

J.P. Morgan Semiconductor and Semiconductor Capital Equipment

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J.P. Morgan Semiconductor Universe Comp Sheet

JPM Rating	Market Cap	3/11/21 Price	Non-GAAP EPS		P/E		Revenue		P/S		EV/Sales		Consensus Non-GAAP EPS		Consensus Sales		Consensus P/E		Consensus P/S		
			C20E	C21E	C20E	C21E	C20E	C21E	C20E	C21E	C20E	C21E	C20E	C21E	C21E	C22E	C21E	C22E	C21E	C22E	C21E
Harlan Sur, Lead Coverage																					
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PC Semiconductors																					
INTC	OW	\$260,774	\$63.31	\$5.30	\$5.10	11.9	12.4	\$77,867	\$74,000	3.3	3.5	3.4	3.6	\$4.70	\$4.83	\$73,307	\$73,201	13.5	13.1	3.6	3.6
NVDA	OW	\$327,956	\$519.74	\$8.99	\$11.95	57.8	43.5	\$15,647	\$19,747	21.0	16.6	20.3	16.1	\$12.98	\$14.34	\$21,744	\$24,045	40.0	36.2	15.1	13.6
AMD	N	\$99,588	\$81.23	\$1.10	\$1.47	73.8	55.3	\$8,883	\$10,214	11.2	9.8	10.9	9.5	\$1.93	\$2.50	\$13,483	\$15,576	42.2	32.5	7.4	6.4
Memory																					
MU	OW	\$101,367	\$89.31	\$2.82	\$3.29	31.7	27.2	\$21,491	\$22,461	4.7	4.5	4.6	4.4	\$6.52	\$10.49	\$29,018	\$35,437	13.7	8.5	3.5	2.9
WDC	N	\$21,088	\$68.69	\$3.51	\$5.00	19.6	13.7	\$16,345	\$17,823	1.3	1.2	1.7	1.5	\$4.77	\$7.68	\$17,483	\$19,266	14.4	8.9	1.2	1.1
Enterprise/Networking/Datacenter Semiconductors																					
XLNX	N	\$31,289	\$126.09	\$2.96	\$3.19	42.5	39.6	\$3,024	\$3,314	10.3	9.4	9.8	9.0	\$3.39	\$3.90	\$3,401	\$3,693	37.2	32.3	9.2	8.5
MRVL	NR	\$31,853	\$46.30	\$0.92	\$1.39	50.6	33.4	\$2,950	\$3,424	10.8	9.3	10.8	9.3	\$1.34	\$1.73	\$3,442	\$3,938	34.7	26.7	9.3	8.1
AVGO	OW	\$194,179	\$453.69	\$23.21	\$26.42	19.5	17.2	\$24,549	\$26,674	7.9	7.3	8.9	8.2	\$27.12	\$29.24	\$27,014	\$28,365	16.7	15.5	7.2	6.8
IPHI	NR	\$8,525	\$161.99	\$3.20	\$3.75	50.5	43.2	\$681	\$797	12.5	10.7	13.3	11.3	\$3.78	\$4.38	\$802	\$925	42.9	37.0	10.6	9.2
Mobile Devices																					
SWKS	N	\$29,016	\$173.75	\$5.90	\$6.89	29.4	25.2	\$3,278	\$3,610	8.9	8.0	8.5	7.7	\$9.76	\$11.10	\$4,768	\$5,248	17.8	15.7	6.1	5.5
QRVO	OW	\$20,240	\$174.95	\$7.09	\$8.02	24.7	21.8	\$3,510	\$3,785	5.8	5.3	5.8	5.4	\$10.33	\$11.12	\$4,364	\$4,590	16.9	15.7	4.6	4.4
KN	UW	\$1,965	\$21.14	\$0.48	\$1.08	44.5	19.5	\$709	\$801	2.8	2.5	2.8	2.5	\$1.27	\$1.44	\$861	\$919	16.6	14.6	2.3	2.1
Analog/Microcontrollers																					
TXN	OW	\$163,053	\$174.95	\$5.20	\$5.50	33.6	31.8	\$13,368	\$14,535	12.2	11.2	12.1	11.1	\$6.91	\$7.58	\$16,597	\$17,383	25.3	23.1	9.8	9.4
ADI	NR	\$56,350	\$151.03	\$5.08	\$6.06	29.7	24.9	\$5,656	\$6,218	10.0	9.1	10.6	9.6	\$6.11	\$6.76	\$6,577	\$7,018	24.7	22.3	8.6	8.0
NXPI	N	\$53,771	\$188.50	\$5.54	\$7.57	34.0	24.9	\$8,402	\$9,495	6.4	5.7	6.9	6.1	\$9.14	\$10.14	\$10,396	\$10,960	20.6	18.6	5.2	4.9
MCHP	OW	\$40,817	\$148.21	\$6.20	\$7.40	23.9	20.0	\$5,298	\$6,109	7.7	6.7	9.2	8.0	\$7.32	\$7.97	\$6,035	\$6,380	20.3	18.6	6.8	6.4
MXIM	NR	\$24,147	\$89.17	\$2.40	\$3.09	37.1	28.9	\$2,223	\$2,550	10.9	9.5	10.4	9.1	\$3.10	\$3.40	\$2,633	\$2,806	28.8	26.2	9.2	8.6
SLAB	OW	\$6,631	\$148.25	\$3.01	\$3.44	49.3	43.1	\$887	\$1,009	7.5	6.6	7.1	6.2	\$3.42	\$3.88	\$1,005	\$1,090	43.3	38.2	6.6	6.1
Diversified/Consumer/Standard Components/Other																					
ON	N	\$16,746	\$38.80	\$0.68	\$1.40	57.3	27.7	\$5,085	\$5,611	3.3	3.0	3.7	3.3	\$1.61	\$1.99	\$5,972	\$6,229	24.1	19.5	2.8	2.7
MTSI	UW	\$4,558	\$67.27	\$1.28	\$1.66	52.6	40.4	\$559	\$630	8.2	7.2	8.8	7.8	\$1.94	\$2.22	\$617	\$674	34.7	30.3	7.4	6.8
MXL	N	\$2,721	\$36.61	\$0.49	\$1.35	74.6	27.1	\$403	\$675	6.8	4.0	7.4	4.4	\$1.93	\$2.15	\$808	\$846	18.9	17.0	3.4	3.2
SYNA	OW	\$6,631	\$136.98	\$6.98	\$7.69	19.6	17.8	\$1,292	\$1,363	3.9	3.7	4.0	3.7	\$8.00	\$9.03	\$1,368	\$1,475	17.1	15.2	4.8	4.5
VSH	N	\$3,583	\$24.67	\$0.78	\$1.18	31.7	20.8	\$2,413	\$2,673	1.5	1.3	1.4	1.2	\$1.59	\$1.77	\$2,916	\$2,980	15.5	14.0	1.2	1.2
Semiconductor Capital Equipment																					
AMAT	OW	\$108,401	\$117.19	\$4.26	\$4.93	27.5	23.8	\$17,622	\$19,135	6.2	5.7	6.1	5.6	\$6.10	\$6.54	\$21,835	\$23,258	19.2	17.9	5.0	4.7
LRCX	OW	\$78,119	\$535.39	\$19.10	\$22.21	28.0	24.1	\$11,495	\$12,875	6.8	6.1	6.6	5.9	\$26.00	\$29.03	\$14,427	\$15,303	20.6	18.4	5.4	5.1
KLAC	OW	\$46,102	\$296.36	\$10.75	\$13.12	27.6	22.6	\$5,864	\$6,450	7.9	7.1	8.0	7.3	\$14.18	\$15.16	\$6,972	\$7,340	20.9	19.5	6.6	6.3
Large Cap Semi Average						37.0	29.8			9.9	8.7							22.8	20.6	8.1	7.5
Small-Mid Cap Semi Average						45.0	29.1			5.8	4.9							25.6	22.4	4.9	4.5
Semi Group Average (ex-outliers)						37.1	26.5			7.4	6.5							23.7	20.9	6.2	5.8
SOX Index			2,997	83	131	36.2	22.9			7.3	6.3							22.9	20.0	6.3	5.8
S&P500			3,939	123	172	32.0	22.9			3.0	2.7							22.9	19.8	2.7	2.6

Source: Company reports, Bloomberg Finance L.P., J.P. Morgan estimates.

Note: Pricing as of 03/11/2021 intra-day.

Semi/Semicaps – Growth and Cyclical Trends Remain Positive Entering 2021 and Beyond

- **We believe the semiconductor industry has entered a more stable and less cyclical growth phase characterized by low- to mid-single-digit annual revenue growth and high-single-digit unit growth**
 - With the industry generally driving high-single-digit Y/Y unit growth, the entire value chain is able to better predict silicon consumption requirements, better respond to perturbations in supply/demand, and more efficiently plan manufacturing output
 - As a result, volatility in semiconductor supply/demand and semiconductor equipment spending has muted significantly
 - Compare this to 15-20 years ago, when unit growth rates were +15% Y/Y – small perturbations in supply/demand would drive significant swings in inventory, shipments, capacity planning, and equipment spending
 - **Bottom line:** The current environment is likely more stable and less cyclical for semiconductor and semiconductor capital equipment suppliers. In a maturing industry, we believe the market will focus on market leadership/scale, operating margin and free cash flow margin expansion, and increasing payout ratios
- **We see semi industry revenue up 10-12% Y/Y (bias upward) in 2021 following a 7% Y/Y growth in 2020. Recall 2H20 demand picked up significantly and growth turned positive after 1H20's weak demand environment and supply chain disruptions (COVID-19). In Semiconductor equipment, we see spending up ~16% Y/Y in 2021 led by DRAM and Foundry strength.**
- **Supply constraints across all end markets...we see multiple quarters of strength for the semi suppliers.**

Channel/customer inventories are at/near historic lows, and lead times are continuing to get stretched out. Given the strong demand environment, combined with supply tightness, we anticipate strong demand trends through 2021.
- **Expect continued industry consolidation (M&A):** Focus on scale, diversification, and margin and FCF expansion
- **Promising outlook for foundry/ memory in 2021 demand and capex spending driving strong semi equipment fundamentals**
- **Govt incentives for US domestic manufacturing capability a positive - innovation and assurance of supply base**

Only 40% Through the Current Up-cycle; Tight Supply Drives Multiple Qtrs of Strength

- The number of companies in 4Q that delivered in-line/better out-quarter guidance rose to 100%. On average, CY21 estimates for the group were revised higher by ~9%
 - We anticipate the market continuing to discount an improving economic outlook in 2021 (semis tend to discount 9 months forward)
- Shipment trends were above historical normal seasonality in 4Q20, and we expect that to continue in 1Q21 as the global economy continues to expand post-COVID lockdown
- Continued positive EPS revisions in 2021, following three consecutive quarters of positive EPS revisions which began in 2Q20
- As we enter 2021, focus will begin to shift to 2022 earnings potential (semis tend to discount 9 months forward) - we see another 20%+ upside to out-year EPS estimates
- We estimate that the industry is only 40% through the current up-cycle. It will take another 4-6 quarters for supply to catch up with demand and inventories across the value chain to get back to normalized levels
 - Companies are shipping 10-30% below current end-market demand
 - Equipment lead times are stretching from 7-9 months to 10-12 months (equipment order to production output)
 - It will take 3-4 quarters for supply to catch up with end-market demand.....and then another 1-2 quarters for value-chain inventory replenishment

We Anticipate the Market Continuing to Discount an Improving Economic Backdrop into 2021 with Strong Demand Drivers in Place

- **Global GDP growth of 6.5% in CY21E (+8% in Q2, +7% in Q3)**
- **Semi industry growth of 10-12% in CY21E (bias upward)**
- **Cloud/hyperscale capex spending growth of 27% in CY21E (top 4 CSPs)**
- **PC shipments up 13-18% in CY21E after 13% growth in CY20**
- **5G smartphone unit shipment growth of >100% in CY21E**
 - **Total smartphone shipments up ~5% Y/Y**
- **5G basestation deployment growth of 35% in CY21E (China up 20% Y/Y – 2H weighted)**
 - **Semi companies are already seeing order visibility for 2H China 5G reacceleration**
- **Global light vehicle production growth of 13% in CY21E**
- **Capacity Optimized HDD growth of 13-15% and Client/Enterprise SSD shipments growth of 10-15%**

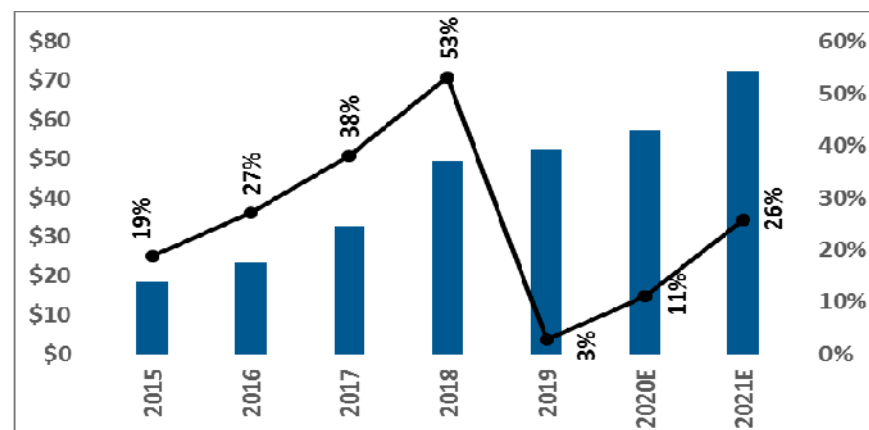
Source: Industry data and J.P. Morgan estimates.

Strong Data Center Spending – Driving Strong Demand for Compute, Networking, and Memory/Storage Semiconductors

Look for companies levered to data center trends to outperform in 2021 across COMPUTE, NETWORKING and STORAGE/MEMORY after digestion cycle in 2H20

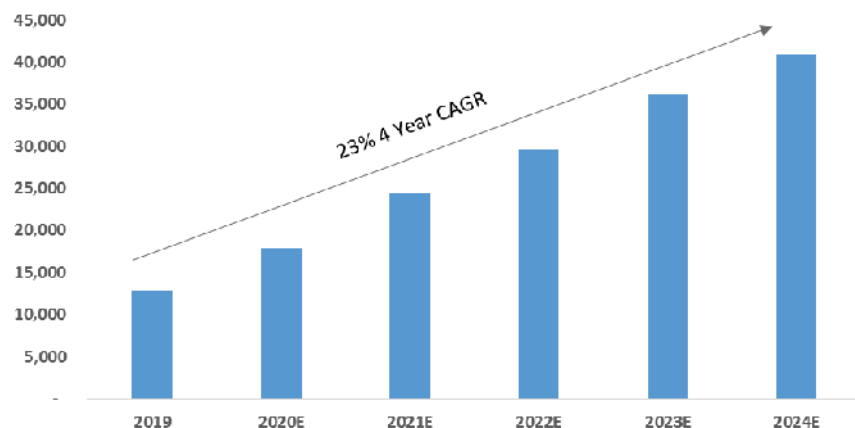
- Cloud Service Provider Spending (top 4) grew by 10% in 2020 and was up 6% in 2019. **We expect cloud spending to reaccelerate in 1H21 and grow 25%+ in 2021 with a 10-15% CAGR over the next few years**
- Cloud services revenue continue growing >40%+ Y/Y
- Over the next 5 years, CIOs should grow spending on public cloud by 4x
- Early ramp of new processors by Intel, AMD, NVIDIA, and ARM-Adopters
- Silicon switch ports (>25Gbps) to grow 23% CAGR - OW AVGO
- DRAM memory content in a cloud server is 50% higher than traditional enterprise server – OW MU
- Datacenter compute acceleration growing >25% CAGR, driven by higher complexity workloads (AI/Deep Learning, Analytics, etc.)

Cloud Service Provider Spending – Top 7 CSPs (2015-2021E)



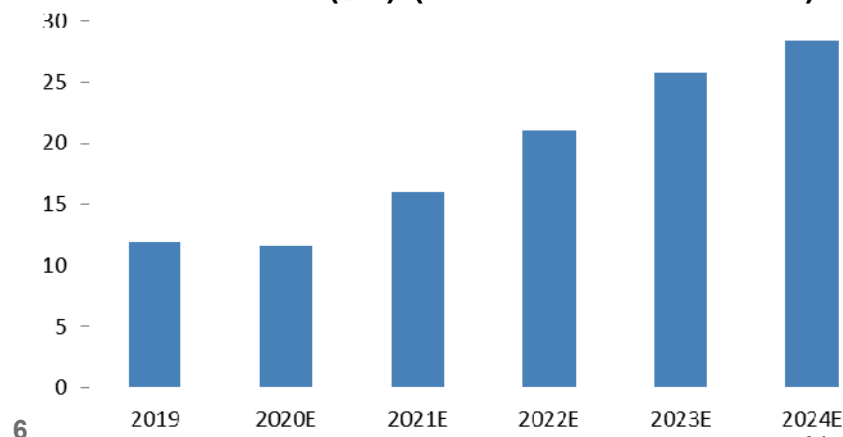
Source: Company reports, Bloomberg Finance L.P., and J.P. Morgan estimates.

Data Center 50G/100G/200G/400G Switch Port Growth (2019-2024E) 23%+ CAGR



Source: Dell'Oro

Cloud Computing Growth - Worldwide Accelerated Server Revenue(\$B) (25% CAGR 2020-2023)



Source: IDC and J.P. Morgan estimates

Custom Chip (ASIC) Market Experiencing a Resurgence in Activity as Large OEMs, Cloud, And Hyperscalers Look to Differentiate at the Silicon Level - \$10-12B Oppty

- Demand is rising for custom ASICs, because many of the large OEMs/CSPs/Hyperscalers are looking for more differentiation, better performance, lower power consumption and overall lower cost of ownership versus off-the-shelf chip solutions (or ASSPs)
- At the same time, these same customers do not have the capabilities to do large complex system-on-a-chip (SOC) designs, nor do they have the broad IP portfolio of on-chip design blocks, like high speed SERDES capabilities or high speed memory interface technology. They need to engage with semiconductor companies (ASIC companies) that have the IP and chip design expertise (Broadcom, Marvell, Intel, MediaTek, as examples).
- The digital custom ASIC chip market is a ~\$10-\$12B per year market opportunity:
 - Cloud/Hyperscale ASICS (AI processors, SmartNICs, Security/Video processors, Networking/Storage acceleration)
 - Telco/service provider equipment OEMs (5G basestation modem, 5G digital front end, 5G MIMO/Beamforming DSPs, Coherent DSPs for long

Snapshot of High Profile Custom ASIC Programs at Broadcom

Broadcom ASIC Customers	Programs	Technology	Status
Google	TPU1	28nm Technology	Deployed
Google	TPU2	16nm Technology	Deployed
Google	TPU3	16nm Technology	Deployed
Google	TPU4	7nm Technology	Begun production in 2Q20
Google	TPU5	5nm Technology	Target tape out 2021
Google	Switching	7nm Technology	Target tape out 2021
Facebook	ASIC	16nm Technology	Security Accel, 2020
Facebook	ASIC	7nm Technology	Video Accel, 2020
Facebook	ASIC	7nm Technology	Security Accel, 2021
Microsoft	ASIC	7nm Technology	Security Accel, 2020
Microsoft	ASIC	7nm Technology	SmartNIC
Tier-1 US Service provider	ASIC	16nm Technology	SmartNIC
Alibaba	ASIC	16nm Technology	SmartNIC
Fujitsu	ASIC	7nm Technology	AI acceleration
Cambricon	ASIC	7nm Technology	AI acceleration
SambaNova	ASIC	7nm Technology	AI acceleration
Nokia/Ericsson/ZTE	ASIC	16nm/7nm Technology	5G Basestation /Radio Head
Apple	ASIC	16nm	Next Gen iPhone Touch IC

New ASIC Programs for Broadcom/Marvell

- Marvell – 5nm ASIC with Microsoft - ARM CPU
- Marvell – 7nm/5nm Cloud Networking ASIC
- Broadcom – 20+, 7nm ASIC designs underway
- Broadcom – 6, 5nm ASIC designs underway
- Broadcom – 3nm ASIC development underway for next gen Tier-1 Cloud AI processor
- Broadcom – new wireless charging ASIC for iPhone 13 and new touch controller ASIC

Source: J.P. Morgan Research

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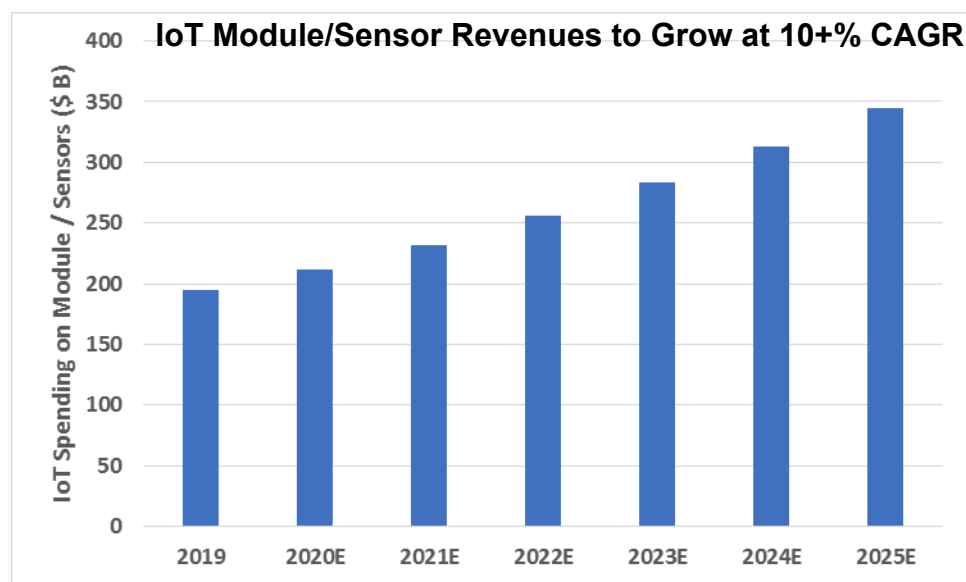
Internet of Things Semiconductor Opportunities Expanding Beyond Consumer with Wireless Connectivity to Deliver Outsized Growth

IoT represents strong double-digit semiconductor growth opportunity

Growth shifting from more consumer-focused end-markets to industrial and automotive

Key drivers:

- Growth from consumer applications such as smart home, smart speakers, wearables, etc. likely to moderate, while Industrial IoT and Automotive IoT growth likely to accelerate
- Wireless Connectivity (e.g. Wi-Fi and Bluetooth) unit growth of >15%
 - 802.11 (Wi-Fi) – 15-17% CAGR
 - 802.15.4 (inc. ZigBee, Thread) – 15-17% CAGR
 - Bluetooth – 25%+ CAGR
 - Other (inc. Z-wave Proprietary) - 13-15% CAGR



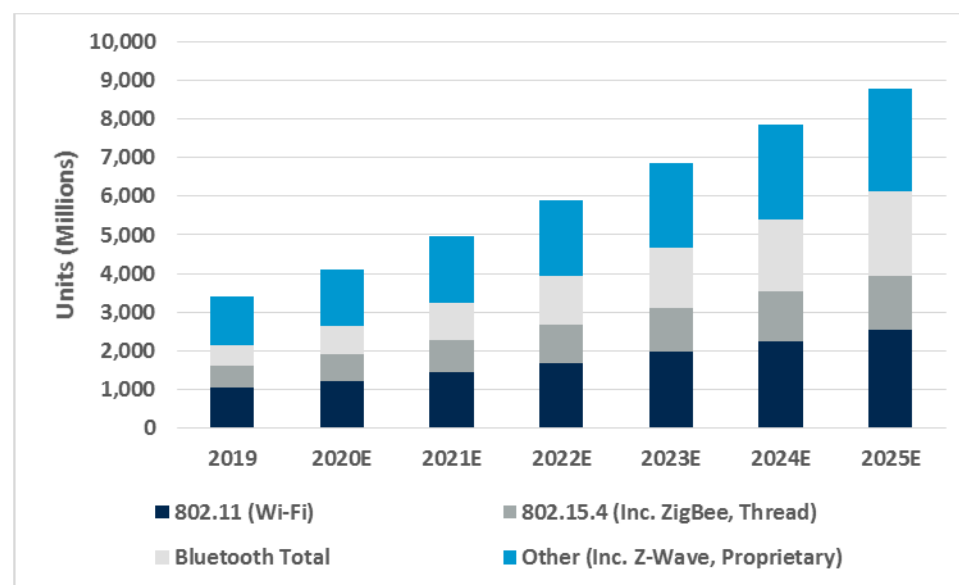
Source: IDC and J.P. Morgan estimates.

IoT Semiconductor Revenue Growth by End-Market 2019-2024E

End-Market	CAGR (2019-2024E)
Consumer	10-11%
Industrial	13-15%
Automotive	>30%
Total:	15-20%

Source: Gartner and J.P. Morgan estimates.

Wireless Connectivity Such as Wi-Fi and Bluetooth to Deliver Outsized Growth



8 Source: Gartner and J.P. Morgan estimates.

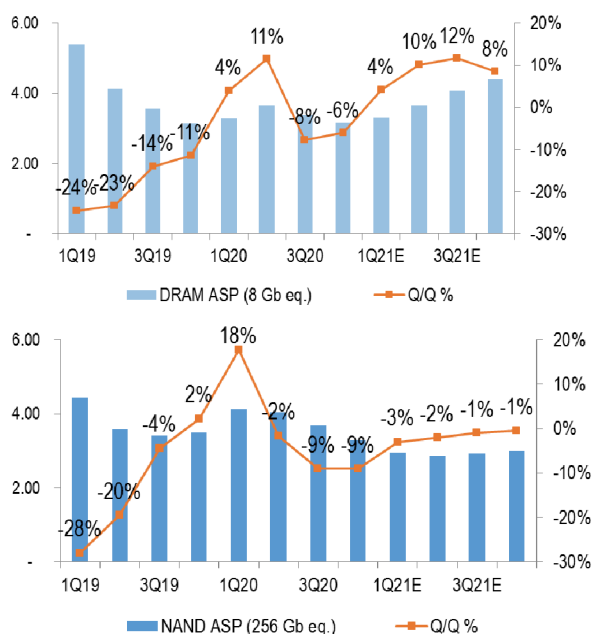
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Demand Growth Accelerating in Memory, Pricing Should Improve Meaningfully in DRAM in Early 2021 While Price Declines in NAND Moderate

■ Bit Demand in DRAM and NAND to accelerate in 2021

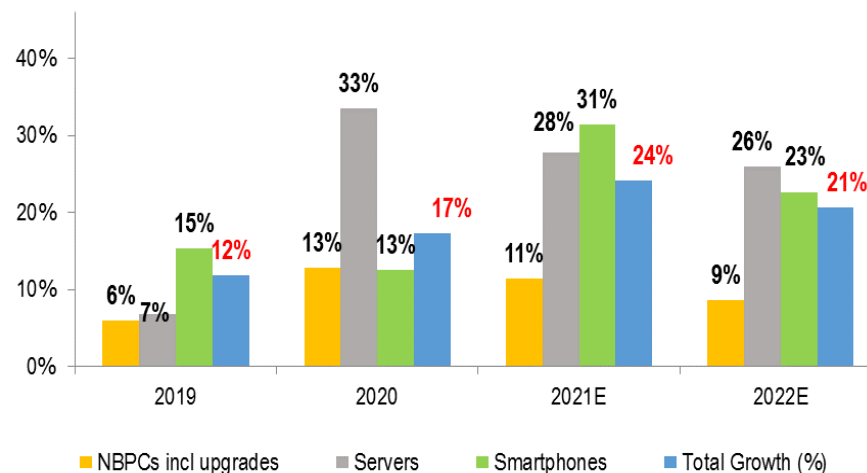
- DRAM bit demand should increase to >20% with strong demand for server and mobile DRAM
- NAND bit demand should increase to ~40%, led by SSDs and mobile devices
- Supply tightness in DRAM as a result of lower DRAM capex in past two years should lead to improved pricing and ASP increases in 2021
- NAND market still in oversupply – ASP declines should decelerate later in 2021
- Improving Memory fundamentals, especially in DRAM, positive for OW-rated MU in 2021

DRAM and NAND ASP Trends



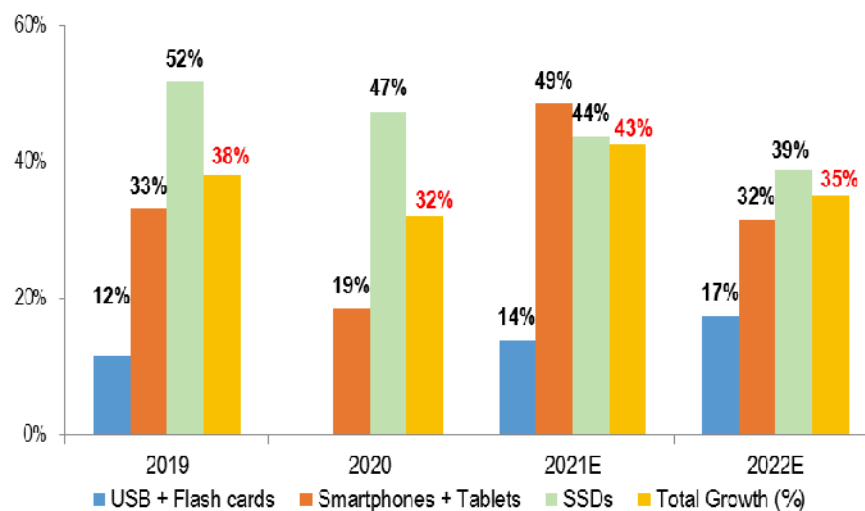
Source: WSTS and J.P. Morgan estimates

DRAM Bit Demand by Market



Source: Gartner and J.P. Morgan estimates.

NAND Bit Demand by Market



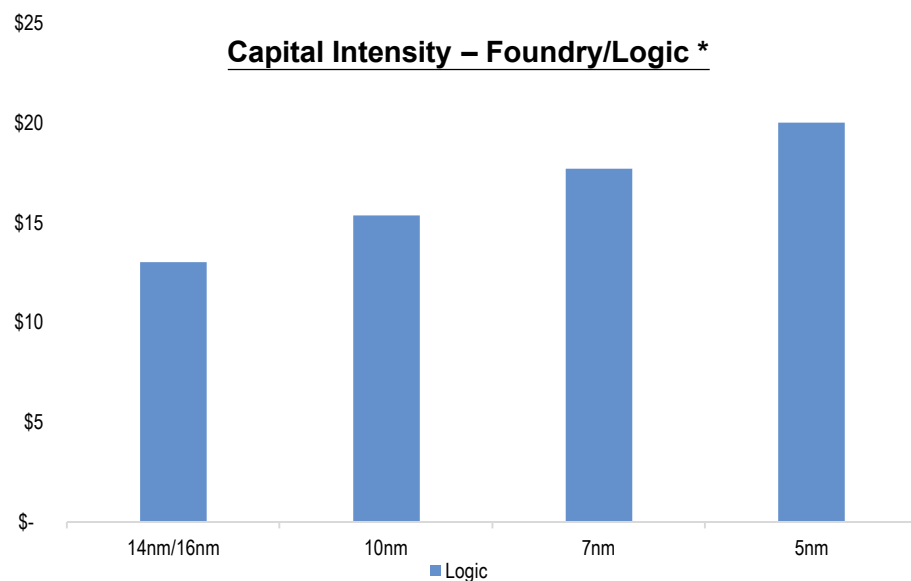
Source: Gartner and J.P. Morgan estimates.

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Capital Intensity Increasing Across Device Types – Positive for Semi Equipment

Capital Intensity Increasing Across Device Types

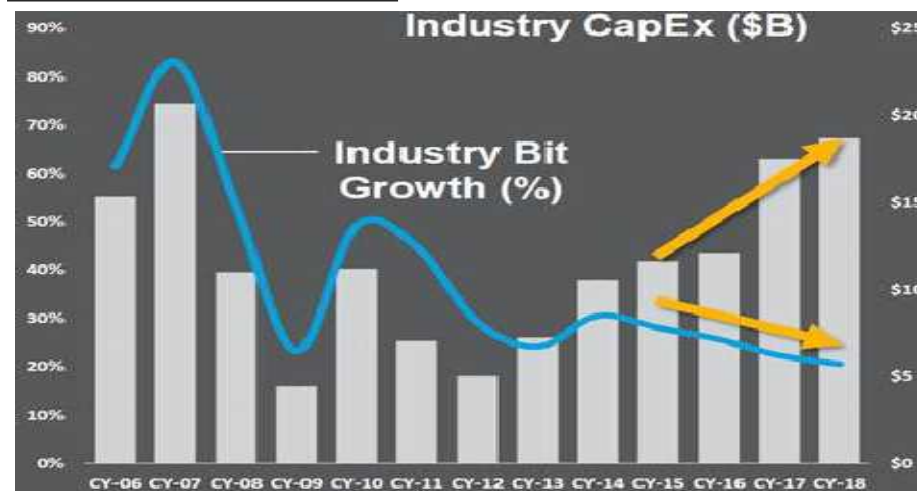
- Increasing capex to drive bit growth for both DRAM and NAND; NAND capital intensity for 12X layer >50% higher than 4X layer NAND
- Require increasing capex to drive bit growth for both DRAM and NAND
- Capital intensity increasing for Foundry/Logic even as EUV has begun ramping; 5nm capital intensity >50% higher than 14nm/16nm
- Increasing capital intensity is positive for semiconductor equipment companies, as spending on equipment will likely have a higher floor and be less cyclical over the next several years



Source: Tokyo Electron SEMICON West 2019, J.P. Morgan estimates

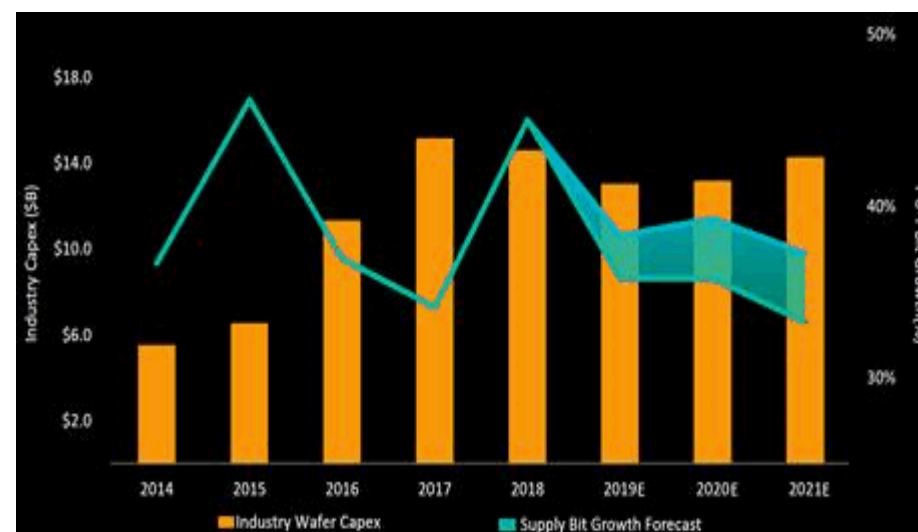
* \$B of WFE required for 100k wafer starts per month (WSPM) greenfield capacity

DRAM Capex vs. Bit Growth



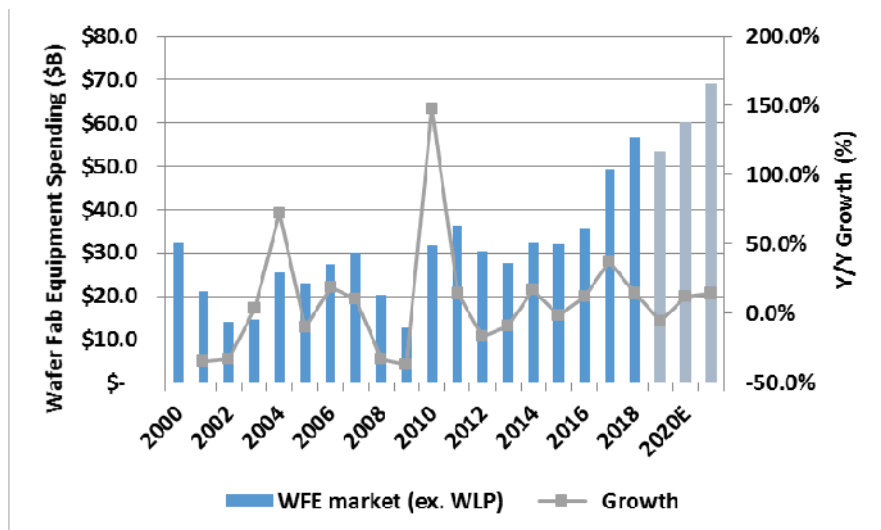
Source: Micron, May 2018 Analyst Day

NAND Capex vs. Bit Growth



Source: Western Digital, December 2018 Analyst Day
Forward Insights, 2018, WDC. 2019-2021 Projection

WFE Forecast and Key Programs for Semiconductor Manufacturers in 2021



Source: Industry data and J.P. Morgan estimates.

We estimate WFE spending is on track to increase by ~16% in 2021 to nearly \$70B

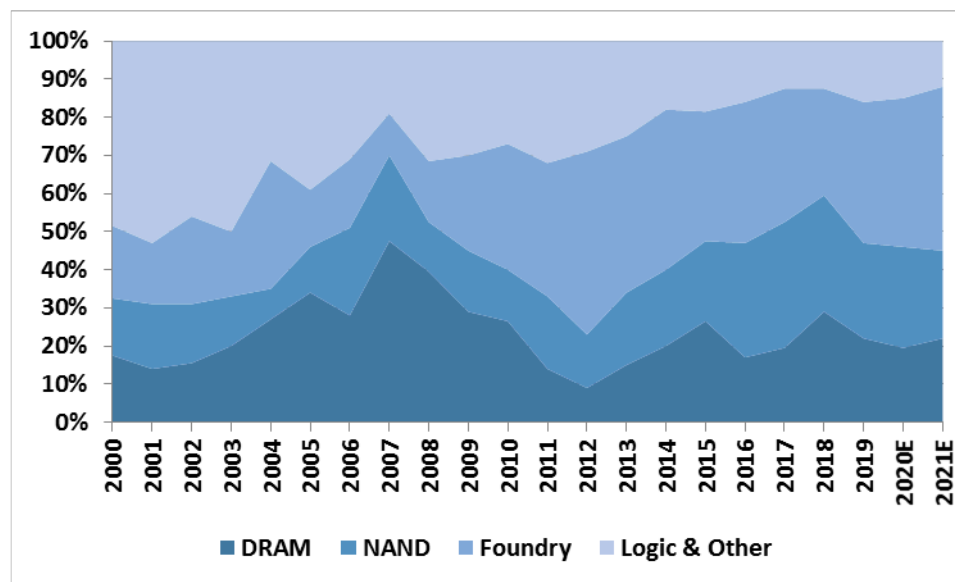
We expect Memory to recover in 2021 led by DRAM on improving S/D fundamentals with Foundry/Logic spending sustainable

Key drivers:

- Following muted Memory WFE in 2020 held back on supply discipline, we expect Memory spending to accelerate to double-digit % in 2021, led by DRAM
- Expect continued Foundry/Logic spending strength in 2021; broad-based across leading and lagging edge technologies
- China spending to remain strong in 2021 as local manufacturers come up the learning curve

Manufacturer	Segment	Technology
China	Foundry	14nm and above (Various)
China	Memory (DRAM)	1Xnm, 1Y DRAM (Changxin Memory Technologies, Hefei)
China	Memory (NAND)	128 layer 3D NAND (YMTC, Wuhan)
Globalfoundries	Foundry	12nm/14nm FinFET (New York)
Intel	Logic	10nm/7nm/5nm FinFET (Israel, Oregon, Arizona)
Micron	Memory (NAND)	3D NAND – 176 L Replacement Gate (Singapore expansion)
Micron	Memory (DRAM)	1αnm DRAM (Taiwan and Hiroshima Japan, expansion)
Samsung	Foundry/Logic	5nm FF/3nm GAA (Hwaseong & Pyeongtaek, South Korea)
Samsung	Memory (NAND)	128/176 L 3D NAND (Pyeongtaek, Korea & Xian, China)
Samsung	Memory (DRAM)	1α nm DRAM (Pyeongtaek, South Korea)
SK hynix	Memory (NAND)	128 3D NAND (Cheongju, South Korea)
SK hynix	Memory (DRAM)	1αnm DRAM (Incheon, Korea; Wuxi, China)
WDC / Partner	Memory (NAND)	112L BiCS 5 3D NAND (Yokkaichi and Kitakami Japan)
TSMC	Foundry	5nm/3nm FF & legacy (Taiwan)
UMC	Foundry	14nm and above

Source: Industry data and J.P. Morgan estimates.



Source: Industry data and J.P. Morgan estimates.

2021 US Government Domestic Manufacturing Incentives and R&D Funding – National Defense Authorization Act, FY2021

- **In 2020, several initiatives were proposed by US lawmakers to provide incentives for semiconductor companies to build/expand semiconductor manufacturing capabilities in the US and provide funding for Semiconductor R&D programs**
 - **CHIPS for America Act and American Foundries Act were two bipartisan initiatives that focused on incentives for domestic manufacturing**
 - **Both of these initiatives were rolled up in the National Defense Authorization Act (NDAA), which had bipartisan support and was passed by congress at the beginning of this year**
- The provisions authorized by the NDAA must still be funded through appropriations made by congress
- We believe up to \$3B of federal government funding for each specific domestic fab program – with total appropriation of \$15-20B and another \$12-15B for specific semiconductor R&D programs. We believe domestic fab programs that qualify for funding can include U S and international companies (i.e. TSMC, Samsung)
- We believe US-based foundry/IDMs will likely benefit the most, especially those that have US defense related qualification
 - **Winners: Global Foundries (#3 global foundry mkt share, US-based), Intel, Micron, Texas Instruments, CREE, Analog Devices, ON Semiconductor**
 - **Secondary Winners: TSMC (#1 global foundry share), Samsung (#2 global foundry share)**

Stock Picks

- **In Semis – Large-cap semis top pick: AVGO; we also favor INTC, MU, TXN, NVDA, MCHP, and QRVO**
 - We focus on market leadership, strong exposure to cloud/5G infrastructure spending trends, strong product cycles, diversification, and margin/free cash flow expansion with increasing payout ratios
 - OW – AVGO: strong FCF generation (dividend raised to \$16 this year) and leadership in cloud datacenter networking, 5G networking, and broadband access silicon technology...strong stable growth infrastructure software business
- **Semi capital equipment fundamentals will benefit from the improved profitability of memory companies, rising complexity and therefore rising equipment intensity and capacity expansion plans by foundry customers: top pick KLAC (OW) – we are also OW LRCX and AMAT**
- **Smid-cap – we are OW SLAB and SYNA on outsized exposure to IoT / embedded markets, with M&A in semiconductors supportive of valuations**

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