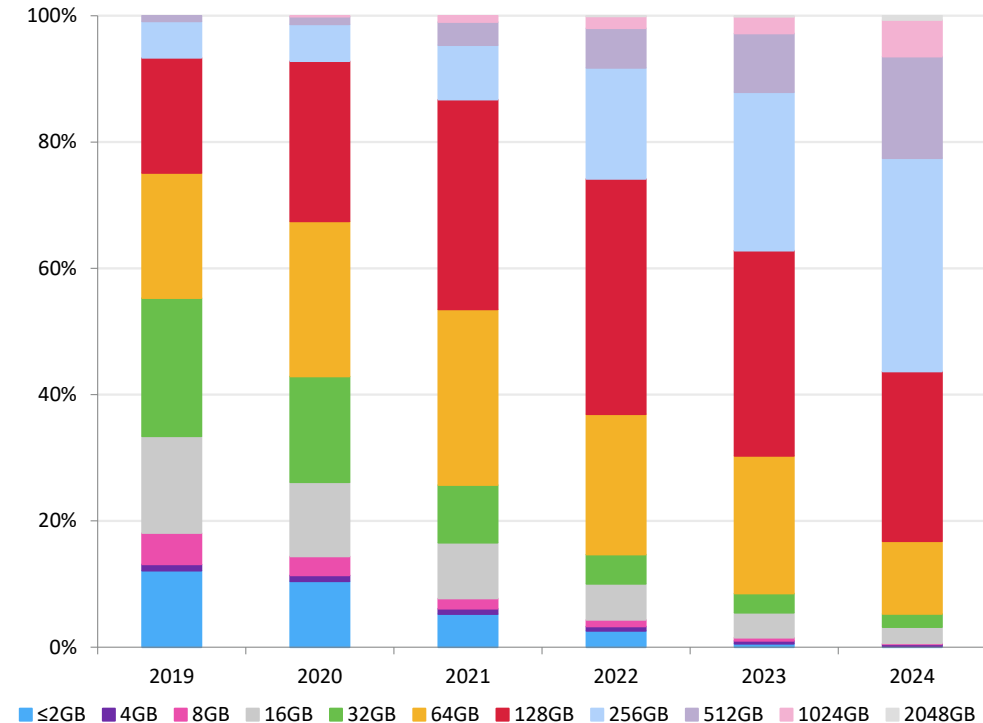
Source: Omdia

© 2020 Omdia

Mobile handset – Density mix

- NAND-based storage capacity continues to be a differentiator in the smartphone market.
 - Within the mix of high-tier, mid-tier, and low-tier smartphones, there is a wide variance of storage capacities with each to fit within a specific consumer pricing point and to meet other technical requirements.
 - Vendors will load high-end models with a very high-capacity storage to show the possibilities, although these high-end models are produced at a much lower volume.
 - In late 2019, 128GB surpassed 64GB to become the mainstream capacity option and is expected to maintain this position throughout 2020 and the coming years.
 - For 5G smartphones, with low-/mid-tier models to hit the market in 2020, what capacities the low-tier models will support is still unknown. Omdia currently forecasts that the upcoming 5G smartphones will have no less than 64GB of storage.
- UFS 3.0 is expected to quickly ramp up thanks to its performance increase over universal flash storage (UFS) 2.1, while embedded multimedia card (eMMC) adoption is predicted to decline as a result.
 - Outside of pure capacity, storage technology such as UFS 3.0 continues to be a differentiating factor that handset makers will use to distinguish themselves from their competitors.

Figure 23: Mobile handset unit density mix



Notes: Only includes handsets with embedded NAND

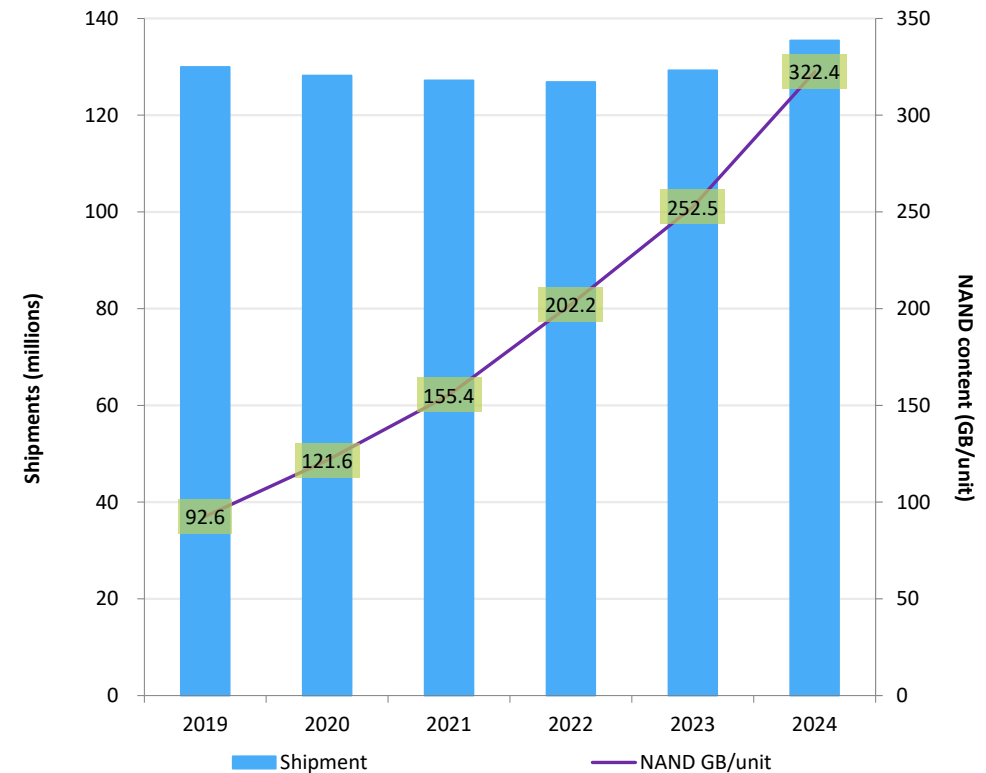
Source: Omdia

© 2020 Omdia

Tablet summary

- Tablet shipments are expected to stay relatively flat during the forecast period, held up by educational demand with Android-based notebooks as well as Apple's iOS tablets.
- There was a short uptick in demand because of COVID-19, the resulting online education requirements and a spike in Android-based Chromebooks. However, this is likely not enough to show any kind of YoY system growth.
- Additionally, the NAND content growth slowed because Chromebooks have a smaller average GB/system.
- The average NAND content in the tablet is not expected to grow to 121.6GB in 2020, which is a 31% YoY increase. This is down from the average 126GB NAND content in the previous forecast. The overall CAGR of 33.6% for the density growth is expected through 2024.

Figure 24: Tablet forecast



Notes: HDD-based tablets excluded

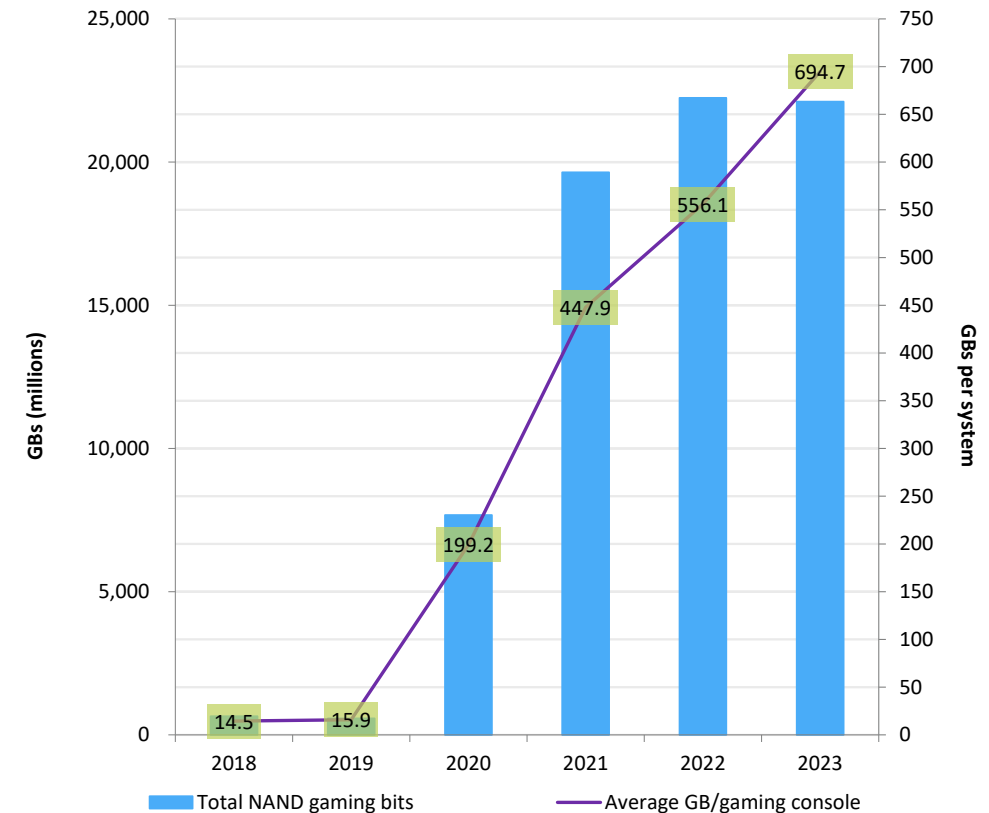
Source: Omdia

© 2020 Omdia

Gaming console summary

- Traditionally, the major gaming consoles have used HDD storage.
- Both Sony and Microsoft will be launching their next-generation gaming consoles, which are expected around the holiday season in 2020. It has been announced that both systems will be moving to a custom SSD for storage.
 - Sony's next gaming console, PlayStation 5 (PS5), is projected to move to an 825GB SSD. The PS5 will also have an M.2 expansion slot for additional storage.
 - Microsoft's next gaming console, Xbox Series X, is projected to move to a 1TB SSD. The Series X will also have an expansion slot to accommodate a custom 1TB Seagate card.
- Both systems are expected to bring a strong boost to NAND demand for 4Q20. As gaming consoles tend to be seasonal (strong holiday shipments), an effect will only occur in 4Q20.
- For 2021, it is projected these two gaming consoles will account for 3.4% of the total NAND industry bit demand, up significantly from 2019 (prior to these new systems) when the gaming consoles only accounted for 0.2%.

Figure 25: Gaming console forecast



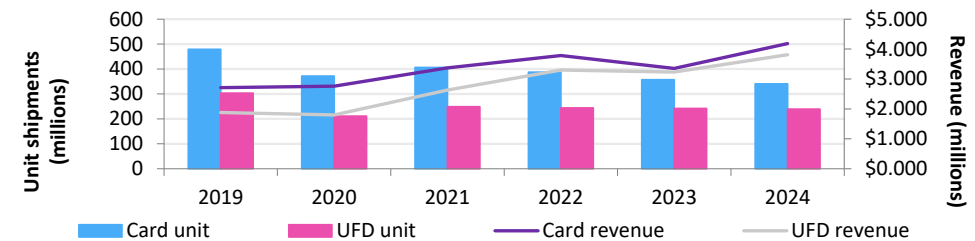
Source: Omdia

© 2020 Omdia

Removable flash storage devices

- Both the card and the USB flash drive markets took considerable downturn in terms of unit shipments in 2Q20 because of COVID-19. With stay-at-home mandates around the world, consumers did not find the need or ability to get to retail outlets or focused spending on other consumer goods.
 - The card market is expected to decline by 22% YoY in 2020, while the UFD market is expected to decline by 30%.
 - Revenue for the card market is projected to be approximately \$2.7 billion in 2020, while the UFD market is forecast to be \$1.8 billion.
- ASPs improved during 1H20 to balance the fall in units. Revenue for both the card market and the UFD market is expected to stay relatively flat in 2020 when compared with 2019.
- In the long term, revenue CAGRs for the card and UFD markets are expected to increase during the 2019–24 period, but this can rapidly change based on specific market conditions and pricing environments.
- The aftermarket microSD cards for mobile handsets continue to drive demand for flash cards.
- WD (formerly SanDisk) continues to be the undisputed leader in the removable storage market.

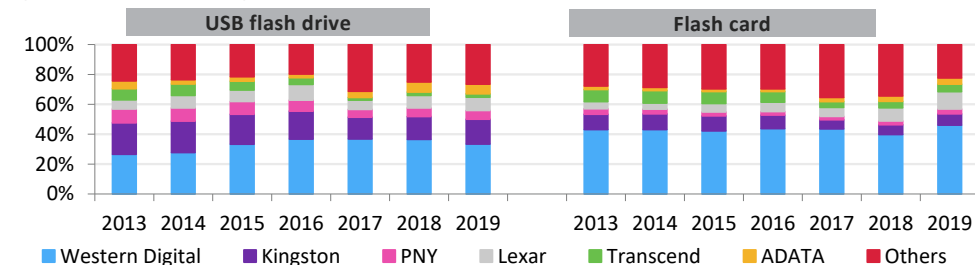
Figure 26: Flash card and UFD shipment and revenue



Source: Omdia

© 2020 Omdia

Figure 27: Flash storage device revenue market share



Source: Omdia

© 2020 Omdia

Flash card summary

Figure 28: Flash card density mix by units

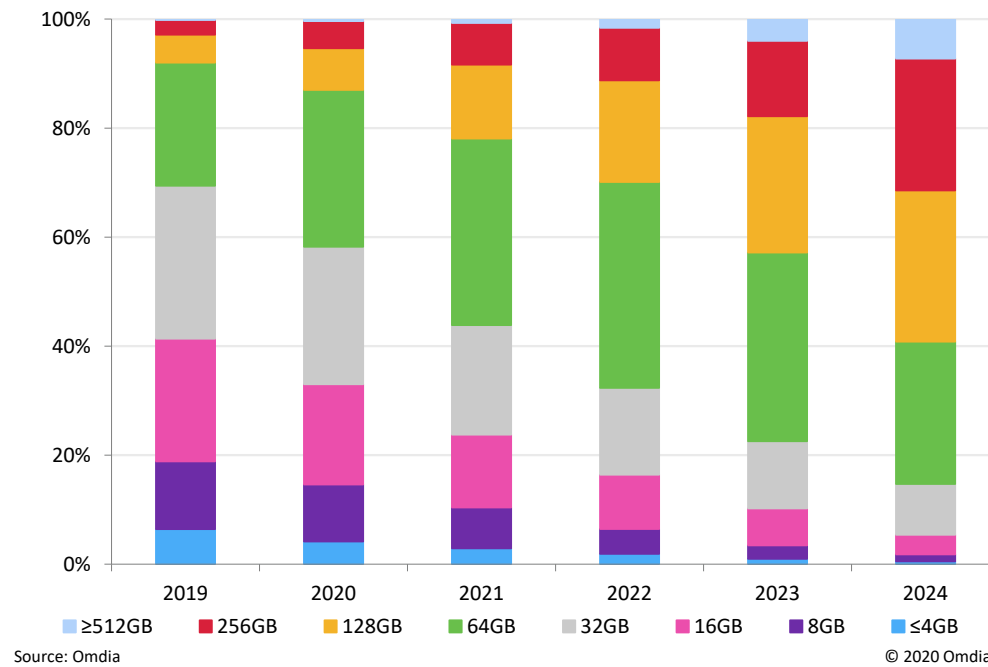


Figure 29: Flash card demand by application (millions of units)

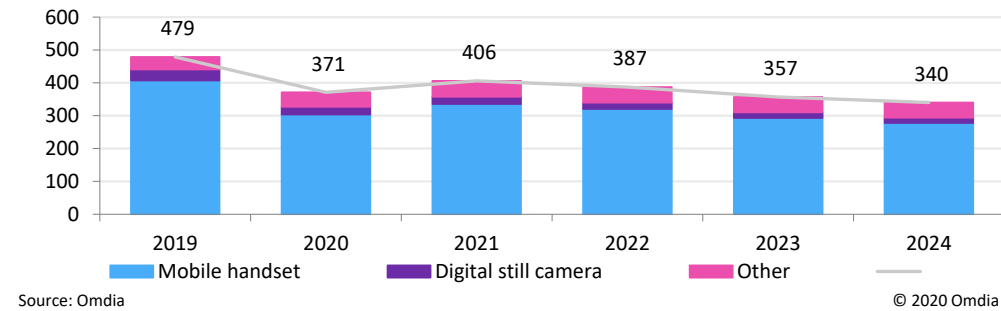
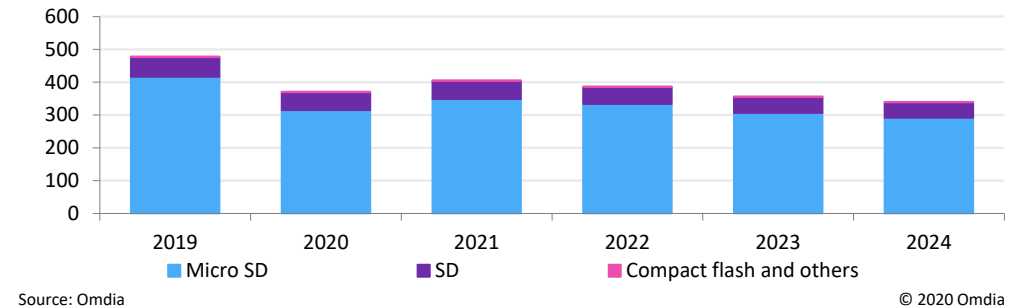
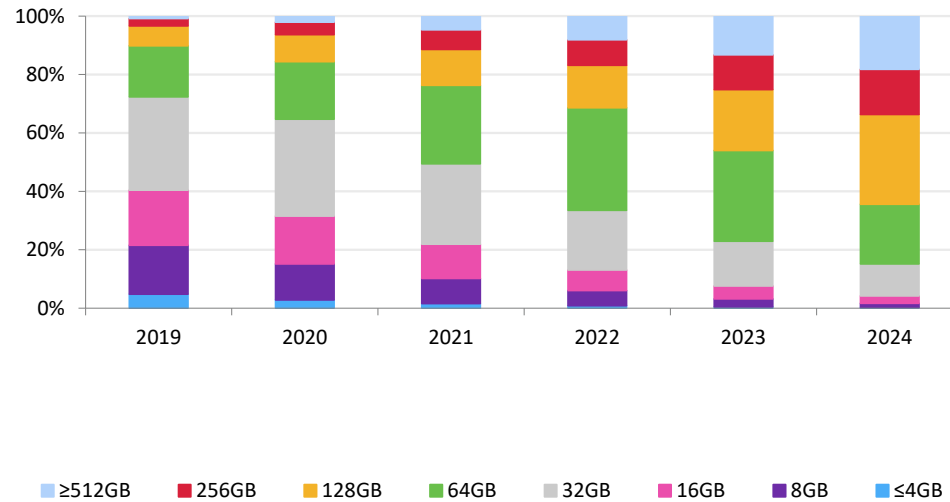


Figure 30: Flash card shipments by form factor (millions of units)



UFD summary

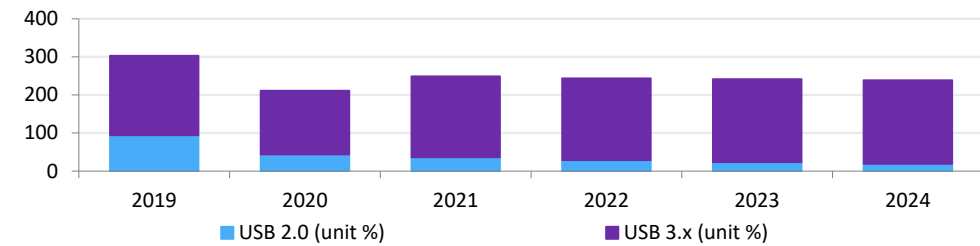
Figure 31: UFD density mix by units



Source: Omdia

© 2020 Omdia

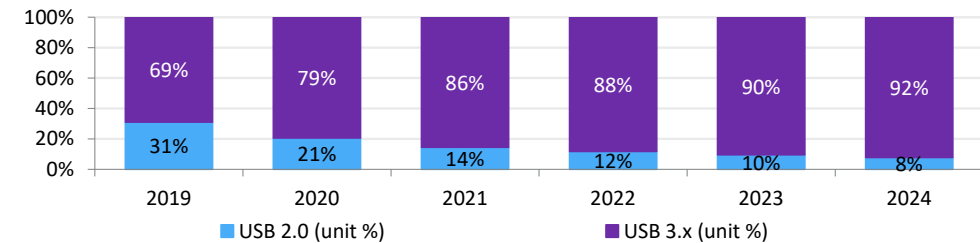
Figure 32: UFD shipment by type (millions of units)



Source: Omdia

© 2020 Omdia

Figure 33: UFD shipment by type (percent of total)



Source: Omdia

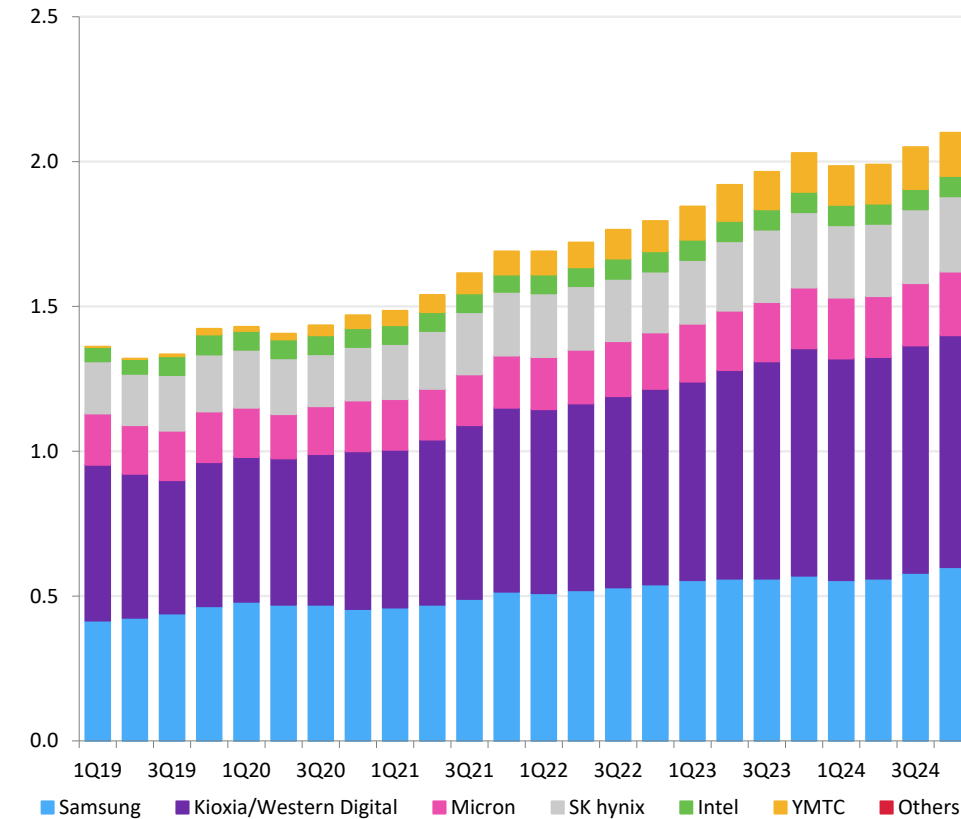
© 2020 Omdia

Supply environment

NAND industry wafer capacity

- The industry wafer starts per month (WSPM) were approximately 1.406 million in 2Q20, down slightly QoQ but an increase of approximately 6.5% YoY.
- Omdia is forecasting a 2020 YoY wafer growth to be in mid-single digits but a growth of approximately 10% YoY for 2021. COVID-19 will have an impact here as to how aggressive vendors want to be in 2021.
 - Should COVID-19 return in the winter months, the wafer starts outlook could become more conservative as NAND manufacturers wait to see how demand is affected.
- The Kioxia/WD camp maintained the largest base of NAND capacity in 2Q20 with approximately 36% of the total industry wafers, followed by Samsung with 33% of industry wafers.
- SK hynix and Micron accounted for 14% and 11%, respectively, in 2Q20.
- Intel's wholly owned fab in Dalian, China accounted for 5%.
- The future wafer growth is expected to be maintained as demand warrants.

Figure 34: Industry wafer capacity (millions of WSPM)



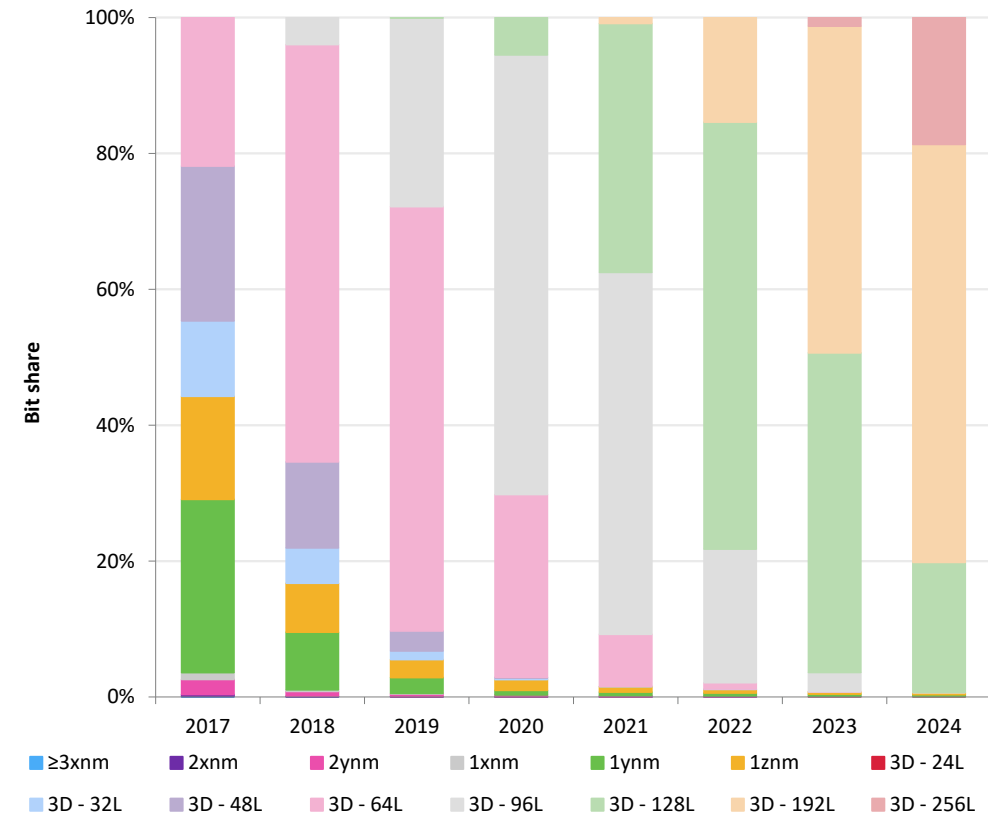
Source: Omdia

© 2020 Omdia

NAND lithography transitions (1/3)

- The production of 96-layer took over that of 64-layer earlier in 2020 to occupy the NAND bit volume. Omdia projects 96-layer will remain as the volume output through most of 2021, giving the next-generation 128-layer time to mature and for yields to improve. As the industry continues through the layer-count roadmap, yield and maturity will take longer to reach appropriate mass production levels.
- in 2020, 96-layer will account for 65% of total NAND bit production, while 128-layer will account for 5.5%. By 2021, 96-layer will account for 53% of bit production while 128-layer will grow to 37% overall for the year.
 - There will be variances in the industry's 128-layer by vendor. As an example, Kioxia and WD announced a 112-layer while Intel announced a 144-layer.
 - Omdia expects that layers counts beyond "128-layer" will continue to vary by vendor. Omdia currently is showing "192-layer" as the next layer count, then followed by a "256-layer." As vendors announce their next-generation layer counts, Omdia will continue to update the data set.
- The 12nm process node will be the final generation of planar NAND. Planar NAND production will continue, driven by segments that demand lower density die, not offered by 3D NAND technology. The industrial and automotive markets (for example) will likely maintain their demand for planar technology because they are not willing to pay for unneeded higher capacity or to go through long qualification processes.

Figure 35: Industry lithography transition



Source: Omdia

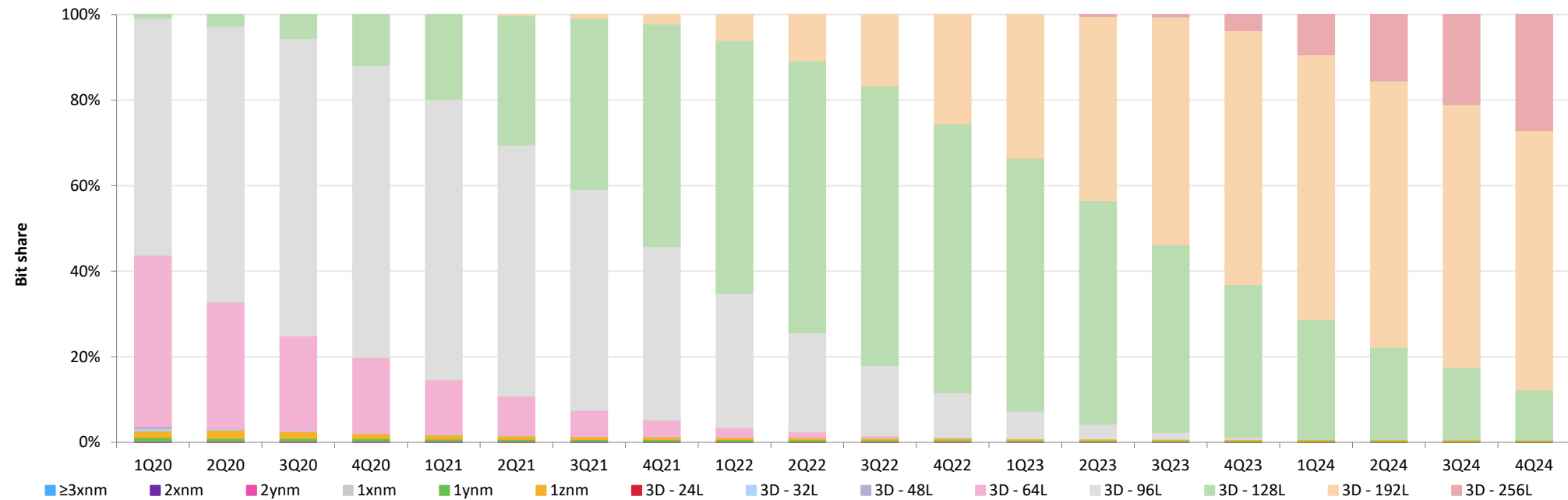
© 2020 Omdia

NAND lithography transitions (2/3)

- In 2Q20, Samsung's 92-layer accounted for 63% of the company's total bit output share, while its 64-layer declined further to a 30% share. Samsung's 128-layer is still in the early production and only projected to have a 13% bit share by the end of 2020. Omdia currently expects Samsung's 128-layer to capture majority of the volume by the end of 2021.
- Micron's 96-layer accounted for 62% of the company's bit output in 2Q20. As Micron works through its replacement gate technology, the company will ramp up its 128-layer aggressively in 2021.
- For the bit production by the Kioxia/WD camp, its 96-layer 3D NAND accounted for 74% in 2Q20. The company's 112-layer is projected to be in volume production in late 2021 to early 2022.
- At SK hynix, its 72-layer remained near volume production in 2Q20 and likely had surpassed by the end of the quarter. Omdia reports SK hynix's 96-layer accounted for 45% of the companies' output in 2Q20 and is projected to increase approximately 56% by 4Q20. As with other major manufacturers, SK hynix is in the early production of its 128-layer and expects to ramp up in 2021 to achieve volume by late in the year.
- Intel's wholly owned Dalian fab achieved the volume crossover for 96-layer as well in 2Q20, accounting for 64% of the company's output. Intel has already announced that its next-generation layer count will jump to 144-layers, with meaningful production not projected to take place until early 2021.
- YMTC now has a stable production of its 64-layer technology. YMTC has announced that it will jump from 64-layer 3D to 128-layer 3D in late 2020, with a meaningful volume of 128-layer in mid-2021.

NAND lithography transitions

Figure 36: Industry lithography transition



Source: Omdia

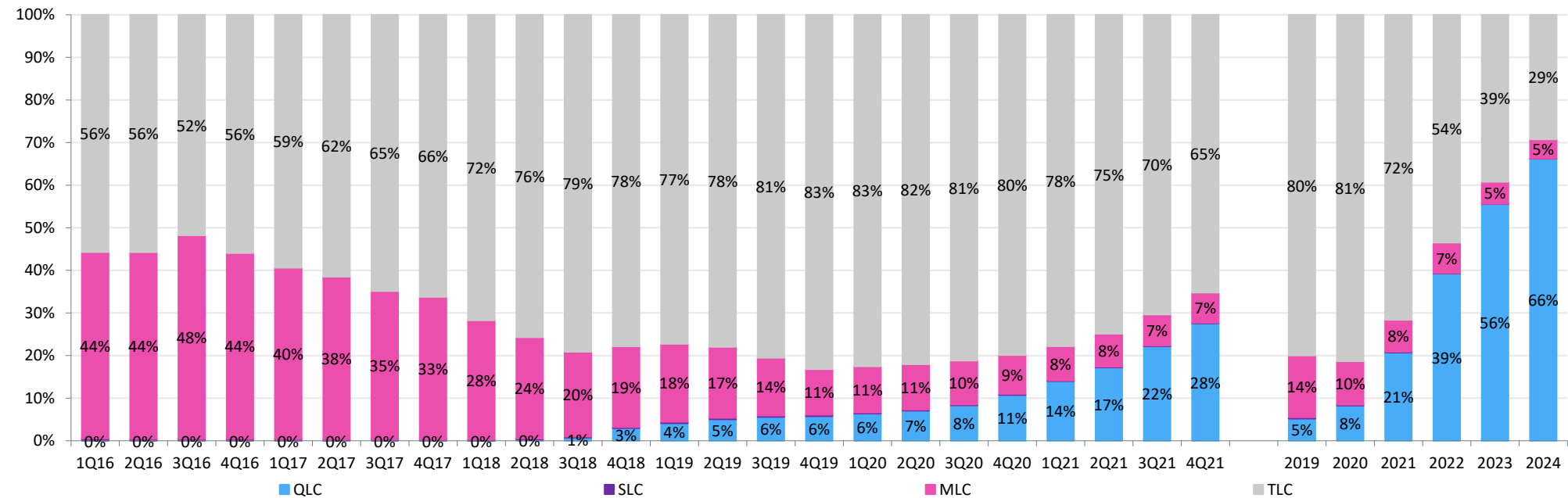
© 2020 Omdia

NAND technology mix

- Triple-level cells (TLC) technology accounted for 82% of total NAND bit mix in 2Q20, down just slightly from the previous quarter as quad-level cells (QLC) slowly increases. TLC is expected to remain the volume solution in terms of bit output until late 2022.
- Early QLC ramp-ups vary by NAND vendor, and the ramp-up has slowed given the capex adjustments made by NAND manufacturers.
 - Intel and Micron have taken the early lead with QLC production. Intel is using the QLC technology on most of its client-based SSDs; it also began to ship QLC-based enterprise SSDs.
 - Micron continues to ramp up its QLC technology within its consumer SSD devices and will take advantage of the lower-cost QLC to penetrate markets using HDD storage.
 - YMTC's next-generation 128-layer was announced to run both with QLC and TLC technology.
 - Other NAND manufacturers are more conservative with QLC production ramp-ups, not wanting to ramp up a product that will ultimately result in a discounted price.
- QLC production bit share remained relatively flat QoQ at 7% in 2Q20. Omdia estimates that QLC will grow to be approximately 10% by the end of 2020, growing further to 27% by the end of 2021.
- Overall, the QLC ramp-up has been slow to take hold. While companies, such as Intel and Micron, are strategically marketing QLC for specific product lines, others are in a wait-and-see mode and unsure when QLC technology will be robust enough to make it into the high-volume markets such as mobile and enterprise. Omdia expects that once QLC is proven to make it into one of these high-volume outlets, then the market will likely accelerate as any NAND manufacturer will need to be price competitive.
- Single-level cell (SLC) and multi-level cell (MLC) are expected to remain in small volume production to support specific markets.

NAND technology bit mix

Figure 37: NAND technology bit mix



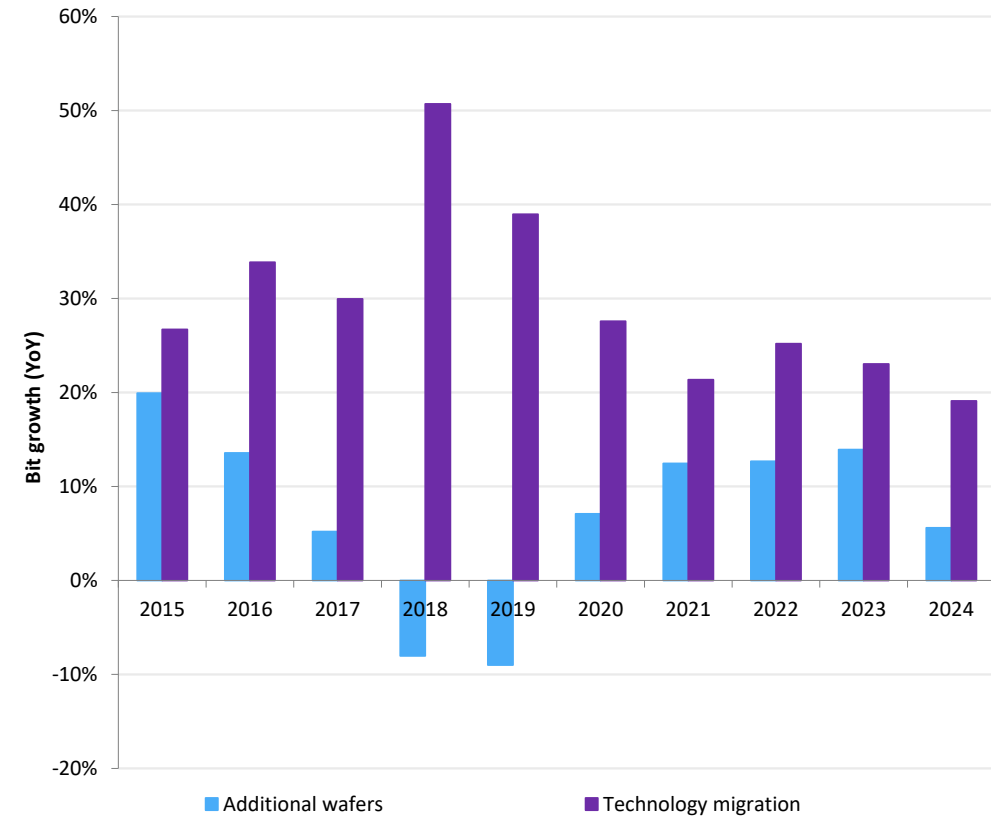
Source: Omdia

© 2020 Omdia

NAND sources of bit growth

- The predominant source of bit growth varies depending on market conditions and technology and can be a source to drive memory supply/demand cycles.
 - NAND manufacturers will use additional wafer capacity to increase the bit growth when demand warrants or based on any vendors' technology roadmaps.
- NAND bit growth from additional wafers is expected to be minimal in 2020. NAND manufacturers came into the year cautiously from a devastating 2019; now with COVID-19, caution remains because of the uncertainty of the economic and demand impact around the world.
- Beyond 2020, barring any unknown major external influences, wafer starts are expected to grow to be a more prominent source of bit growth, especially as NAND layer count stacks become higher and roadmap transitions take longer to achieve maturity.

Figure 38: Sources of bit growth



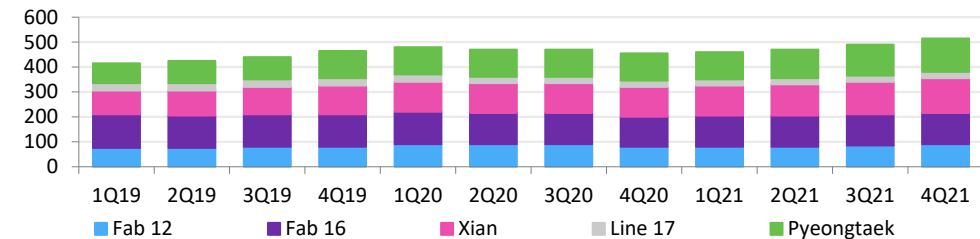
Source: Omdia

© 2020 Omdia

NAND capacity and technology – Samsung

- Samsung's bit shipments decreased by 3.0% QoQ in 2Q20. ASPs increased by 6.3% QoQ.
- Samsung's wafer output levels were at approximately 470,000 WPM in 2Q20 and is projected to stay relatively flat for the rest of the year.
- In 2021, Omdia expects Samsung to have a modest wafer growth of 485,000 WPM on average.
- Samsung's primary source of wafer growth in 2021 will be from its fabs in Pyeongtaek, South Korea and Xi'an, China.
 - Recently, Samsung announced that it would construct a second line at its Pyeongtaek facility. While the actual capacity of Line 2 was not announced, Omdia predicts it will be something less than Line 1.
 - A second line in Xi'an, China is expected to bring an additional 160,000 WPM to the fab's total capacity, with output in 2H20.
- For 2020, Omdia is forecasting that Samsung's YoY bit growth will be approximately 28%, growing to more than 30% YoY in 2021.

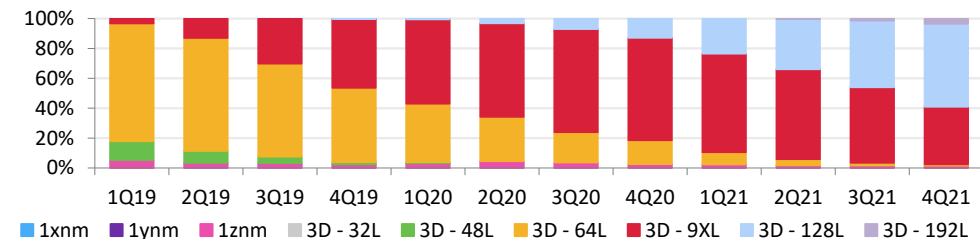
Figure 39: Samsung's wafer capacity (thousands of WSPM)



Source: Omdia

© 2020 Omdia

Figure 40: Samsung node mix (% of bit production)



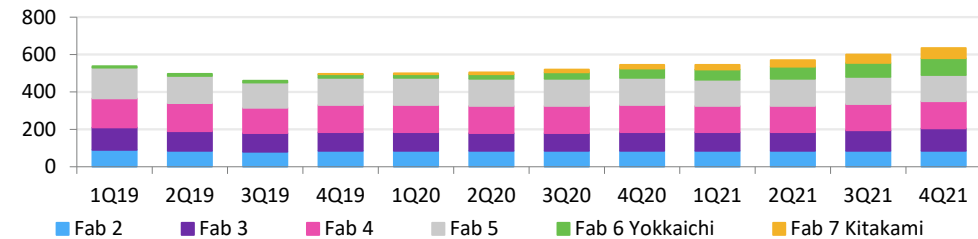
Source: Omdia

© 2020 Omdia

NAND capacity and technology – Kioxia/WD

- The total bit shipment growth of Kioxia/WD was 1.1% QoQ in 2Q20, with Kioxia's bit shipments declined by 3.7% QoQ while WD's bit shipments grew 7.3% QoQ.
- Kioxia's ASP grew by 1.1% QoQ while WD's ASP increased by 1.7% QoQ.
- The two companies' wafer outputs were 505,000 WPM in 2Q20, up just slightly QoQ. Omdia expects wafers to further ramp up and increase to 545,000 WPM by the end of the year.
- For 2021, Omdia is projecting the two companies' wafer outputs to be on an average of 587,000 WPM.
- The main source of wafer growth for the two companies will be from its newest fabs, Fab 6 (Yokkaichi) and Fab 7 (Kitakami).
 - The new Fab 6 facility began its ramp-up in late 2018, but the ramp-up was slower because of market conditions in 2020. Kioxia's Fab 6 is estimated to ramp up to 50,000 WPM in 2020, then continue ramping up to 90,000 WPM by the end of 2021.
 - The new Fab 7 started production in late 2019 and is projected to ramp up to just 20,000 WPM by the end of 2020, then continue to ramp to 55,000 WPM by the end of 2021.
- Omdia is projecting Kioxia's YoY bit growth (including WD) to be 37% YoY in 2020 and 32% YoY in 2021.

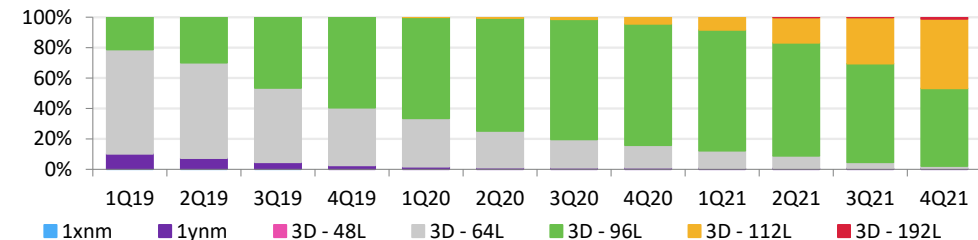
Figure 41: Kioxia/WD wafer capacity (thousands of WSPM)



Source: Omdia

© 2020 Omdia

Figure 42: Kioxia/WD snode mix (% of bit production)



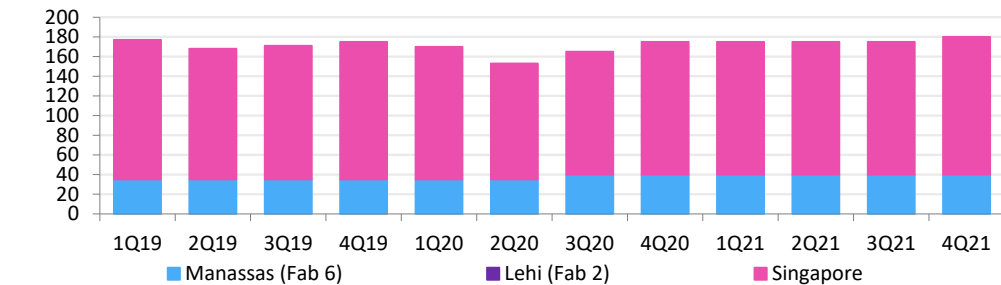
Source: Omdia

© 2020 Omdia

NAND capacity and technology – Micron

- Micron's QoQ bit shipments decreased in 2Q20 by 12.1% as it continues to move through its replacement gate technology. Micron's ASPs increased by 2.3% QoQ.
- Micron's wafer outputs were approximately 155,000 WPM in 2Q20 but projected to grow to 175,000 WPM by the end of 2020.
- For 2021, Micron is expected to stay relatively flat with approximately 180,000 WPM.
- Micron's output is from its facilities in Singapore, Fab 10N, 10X, and the 10X expansion.
- Omdia is projecting Micron's 2020 YoY bit growth to be minimal at 23.6% because of the replacement gate technology transition. Micron's YoY bit growth in 2021 is then projected to grow to 31.5%.
- The 2Ynm and 1Ynm offerings from the Manassas facility were 4% of the total bit output in 2Q20.

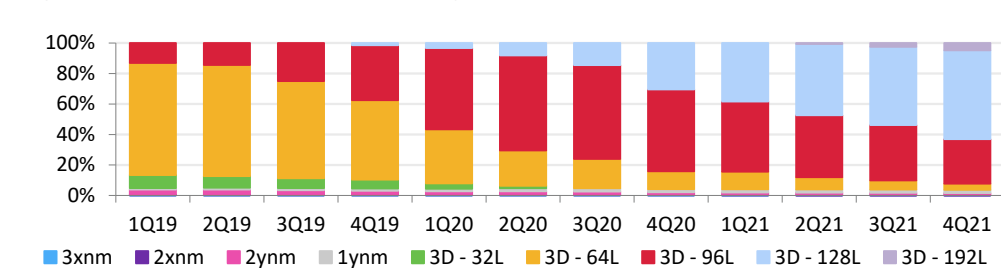
Figure 43: Micron's wafer capacity (thousands of WSPM)



Source: Omdia

© 2020 Omdia

Figure 44: Micron's node mix (% of bit production)



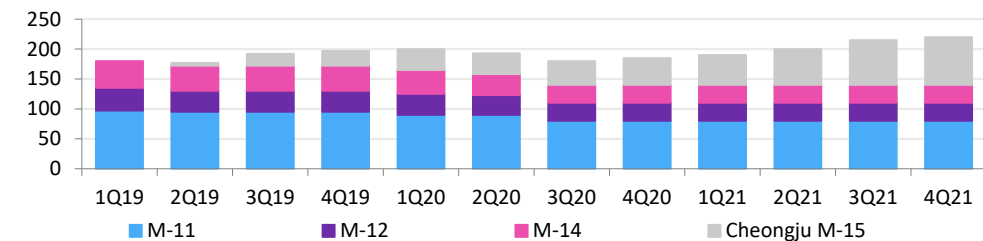
Source: Omdia

© 2020 Omdia

NAND capacity and technology – SK hynix

- SK hynix's bit shipments increased by 5.9% QoQ in 2Q20. Its ASPs increased by 8.6% QoQ.
- SK hynix's wafer outputs were 190,000 WPM in 2Q20 and are expected to stay relatively flat for the rest of the year.
- For 2021, SK hynix is projected to ramp up to an average of 205,000 WPM.
- SK hynix's main source of wafer growth will be from its newest fab, M-15, in Cheongju, South Korea. Omdia projects that M-15 will ramp up to approximately 45,000 WPM by the end of 2020, then continue to ramp up aggressively in 2021 to 80,000 WPM.
- SK hynix's YoY bit growth is projected to be 41% in 2020. However, Omdia expects that this aggressive growth will slow in 2021, currently projected at more than 30% YoY.

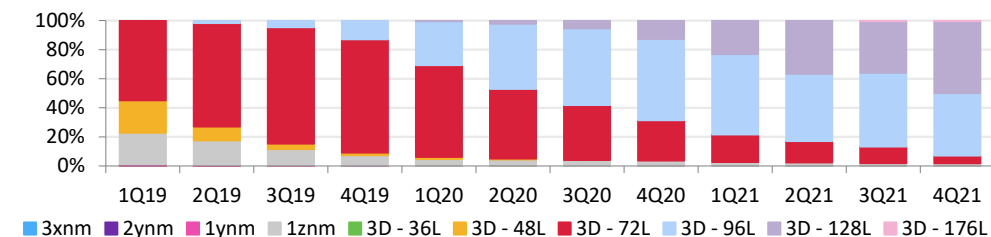
Figure 45: SK hynix's wafer capacity (thousands of WSPM)



Source: Omdia

© 2020 Omdia

Figure 46: SK hynix's node mix (% of bit production)



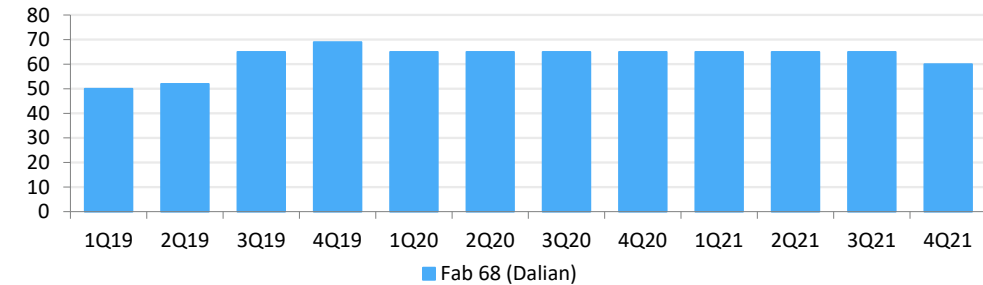
Source: Omdia

© 2020 Omdia

NAND capacity and technology – Intel (excluding IM Flash)

- Intel's bit shipments increased by 12.2% QoQ in 2Q20. ASPs increased by 10.5% QoQ. It should be noted that Intel's ASPs are influenced by its Optane product line.
- Intel's wafer outputs for its Dalian fab are estimated at 65,000 WPM and are expected to remain flat at this level throughout 2020.
- Intel has not announced further wafer capacity expansion, at least in the near term. Therefore, Omdia expects Intel's Dalian fab to remain flat at 65,000 WPM in 2021 as well.
 - The Dalian fab is estimated to have a maximum capacity of 100,000 should Intel choose to ramp up. However, the Dalian fab may also have capabilities to support 3D XPoint in the future should Intel need the capacity in addition to, or in place of, its contract with Micron and wafers from the Lehi fab.
 - Omdia predicts Intel's YoY bit growth of 49% in 2020, thanks to its aggressive ramp-up of 96-layer and 144-layer. Intel's bit growth is then estimated to slow in 2021 to 33% YoY.

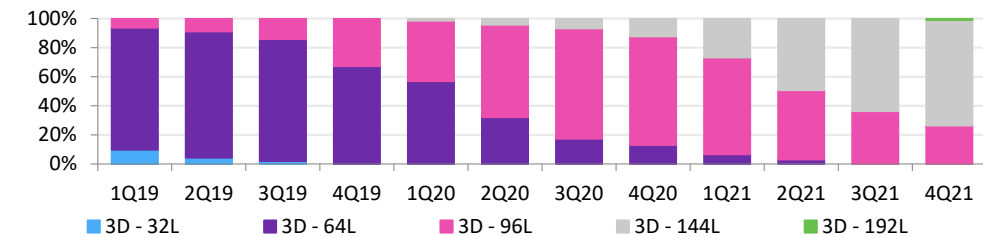
Figure 47: Intel's wafer capacity (thousands of WSPM)



Source: Omdia

© 2020 Omdia

Figure 48: Intel's node mix (% of bit production)



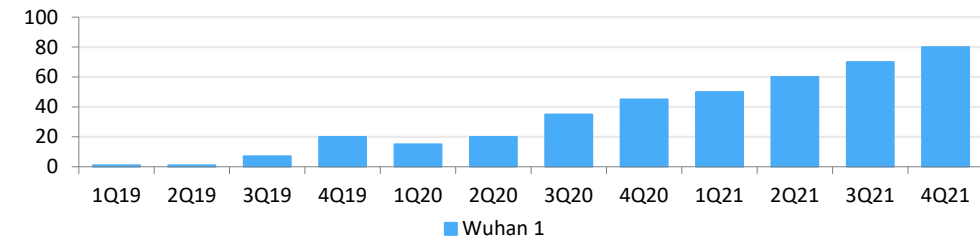
Source: Omdia

© 2020 Omdia

NAND capacity and technology – Yangtze Memory Technologies Co. (YMTC)

- YMTC's 64-layer technology has a meaningful volume production, but the total wafer output at the company's first Wuhan fab remains limited. Omdia analyzes that the company was running approximately 20,000 WPM in 2Q20 and is expected to ramp up to approximately 45,000 WPM by the end of 2020.
- For 2021, it is unclear if YMTC will be able to reach its maximum capacity of 100,000 WPM, but Omdia currently estimates YMTC will get close to approximately 80,000 WPM by the end of 2021
 - Construction of the second YMTC fab is expected to begin in 2H20, and thus far, there does not appear to be any impact to this schedule from COVID-19. Production is then projected for 2022. The aggressiveness of this ramp-up depends on the market.
- YMTC has been ramping up 64-layer slowly to improve yields. Then, the company will skip 96-layer and increase 128-layer. YMTC has already announced its 128-layer product is in early volume, but it should ramp up to meaningful volumes in 2H21.

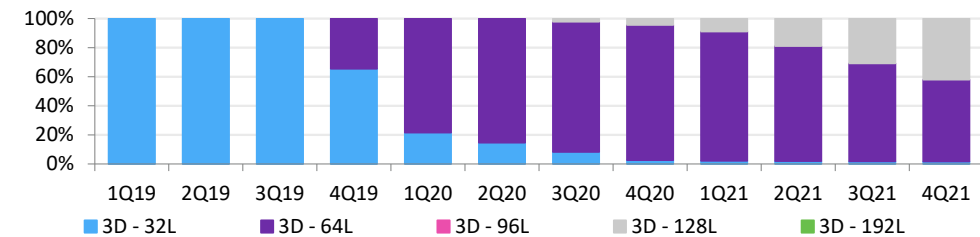
Figure 49: YMTC's wafer capacity (thousands of WSPM)



Source: Omdia

© 2020 Omdia

Figure 50: YMTC's node mix (% of bit production)



Source: Omdia

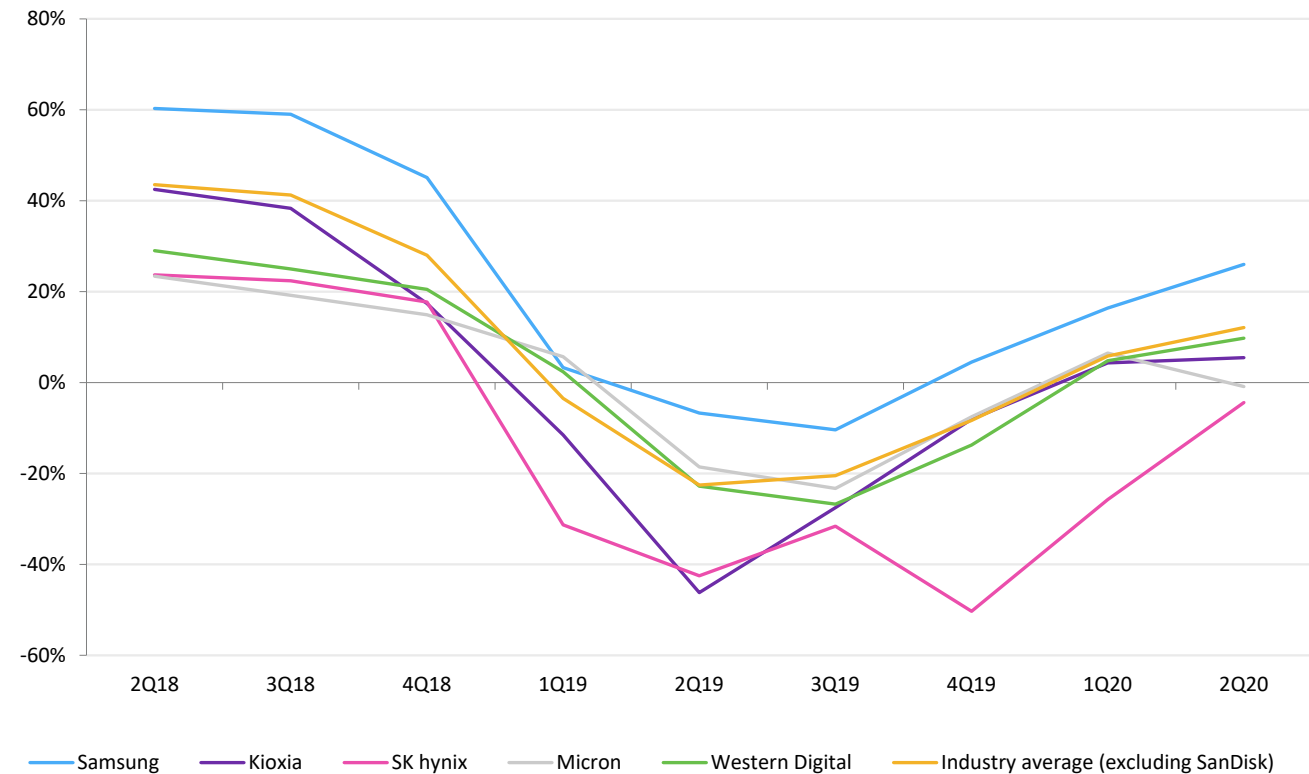
© 2020 Omdia

Cost/financial update

NAND operating profit margin

- Industry operating profit margins (OPMs) continued to improve in 2Q20 as ASPs increased for the third quarter in a row.
- In 2Q20, the industry average OPM was at 12.1%, an improvement from the 5.8% OPM in the previous quarter.
- With ASPs expected to decline in 3Q20 against softening demand, OPM is then expected to decline. Its rate of decline will likely vary between vendors, with each vendor's pending market strategy and inventory strategy, which have been accumulating.

Figure 51: NAND suppliers' operating profit margin



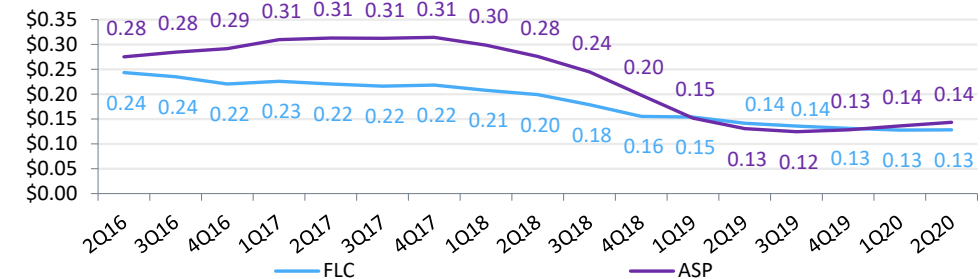
Source: Omdia

© 2020 Omdia

NAND industry cost and ASP

- Fully-loaded cost-per-bit (FLC) remained relatively flat in 2Q20 but had a minor overall increase of 0.4%. ASPs increased by 4.4% in the same quarter.
- For the second quarter in a row, there was a positive margin in the NAND industry as ASPs remained above FLC. In 2Q20, the margin between ASP and FLC improved to 10.6%.
- With ASPs expected to decline in 2H20, this could once again reduce the margin gains; however, cost reductions efforts and yield improvements could counter some of the loss.
- The transition of 3D NAND will be expensive, and it creates headwinds for future cost-per-bit declines.
 - Ongoing 3D layer count transitions will result in increasingly challenging yields.
 - An expensive greenfield space is required to support space-hungry 3D NAND production.
 - An expensive tooling is needed for 3D production.
 - Node transitions may be slower given the added costs and complexities associated with each transition.

Figure 52: NAND 1GB-equivalent fully loaded cost and ASP



Source: Omdia

© 2020 Omdia

Table 2: NAND suppliers ASP

(\$ per gigabyte)

	2Q18	3Q18	4Q18	1Q19	2Q19	3Q19	4Q19	1Q20	2Q20
Samsung	\$0.316	\$0.285	\$0.220	\$0.157	\$0.139	\$0.129	\$0.138	\$0.144	\$0.153
Kioxia	\$0.232	\$0.213	\$0.176	\$0.145	\$0.121	\$0.109	\$0.117	\$0.125	\$0.126
Western Digital	\$0.213	\$0.191	\$0.181	\$0.142	\$0.122	\$0.126	\$0.117	\$0.124	\$0.126
SK hynix	\$0.281	\$0.252	\$0.199	\$0.135	\$0.110	\$0.112	\$0.113	\$0.119	\$0.129
Micron	\$0.238	\$0.194	\$0.149	\$0.122	\$0.101	\$0.101	\$0.109	\$0.123	\$0.126
Industry average	\$0.276	\$0.245	\$0.198	\$0.152	\$0.131	\$0.125	\$0.128	\$0.136	\$0.144

Source: Omdia

© 2020 Omdia

Appendix

Appendix

Author

Craig Stice, Chief Analyst, NAND Intelligence
askananalyst@omdia.com

Omdia Consulting

We hope that this analysis will help you make informed and imaginative business decisions. If you have further requirements, Omdia's consulting team may be able to help you. For more information about Omdia's consulting capabilities, please contact us directly at consulting@omdia.com.

Citation Policy

Request external citation and usage of Omdia research and data via citations@omdia.com.

Disclaimer

The Omdia research, data and information referenced herein (the “Omdia Materials”) are the copyrighted property of Informa Tech and its subsidiaries or affiliates (together “Informa Tech”) and represent data, research, opinions or viewpoints published by Informa Tech, and are not representations of fact.

The Omdia Materials reflect information and opinions from the original publication date and not from the date of this document. The information and opinions expressed in the Omdia Materials are subject to change without notice and Informa Tech does not have any duty or responsibility to update the Omdia Materials or this publication as a result.

Omdia Materials are delivered on an “as-is” and “as-available” basis. No representation or warranty, express or implied, is made as to the fairness, accuracy, completeness or correctness of the information, opinions and conclusions contained in Omdia Materials.

To the maximum extent permitted by law, Informa Tech and its affiliates, officers, directors, employees and agents, disclaim any liability (including, without limitation, any liability arising from fault or negligence) as to the accuracy or completeness or use of the Omdia Materials. Informa Tech will not, under any circumstance whatsoever, be liable for any trading, investment, commercial or other decisions based on or made in reliance of the Omdia Materials.

Get in touch

Americas

E: customersuccess@omdia.com

08:00 – 18:00 GMT -5

Europe, Middle East & Africa

E: customersuccess@omdia.com

8:00 – 18:00 GMT

Asia Pacific

E: customersuccess@omdia.com

08:00 – 18:00 GMT + 8

© 2020 Omdia

Brought to you by Informa Tech

The Omdia logo is displayed in a large, bold, black font. It features a stylized 'O' that is partially enclosed by a blue shape, which is part of a larger graphic element on the right side of the page. The letters 'M', 'D', 'I', and 'A' follow in a similar bold, sans-serif font.