






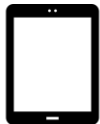



Trends in NAND Flash Market and Risks Faced by NAND Flash Industry

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Demand in Different Application Segments

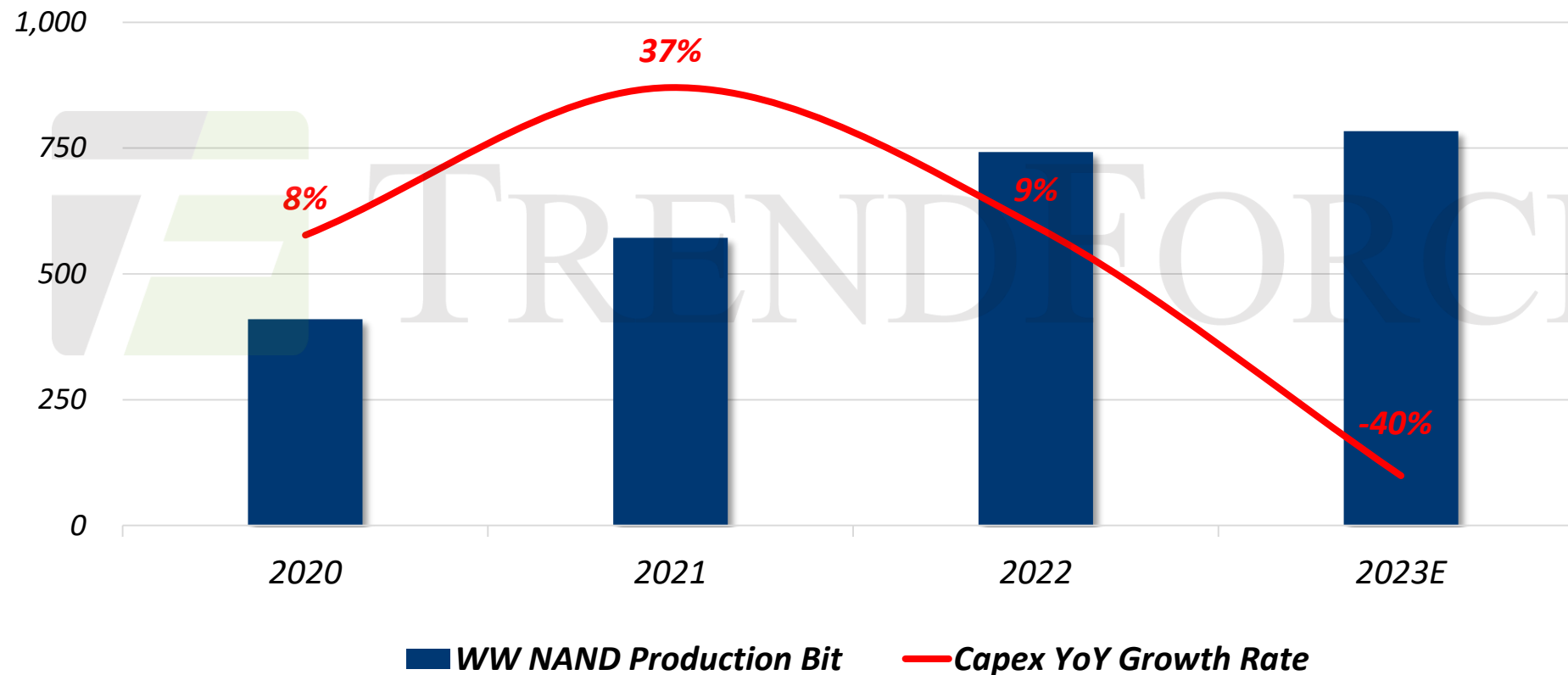


	Smartphone	Server	Notebook	Tablet	TV	Monitor	Automotive
							
2022	-10.6%	4.7%	-24.5%	-8.8%	-4.4%	-8.4%	-0.1%
2023E	-4.2%	-4.3%	-14.2%	-5.4%	-1.3%	-5.9%	3.2%
2024F	2.2%	2.3%	2.6%	-3.1%	2.6%	0.6%	5.0%

Source: TrendForce, Jul., 2023

NAND Flash Industry: Capex and Output from 2020 to 2023

Unit: EB



Source: TrendForce, Jul., 2023

Long-Term Demand Drivers – Growth of Enterprise SSDs Will Outpace That of Mobile NAND Flash Solutions by 2026

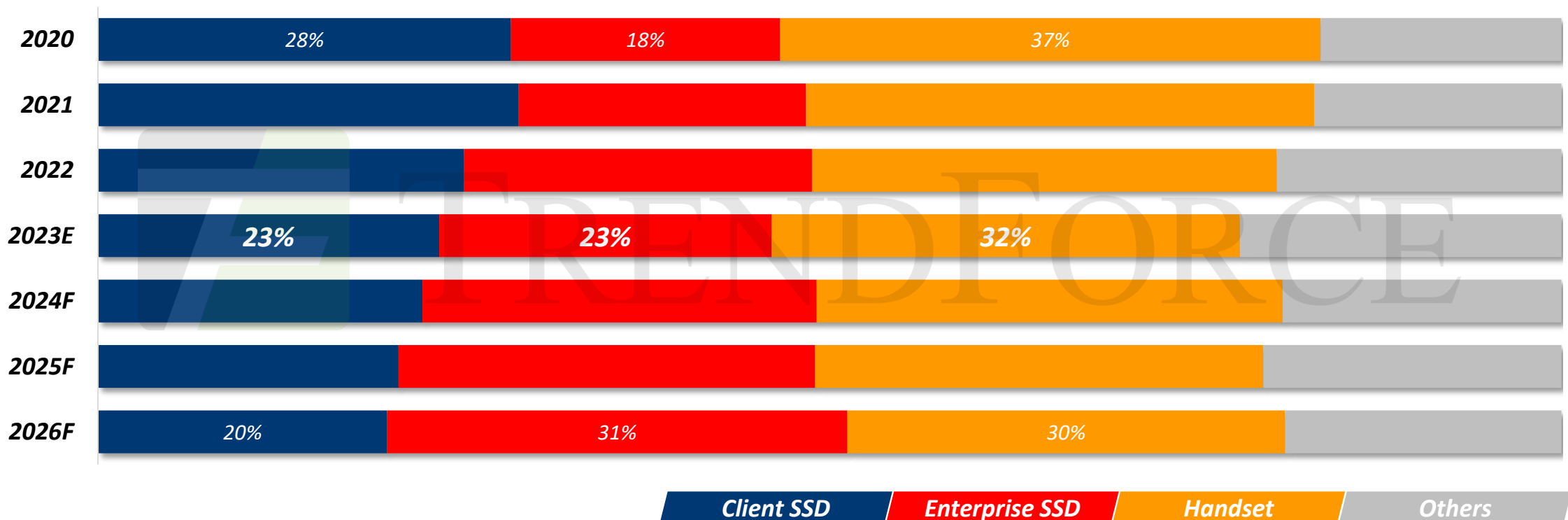


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□ TrendForce believes that enterprise SSDs will continue to be the strongest demand driver over the long term due to following reasons:

1. Unlike the client SSD segment, the enterprise SSD segment still has room for growth with respect to content per box.
2. Applications related to HPC, AI, and ML generate demand for storage solutions that offer faster data access, thus sustaining the growth momentum in the enterprise SSD segment.

Distribution of NAND Flash Demand, 2020-2026








Source: TrendForce, Jul., 2023

NAND Flash Technology Roadmap



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Vendors	2020		2021		2022		2023	
	1H	2H	1H	2H	1H	2H	1H	2H
SAMSUNG	14nm (MLC/TLC)							
	128L (TLC)				176L (TLC/QLC) ★		236L (TLC)	
 SK hynix	14nm (MLC/TLC)							
	128L (TLC)				176L (TLC/QLC) ★		238L (TLC/QLC)	
 SOLIDIGM	96L (TLC/QLC)	144L FG (TLC/QLC) ★				192L FG (QLC)		
KIOXIA	15nm (MLC/TLC)							
 Western Digital®	96L (TLC/QLC)		112L(TLC/QLC) ★			162L (TLC/QLC)		
 Micron®	16nm (MLC/TLC)							
	96L (TLC/QLC)	128L RG (TLC)		176L RG (TLC/QLC) ★		232L RG (TLC/QLC)		
	64L (TLC)		128L (TLC/QLC) ★			232L		
	19nm (SLC/MLC) ★							
MXIC	48L (TLC)				96L (TLC)		192L (TLC)	
<div>Source: TrendForce, Jul., 2023</div> <div>Note: ★ indicates the supplier's current primary technology.</div> <div><div>2D NAND</div><div><48L</div><div>64/72L</div><div>92/96L</div><div>1XX L</div><div>1YY L</div><div>2XX L</div></div>								

Note: ★ indicates the supplier's current primary technology.

Source: TrendForce, Jul., 2023

Key Takeaways



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The quarterly sufficiency ratio will improve in 2H23 because suppliers have enlarged their production cuts. TrendForce forecasts that the NAND Flash market will experience a supply shortage in 2H24 due to the slow ramp-up of the production lines that deploy advanced 3D NAND technologies (i.e., 23X-L).

1

Export control rules will limit the expansion of NAND Flash production capacity and the advancement of NAND Flash process technology in China. However, after the COVID-19 pandemic, these restrictions will also compel China to be even more committed to supporting the localization of semiconductor manufacturing in face of geopolitical uncertainties.

2

The increase in capex and the prolonging of production cycle time will lead to slower ROI as suppliers migrate to 3XX-L processes. Hence, the pace of the NAND Flash industry's technology migration will likely decelerate.

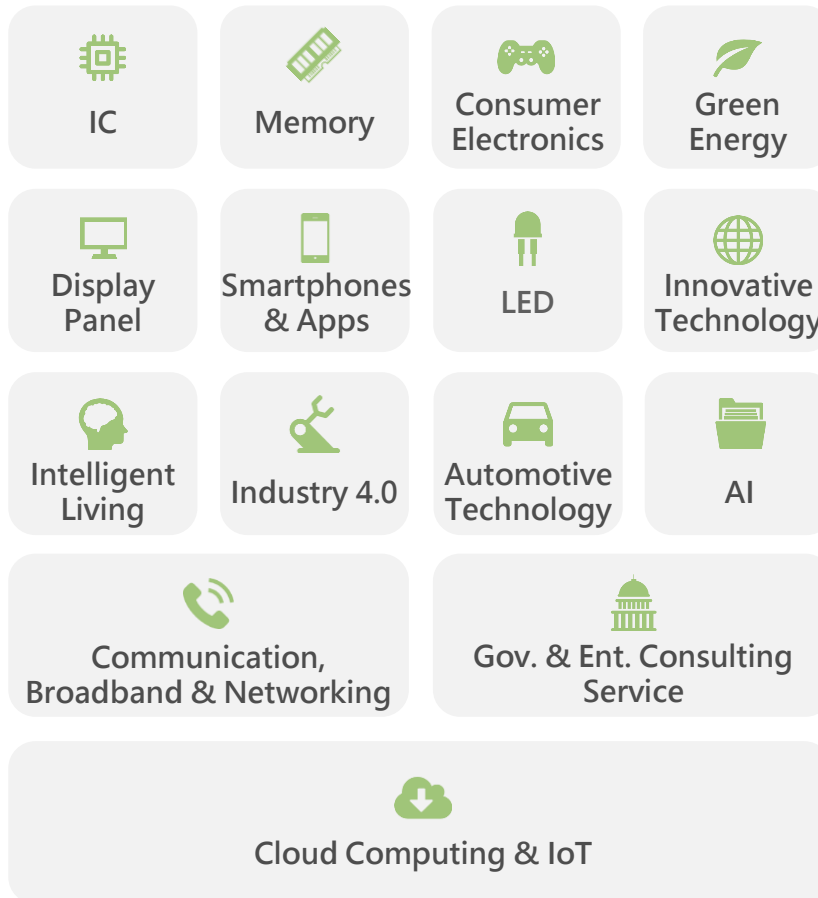
3

More consolidation activities will take place in the NAND Flash industry in the future.

4

Source: TrendForce, Jul., 2023

TrendForce & TRI Research Areas



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