

## US Semiconductors

## State of the Union: acceleration, driven by secular drivers + cyclical recovery

Price Objective Change

## Accelerating growth with first \$0.5Tn year by CY22E

We reiterate our strongly positive view on the semi industry and forecast industry growth will accelerate to 8% CAGR from CY20-22E, or 4x the sluggish 2% rate of the past 3 years that was impacted by trade tensions, a global pandemic and a maturing 4G smartphone cycle. We believe the next 2 years will drive the industry to its first \$0.5T+ sales year, driven by: (1) secular drivers of cloud/AI, gaming, smart industry/home/IoT; the telework and teleplay economy will remain strong even post-vaccine, in our view; (2) cyclical recovery in auto/industrials; (3) expanding adoption of 5G smartphones/wireless infra; and (4) stabilization in memory pricing. To be sure, China/US trade tensions appear here to stay, but prospects of more localization (duplicated infrastructure), competition (faster tech/5G adoption, green energy investments) and less relationship volatility could be a net positive. Our report details industry growth by end-market and product-type.

## Computing: preferred area, Buy NVDA, AMD, MRVL

While exposed to periodic market rotation/rising interest-rate risks, we still expect stocks exposed to secular growth drivers to continue to outperform. NVDA, AMD, MRVL are our top picks, with est. ~20% sales/~30% EPS growth rates for the next two years. Importantly these companies are exposed to the right, duopolistic growth markets with significant barriers to entry, with prospects of share gains from incumbents.

## Semicaps: Buy AMAT (new top pick), LRCX, KLAC

We also raise our forecast for wafer fab equipment (WFE) to +17%/+8% in 2020/2021 (vs. +13%/-0.5% prior) as China (SMIC) restriction headwinds are more moderate than initially expected and are offset by continued strong demand for both leading/lagging edge technologies. AMAT is our new top pick within semicaps on demonstrated CY20 WFE share gains; prospects for stronger DRAM recovery; potential benefits from closure of the Kokusai acquisition (expected year-end, adds 200bps WFE share, immediately EPS accretive) and/or buybacks resumption; derisked display biz; and potential to close the 3-4 turn PE discount to peers. We raise our AMAT PO to \$93 from \$78 and continue to like Buy-rated LRCX (PO raised to \$485 from \$420, and KLAC (PO to \$268 from \$225).

## Rise of autos/EVs: Buy NXPI, ADI, IIVI

We expect units and content recovery in automotive, especially in EVs, to be a strong industry growth driver in CY21/22E. We especially like: 1) multi-engine/multi-catalyst growth at NXPI (top 2 auto vendor, growth in battery management systems, ultra wide band, WiFi/IoT, buyback resumption, potential for SPX inclusion; raise PO to \$175 from \$160); 2) ADI (5G radio growth, EV battery management systems, buyback resumption, potential to close 2-3 turn valuation gap with TXN); and 3) IIVI (top SMidcap growth, just recognized for photonics/iPhone 3D sensing, with no value placed on SiC/GaN materials which are often valued as much as ~8x sales at peers, raise PO to \$80 from \$70).

## Smartphone: awaiting iPhone 5G sell-through

We continue to like RF vendors (SWKS, QROV) and note advancements made by Qualcomm (covered by Tal Liani). However, we tweak down SWKS PO (to \$165 from \$180) on elevated Apple exposure ([per recent 10K](#)) and limited clarity on 5G iPhone sell-through. Our report presents our updated RF model showing 16% RF TAM CAGR (2020-2022E), but in the near term we await the sell-through trends for iPhone 5G.

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**Refer to important disclosures on page 25 to 28. Analyst Certification on page 23. Price Objective Basis/Risk on page 19.**

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ADI – Analog Devices

AMAT – Applied Materials

AMD – Advanced Micro Devices

DRAM – Dynamic Random Access Memory

EV – Electric Vehicles

GaN – Gallium Nitride

IoT – Internet of Things

KLAC – KLA Corp

LRCX – Lam Research

MRVL – Marvell

NVDA – Nvidia

QROV - Qorvo

RF – Radio Frequency

SiC – Silicon Carbide

SMIC – Semiconductor Manufacturing International Corp.

SWKS - Skyworks

TAM – Total Addressable Market

# Updated Global Semis Forecast

We revise our global semis forecast and now project semi sales to grow 6% YoY in 2020 (vs. +3% prior), led by a rebound in memory (+12% YoY) after a down cycle in 2019. Additionally, our stronger semi ex-memory sales (+4% YoY vs +1% YoY) reflects elevated MPU/Logic demand driven by work from home trends. In 2021, we expect a sustained recovery in semis as COVID-19 headwinds dissipate, with semis ex-memory sales growing +6.4% YoY, memory +13%, and overall semis growth of +8% YoY.

We expect more robust semis growth through CY22 following two years of macro headwinds (memory supply/demand issues, trade tensions, COVID-19). Notably, we forecast semis to grow at an 8% CAGR (2020-22E), well above the 2% CAGR from 2017-20E. Ex-memory, our outlook assumes semis to grow at ~5.5% CAGR from 2019-22E, which is relatively in line with normal 2x GDP growth. Notably, we expect a modest rebound in growth across Analog/MCU devices (exposed to rebounding auto/industrial demand).

**Table 1: We expect semis to grow at a 8% CAGR from 2020-22E**

| Revenue (\$mn)                             | 2014             | 2015             | 2016             | 2017             | 2018             | 2019             | 2020E            | 2021E            | 2022E            | 2020-22E     | 2017-20E      | 2015-20E     |
|--|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|--------------|---------------|--------------|
| <b>Total Semis</b>                         | <b>\$335,843</b> | <b>\$335,169</b> | <b>\$338,931</b> | <b>\$412,221</b> | <b>\$468,778</b> | <b>\$412,307</b> | <b>\$437,110</b> | <b>\$472,218</b> | <b>\$509,407</b> | <b>8.0%</b>  | <b>2.0%</b>   | <b>9.3%</b>  |
| YoY%                                       | 9.9%             | -0.2%            | 1.1%             | 21.6%            | 13.7%            | -12.0%           | 6.0%             | 8.0%             | 7.9%             |              |               |              |
| <b>Memory*</b>                             | <b>\$79,232</b>  | <b>\$77,205</b>  | <b>\$76,767</b>  | <b>\$123,974</b> | <b>\$157,967</b> | <b>\$106,440</b> | <b>\$119,066</b> | <b>\$133,927</b> | <b>\$155,255</b> | <b>14.2%</b> | <b>-1.3%</b>  | <b>15.5%</b> |
| YoY%                                       | 18.2%            | -2.6%            | -0.6%            | 61.5%            | 27.4%            | -32.6%           | 11.9%            | 12.5%            | 15.9%            |              |               |              |
| <b>DRAM</b>                                | <b>\$46,858</b>  | <b>\$44,970</b>  | <b>\$41,179</b>  | <b>\$72,802</b>  | <b>\$99,308</b>  | <b>\$62,475</b>  | <b>\$65,123</b>  | <b>\$73,792</b>  | <b>\$86,344</b>  | <b>15.1%</b> | <b>-3.6%</b>  | <b>13.1%</b> |
| YoY%                                       | 34.7%            | -4.0%            | -8.4%            | 76.8%            | 36.4%            | -37.1%           | 4.2%             | 13.3%            | 17.0%            |              |               |              |
| <b>NAND</b>                                | <b>\$28,234</b>  | <b>\$28,845</b>  | <b>\$32,023</b>  | <b>\$47,227</b>  | <b>\$54,227</b>  | <b>\$40,180</b>  | <b>\$50,229</b>  | <b>\$56,082</b>  | <b>\$64,550</b>  | <b>13.4%</b> | <b>2.1%</b>   | <b>20.3%</b> |
| YoY%                                       | 2.8%             | 2.2%             | 11.0%            | 47.5%            | 14.8%            | -25.9%           | 25.0%            | 11.7%            | 15.1%            |              |               |              |
| <b>Semis ex-Memory</b>                     | <b>\$256,611</b> | <b>\$257,964</b> | <b>\$262,164</b> | <b>\$288,247</b> | <b>\$310,812</b> | <b>\$305,867</b> | <b>\$318,044</b> | <b>\$338,291</b> | <b>\$354,152</b> | <b>5.5%</b>  | <b>3.3%</b>   | <b>7.2%</b>  |
| YoY%                                       | 7.6%             | 0.5%             | 1.6%             | 9.9%             | 7.8%             | -1.6%            | 4.0%             | 6.4%             | 4.7%             |              |               |              |
| <b>IC ex-Memory</b>                        | <b>\$198,070</b> | <b>\$197,278</b> | <b>\$199,931</b> | <b>\$219,212</b> | <b>\$235,321</b> | <b>\$226,914</b> | <b>\$237,969</b> | <b>\$252,897</b> | <b>\$264,396</b> | <b>5.4%</b>  | <b>2.8%</b>   | <b>6.5%</b>  |
| YoY%                                       | 7.2%             | -0.4%            | 1.3%             | 9.6%             | 7.3%             | -3.6%            | 4.9%             | 6.3%             | 4.5%             |              |               |              |
| <b>Analog</b>                              | <b>\$44,365</b>  | <b>\$45,228</b>  | <b>\$47,848</b>  | <b>\$53,070</b>  | <b>\$58,785</b>  | <b>\$53,939</b>  | <b>\$52,878</b>  | <b>\$56,036</b>  | <b>\$58,827</b>  | <b>5.5%</b>  | <b>-0.1%</b>  | <b>5.3%</b>  |
| YoY%                                       | 10.6%            | 1.9%             | 5.8%             | 10.9%            | 10.8%            | -8.2%            | -2.0%            | 6.0%             | 5.0%             |              |               |              |
| <b>Microprocessors</b>                     | <b>\$44,033</b>  | <b>\$43,268</b>  | <b>\$43,142</b>  | <b>\$44,300</b>  | <b>\$46,899</b>  | <b>\$47,974</b>  | <b>\$51,331</b>  | <b>\$52,148</b>  | <b>\$53,197</b>  | <b>1.8%</b>  | <b>5.0%</b>   | <b>5.9%</b>  |
| YoY%                                       | 7.1%             | -1.7%            | -0.3%            | 2.7%             | 5.9%             | 2.3%             | 7.0%             | 1.6%             | 2.0%             |              |               |              |
| <b>Microcontrollers</b>                    | <b>\$15,310</b>  | <b>\$15,479</b>  | <b>\$14,573</b>  | <b>\$16,348</b>  | <b>\$17,069</b>  | <b>\$15,808</b>  | <b>\$14,944</b>  | <b>\$16,181</b>  | <b>\$16,296</b>  | <b>4.4%</b>  | <b>-2.9%</b>  | <b>-1.2%</b> |
| YoY%                                       | 4.4%             | 1.1%             | -5.9%            | 12.2%            | 4.4%             | -7.4%            | -5.5%            | 8.3%             | 0.7%             |              |               |              |
| <b>DSP</b>                                 | <b>\$2,728</b>   | <b>\$2,551</b>   | <b>\$2,869</b>   | <b>\$3,286</b>   | <b>\$3,265</b>   | <b>\$2,658</b>   | <b>\$2,367</b>   | <b>\$2,271</b>   | <b>\$2,134</b>   | <b>-5.0%</b> | <b>-10.4%</b> | <b>-2.5%</b> |
| YoY%                                       | -6.2%            | -6.5%            | 12.5%            | 14.5%            | -0.6%            | -18.6%           | -11.0%           | -4.1%            | -6.0%            |              |               |              |
| <b>Logic</b>                               | <b>\$91,633</b>  | <b>\$90,753</b>  | <b>\$91,498</b>  | <b>\$102,209</b> | <b>\$109,303</b> | <b>\$106,535</b> | <b>\$116,449</b> | <b>\$126,262</b> | <b>\$133,942</b> | <b>7.2%</b>  | <b>4.4%</b>   | <b>8.7%</b>  |
| YoY%                                       | 6.6%             | -1.0%            | 0.8%             | 11.7%            | 6.9%             | -2.5%            | 9.3%             | 8.4%             | 6.1%             |              |               |              |
| <b>Discretes, optoelectronics, sensors</b> | <b>\$58,541</b>  | <b>\$60,685</b>  | <b>\$62,233</b>  | <b>\$69,035</b>  | <b>\$75,490</b>  | <b>\$78,953</b>  | <b>\$80,075</b>  | <b>\$85,394</b>  | <b>\$89,756</b>  | <b>5.9%</b>  | <b>5.1%</b>   | <b>9.7%</b>  |
| YoY%                                       | 8.8%             | 3.7%             | 2.6%             | 10.9%            | 9.4%             | 4.6%             | 1.4%             | 6.6%             | 5.1%             |              |               |              |

Source: BofA Global Research estimates, SIA

\*Our memory forecast, which is based on bottom-up analysis, differs from WSTS industry estimates



# Updated global semis forecast by end mkt

In 2020, by end market we expect: (1) **autos** down -13% YoY (SAAR down roughly 21% with production partially offset by content); (2) **industrial** up +3% YoY benefiting from resiliency across select end markets (such as medical) as well as a strong recovery in global PMIs since bottoming in late Q1/early Q2; (3) **compute and storage** growth of +10% YoY, driven by elevated demand for bandwidth driven by increased streaming and work-from-home activity which drove strong PC sales and led to hyperscalers rapidly increasing capacity; (4) **wired comms** up +9% YoY supporting the “stay-at-home” economy, with **wireless comms** up a more modest +3.5% YoY as the 5G ramp is partially offset by smartphone units declining upwards of 10% YoY; (5) **consumer** up a modest 4% as macro trends broadly improve since March/April.

Looking out to 2021, by end market we forecast: (1) **autos** strongly up 16% as units rebound double digits and content gains continue; (2) **industrial** up 9% on continued demand for resilient medical end markets as well as a recovery in more cyclical factory automation/robotics markets; (3) **compute and storage** up modestly 1% on tough compares especially in PC market (50% of demand); (4) **wired comms** also decelerating to up 5% on tough compares and temporary pause in 5G spending through early 1Q21. For **wireless comms** we expect a slight deceleration in wireless infrastructure more than offset by strong growth in smartphones driven by unit rebound and 5G proliferation; (5) **consumer** we expect modest 1% decline.

**Table 2: We expect automotive, SSDs, smartphones, industrial and servers to be the fastest growing markets in semis from 2020-2022E**

| Revenue (\$mn)            | 2014      | 2015      | 2016      | 2017      | 2018      | 2019      | 2020E     | 2021E     | 2022E     | 2020-22E | 2017-20E |
|---------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|
| Total Semis               | \$335,843 | \$335,169 | \$338,931 | \$412,221 | \$468,778 | \$412,307 | \$437,110 | \$472,218 | \$509,407 | 8.0%     | 2.0%     |
| YoY%                      | 9.9%      | -0.2%     | 1.1%      | 21.6%     | 13.7%     | -12.0%    | 6.0%      | 8.0%      | 7.9%      |          |          |
| Memory                    | \$79,232  | \$77,205  | \$76,767  | \$123,974 | \$157,967 | \$106,440 | \$119,066 | \$133,927 | \$155,255 | 14.2%    | -1.3%    |
| YoY%                      | 18.2%     | -2.6%     | -0.6%     | 61.5%     | 27.4%     | -32.6%    | 11.9%     | 12.5%     | 15.9%     |          |          |
| Semis ex-Memory           | \$256,611 | \$257,964 | \$262,164 | \$288,247 | \$310,812 | \$305,867 | \$318,044 | \$338,291 | \$354,152 | 5.5%     | 3.3%     |
| YoY%                      | 7.6%      | 0.5%      | 1.6%      | 9.9%      | 7.8%      | -1.6%     | 4.0%      | 6.4%      | 4.7%      |          |          |
| Compute and Storage       | \$88,441  | \$82,699  | \$83,686  | \$90,786  | \$100,700 | \$99,010  | \$109,291 | \$110,726 | \$110,469 | 0.5%     | 6.4%     |
| YoY%                      | 3.2%      | -6.5%     | 1.2%      | 8.5%      | 10.9%     | 0.5%      | 10.4%     | 1.3%      | -0.2%     |          |          |
| PC                        | \$50,256  | \$44,196  | \$43,431  | \$44,888  | \$46,957  | \$46,292  | \$51,523  | \$50,477  | \$48,216  | -3.3%    | 4.7%     |
| YoY%                      | 1.0%      | -12.1%    | -1.7%     | 3.4%      | 4.6%      | -1.4%     | 11.3%     | -2.0%     | -4.5%     |          |          |
| Server                    | \$13,784  | \$15,034  | \$16,049  | \$17,874  | \$23,139  | \$22,765  | \$24,898  | \$26,622  | \$28,675  | 7.3%     | 11.7%    |
| YoY%                      | 17.9%     | 9.1%      | 6.8%      | 11.4%     | 29.5%     | -1.6%     | 9.4%      | 6.9%      | 7.7%      |          |          |
| Hard Disk Drives (HDDs)   | \$1,578   | \$1,905   | \$1,791   | \$1,877   | \$1,649   | \$1,136   | \$960     | \$855     | \$742     | -12.1%   | -20.0%   |
| YoY%                      | -14.5%    | 20.7%     | -6.0%     | 4.8%      | -12.2%    | -31.1%    | -15.5%    | -10.9%    | -13.2%    |          |          |
| Solid State Drives (SSDs) | \$892     | \$1,096   | \$1,423   | \$1,864   | \$2,879   | \$3,276   | \$3,815   | \$4,396   | \$4,745   | 11.5%    | 27.0%    |
| YoY%                      | 40.1%     | 22.8%     | 29.9%     | 31.0%     | 54.4%     | 13.8%     | 16.4%     | 15.2%     | 7.9%      |          |          |
| Other Compute/Storage     | \$21,931  | \$20,469  | \$20,991  | \$24,282  | \$26,075  | \$25,541  | \$28,095  | \$28,376  | \$28,092  | 0.0%     | 5.0%     |
| YoY %                     | 0.6%      | -6.7%     | 2.6%      | 15.7%     | 7.4%      | -2.0%     | 10.0%     | 1.0%      | -1.0%     |          |          |
| Wired Communications      | \$16,068  | \$16,444  | \$18,166  | \$18,405  | \$18,172  | \$17,727  | \$19,322  | \$20,288  | \$20,998  | 4.2%     | 1.6%     |
| YoY%                      | 6.7%      | 2.3%      | 10.5%     | 1.3%      | -1.3%     | -2.5%     | 9.0%      | 5.0%      | 3.5%      |          |          |
| Wireless Communications   | \$63,833  | \$65,425  | \$66,467  | \$71,931  | \$74,649  | \$77,629  | \$80,331  | \$89,129  | \$95,781  | 9.2%     | 3.8%     |
| YoY%                      | 7.7%      | 2.5%      | 1.6%      | 8.2%      | 3.8%      | 4.0%      | 3.5%      | 11.0%     | 7.5%      |          |          |
| Smartphone                | \$54,604  | \$55,548  | \$57,482  | \$62,606  | \$64,674  | \$67,603  | \$69,603  | \$77,758  | \$83,955  | 9.8%     | 3.6%     |
| YoY%                      | 8.3%      | 1.7%      | 3.5%      | 8.9%      | 3.3%      | 4.5%      | 3.0%      | 11.7%     | 8.0%      |          |          |
| Wireless Infrastructure   | \$9,229   | \$9,878   | \$8,986   | \$9,325   | \$9,975   | \$10,026  | \$10,728  | \$11,371  | \$11,826  | 5.0%     | 4.8%     |
| YoY%                      | 4.7%      | 7.0%      | -9.0%     | 3.8%      | 7.0%      | 0.5%      | 7.0%      | 6.0%      | 4.0%      |          |          |
| Consumer                  | \$31,337  | \$29,538  | \$29,290  | \$32,449  | \$34,617  | \$32,889  | \$34,204  | \$34,033  | \$34,374  | 0.2%     | 1.8%     |
| YoY%                      | -0.7%     | -5.7%     | -0.8%     | 10.8%     | 6.7%      | -5.0%     | 4.0%      | -0.5%     | 1.0%      |          |          |
| Automotive                | \$28,195  | \$30,060  | \$33,074  | \$36,243  | \$39,490  | \$38,460  | \$33,478  | \$38,869  | \$43,673  | 14.2%    | -2.6%    |
| YoY%                      | 9.8%      | 6.6%      | 10.0%     | 9.6%      | 9.0%      | -2.6%     | -13.0%    | 16.1%     | 12.4%     |          |          |
| Industrial & Other        | \$28,736  | \$33,797  | \$31,481  | \$38,434  | \$43,183  | \$40,153  | \$41,418  | \$45,245  | \$48,857  | 8.6%     | 2.5%     |
| YoY%                      | 35.3%     | 17.6%     | -6.9%     | 22.1%     | 12.4%     | -7.0%     | 3.2%      | 9.2%      | 8.0%      |          |          |

Source: BofA Global Research, Gartner, IDC

## Coverage outlook by end market

We highlight valuation of major semiconductor companies by end market. We note (1) we expect **compute** (11% CAGR 2020-22E, 12% ex-INTC) slightly outgrowing more cyclically-exposed auto/industrial peers, though the sector is trading at a premium (22x CY22E P/E vs semi peers 16x-21x); (2) **auto/industrial** exposed names are expected to see a strong rebound, as we model a 29% EPS CAGR through 2022E (with larger cap TXN/ADI/MCHP seeing low-double-digit growth); (3) **smartphone vendors** are also on a path to see double-digit sales/EPS CAGR through CY22E and trade ~5x lower vs cyclically-exposed diversified peers (16x CY22E P/E vs 21x for diversified peers), likely due to caution surrounding the pace of the 5G rollout; (4) **semicaps/EDA** vendors sales/EPS growth forecasts at the lower end vs semi peers, though we see resilient CY20 performance (semicap/EDA sales +20%/+11% YoY) creating tougher comps.

Table 3: BofA Sales/EPS growth trends,

| Ticker       | Sales CAGR | EPS CAGR   | P/E          |              |
|--------------|------------|------------|--------------|--------------|
|              | 2020-2022E | 2020-2022E | 2021E        | 2022E        |
| Compute      | 11%        | 19%        | 26.4x        | 22.2x        |
| Diversified  | 9%         | 29%        | 23.1x        | 20.6x        |
| Smartphone   | 12%        | 16%        | 18.4x        | 15.9x        |
| Semicap      | 7%         | 10%        | 19.4x        | 17.2x        |
| EDA          | 9%         | 12%        | 36.9x        | 36.6x        |
| <b>Semis</b> | <b>9%</b>  | <b>16%</b> | <b>19.9x</b> | <b>18.0x</b> |

Source: BofA Global Research estimates, Bloomberg

## Compute

### Bull Points

- Exposure to our favorite end markets including data center, cloud computing, artificial intelligence (AI), gaming, autonomous driving
- Rapidly consolidated market with scarce assets and high barriers to entry

### Bear Points

- Potential rotation from growth to cyclical post COVID-19 pandemic
- Valuations high compared with semi industry average

In our preferred end market of compute, we highlight (1) strong **AMD** growth outlook (sales/EPS CAGR of 20%/36% from 2020E-22E) as it ramps new products and continues to take share from INTC; (2) **NVDA**'s high-teens/low-20s sales/EPS CAGR (above consensus 16%/18% sales/EPS CAGR), a potentially low bar given major gaming upgrade cycle and elevated demand for bandwidth; (3) Continued concern over **INTC**'s ability to maintain market share and deliver given manufacturing issues, with top-line growth expected to remain below 2020 levels through CY22E, -5% CAGR. Ex-INTC (and AVGO software), we expect compute to grow fastest amongst semis (12% CY20-22E).

Table 4: BofA sales/EPS outlook for compute vendors

| Ticker                                   | Sales (\$mn) |          |          |          | Sales CAGR<br>2020-2022E | EPS (\$) |         |         |         | EPS CAGR<br>2020-2022E | P/E          |              | YTD performance<br>CY20 YTD |
|--|--------------|----------|----------|----------|--------------------------|----------|---------|---------|---------|------------------------|--------------|--------------|-----------------------------|
|  | 2019         | 2020E    | 2021E    | 2022E    |                          | 2019     | 2020E   | 2021E   | 2022E   |                        | 2021E        | 2022E        |                             |
| INTC                                     | \$71,965     | \$75,289 | \$69,392 | \$67,284 | -5%                      | \$4.87   | \$4.90  | \$4.66  | \$4.71  | -2%                    | 9.8x         | 9.7x         | -24%                        |
| AVGO                                     | \$22,666     | \$24,451 | \$26,048 | \$27,352 | 6%                       | \$21.01  | \$23.02 | \$25.16 | \$27.18 | 9%                     | 15.4x        | 14.3x        | 23%                         |
| NVDA                                     | \$10,918     | \$16,472 | \$19,963 | \$23,365 | 19%                      | \$5.79   | \$9.69  | \$11.70 | \$14.26 | 21%                    | 45.6x        | 37.4x        | 126%                        |
| AMD                                      | \$6,731      | \$9,519  | \$11,649 | \$13,752 | 20%                      | \$0.64   | \$1.24  | \$1.81  | \$2.31  | 36%                    | 47.1x        | 36.9x        | 86%                         |
| MRVL                                     | \$2,699      | \$2,961  | \$3,379  | \$3,845  | 14%                      | \$0.66   | \$0.92  | \$1.32  | \$1.73  | 37%                    | 33.7x        | 25.7x        | 67%                         |
| IIVI                                     | \$1,712      | \$2,866  | \$3,212  | \$3,522  | 11%                      | \$2.19   | \$3.35  | \$3.32  | \$3.89  | 8%                     | 19.4x        | 16.6x        | 92%                         |
| MTSI                                     | \$468        | \$559    | \$607    | \$664    | 9%                       | (\$0.40) | \$1.33  | \$1.60  | \$1.90  | 19%                    | 27.1x        | 22.8x        | 63%                         |
| <b>Compute</b>                           |              |          |          |          | <b>11%</b>               |          |         |         |         | <b>19%</b>             | <b>27.1x</b> | <b>22.8x</b> | <b>67%</b>                  |
| <i>Compute ex-INTC, AVGO ex-Software</i> |              |          |          |          | <b>12%</b>               |          |         |         |         | <b>21%</b>             |              |              |                             |

Source: BofA Global Research estimates, Bloomberg



# Semicaps

## Bull Points

- “Arms dealers” to global semiconductor battles between Intel vs. TSMC, US vs. domestic China manufacturing, growing difficulty of scaling vs. Moore’s Law
- Global reshoring (duplicating of supply chains) beneficiaries

## Bear Points

- Nearly 50% of WFE tied to volatile and cyclical memory market which adds to uncertainty and pressures multiples
- Foundry/logic WFE at peak levels in 2020, creates tough compares for future growth

We expect major semicaps to grow top line at a 7% CAGR (CY20-22E) on average, with EPS increasing at a 10% CAGR. The solid outlook comes after the group was able to see sales growth of +20% YoY combined, benefitting from a strong rebound in memory. We highlight (1) **AMAT** trading ~3x below semicap peers (likely due to sluggish trends in display biz), but could present an enhanced buying oppty; (2) strong **LRCX** 8%/12% sales/EPS CAGR outlook (above AMAT/KLAC). With the overall semiconductor market showing signs of a rebound and the memory market improving, we believe semicaps will be key beneficiaries of an economic recovery.

**Table 5: BofA sales/EPS outlook for semicap vendors**

| Ticker         | Sales (\$mn) |          |          |          | Sales CAGR<br>2020-2022E | EPS (\$) |         |         |         | EPS CAGR<br>2020-2022E | P/E          |              | YTD performance<br>CY20 YTD |
|----------------|--------------|----------|----------|----------|--------------------------|----------|---------|---------|---------|------------------------|--------------|--------------|-----------------------------|
|                | 2019         | 2020E    | 2021E    | 2022E    |                          | 2019     | 2020E   | 2021E   | 2022E   |                        | 2021E        | 2022E        |                             |
| AMAT           | \$15,017     | \$17,990 | \$19,072 | \$20,402 | 6%                       | \$3.22   | \$4.46  | \$4.83  | \$5.44  | 10%                    | 16.1x        | 14.3x        | 27%                         |
| ASML           | \$13,232     | \$15,912 | \$17,906 | \$20,239 | 13%                      | \$6.82   | \$9.08  | \$11.55 | \$14.25 | 25%                    | 37.0x        | 30.0x        | 45%                         |
| LRCX           | \$9,549      | \$11,773 | \$12,764 | \$13,646 | 8%                       | \$14.51  | \$20.02 | \$22.14 | \$25.22 | 12%                    | 19.9x        | 17.4x        | 50%                         |
| KLAC           | \$5,279      | \$6,007  | \$6,402  | \$6,763  | 6%                       | \$8.72   | \$11.37 | \$12.53 | \$13.83 | 10%                    | 19.6x        | 17.8x        | 38%                         |
| TER            | \$2,295      | \$3,073  | \$3,318  | \$3,502  | 7%                       | \$2.85   | \$4.49  | \$4.84  | \$5.09  | 7%                     | 22.2x        | 21.1x        | 57%                         |
| <b>Semicap</b> |              |          |          |          | <b>7%</b>                |          |         |         |         | <b>10%</b>             | <b>19.9x</b> | <b>17.8x</b> | <b>45%</b>                  |

Source: BofA Global Research estimates, Bloomberg

\*Consensus estimates



## Updated Semi Capex & WFE analysis

In this report, we update our Global Semiconductor Capex & Wafer Fab Equipment (WFE) industry analysis, which reflects bottom-up capex estimates for the top 15-20 spenders (representing almost 90% of total capex), by device type (memory, foundry, and IDM/logic). Bottom-up capex implies capital spending up +10% YoY in 2020E. Overall, we forecast WFE up +17% in 2020E to \$60.1bn from \$51.3bn in 2019 and up 8% in 2021E to \$65.0bn. This compares to Global GDP growth expected to be down 4%/up 6% in 2020E/2021E, Global semi sales expected up 6%/up 8%, and memory/logic/MPU semi sales expected up 10%/8%.

**Table 6: We expect CY20/21 WFE spend to increase +17%/+8% YoY**

| Top-down analysis                     | 2010     | 2011     | 2012     | 2013     | 2014     | 2015     | 2016     | 2017     | 2018     | 2019     | 2020E    | 2021E    | 2022E    | '20-'22 | '17-'20E | '15-'20E |
|---------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|----------|
| Real global GDP (\$tn)                | \$66,037 | \$73,358 | \$75,046 | \$77,190 | \$79,297 | \$75,002 | \$76,104 | \$80,886 | \$85,791 | \$88,450 | \$85,089 | \$89,854 | \$92,101 | 4.0%    | 1.7%     | 2.6%     |
| YoY                                   | 9.4%     | 11.1%    | 2.3%     | 2.9%     | 2.7%     | -5.4%    | 1.5%     | 6.3%     | 6.1%     | 3.1%     | -3.8%    | 5.6%     | 2.5%     |         |          |          |
| Semiconductor sales (\$bn)            | \$298    | \$300    | \$292    | \$306    | \$336    | \$335    | \$339    | \$412    | \$469    | \$412    | \$437    | \$471    | \$507    | 7.7%    | 2.0%     | 5.5%     |
| YoY                                   | 31.8%    | 0.4%     | -2.7%    | 4.8%     | 9.9%     | -0.2%    | 1.1%     | 21.6%    | 13.7%    | -12.0%   | 6.0%     | 7.8%     | 7.5%     |         |          |          |
| Semi sales, excl. memory (\$bn)       | \$229    | \$239    | \$235    | \$239    | \$257    | \$258    | \$262    | \$288    | \$311    | \$306    | \$318    | \$337    | \$351    | 5.1%    | 3.3%     | 4.3%     |
| YoY                                   | 26.0%    | 4.4%     | -1.8%    | 1.7%     | 7.6%     | 0.5%     | 1.6%     | 9.9%     | 7.8%     | -1.6%    | 4.0%     | 6.1%     | 4.1%     |         |          |          |
| Memory sales (\$bn)                   | \$70     | \$61     | \$57     | \$67     | \$79     | \$77     | \$77     | \$124    | \$158    | \$106    | \$119    | \$134    | \$155    | 14.2%   | -1.3%    | 9.1%     |
| YoY                                   | 55.4%    | -12.7%   | -6.2%    | 17.6%    | 18.2%    | -2.6%    | -0.6%    | 61.5%    | 27.4%    | -32.6%   | 11.9%    | 12.5%    | 15.9%    |         |          |          |
| Logic sales (\$bn)                    | \$77     | \$79     | \$82     | \$86     | \$92     | \$91     | \$91     | \$102    | \$109    | \$107    | \$116    | \$124    | \$130    | 5.5%    | 4.4%     | 5.1%     |
| YoY                                   | 18.7%    | 1.8%     | 3.7%     | 5.2%     | 6.6%     | -1.0%    | 0.8%     | 11.7%    | 6.9%     | -2.5%    | 9.3%     | 6.8%     | 4.2%     |         |          |          |
| MPU sales (\$bn)                      | \$40     | \$45     | \$42     | \$41     | \$44     | \$43     | \$43     | \$44     | \$47     | \$48     | \$51     | \$52     | \$53     | 2.0%    | 5.0%     | 3.5%     |
| YoY                                   | 23.5%    | 12.0%    | -6.4%    | -1.8%    | 7.1%     | -1.7%    | -0.3%    | 2.7%     | 5.9%     | 2.3%     | 7.0%     | 2.2%     | 1.8%     |         |          |          |
| Memory, Logic, MPU sales (\$bn)       | \$187    | \$184    | \$181    | \$194    | \$215    | \$211    | \$211    | \$270    | \$314    | \$261    | \$287    | \$311    | \$338    | 8.6%    | 2.0%     | 6.3%     |
| YoY                                   | 31.3%    | -1.4%    | -2.0%    | 7.5%     | 10.7%    | -1.7%    | 0.1%     | 27.9%    | 16.2%    | -16.9%   | 9.9%     | 8.3%     | 8.9%     |         |          |          |
| Semiconductor capital spending (\$bn) | \$56.5   | \$66.7   | \$58.7   | \$57.8   | \$64.5   | \$64.4   | \$70.4   | \$92.3   | \$100.4  | \$99.4   | \$108.9  | \$111.5  | \$115.2  | 2.8%    | 5.7%     | 11.1%    |
| YoY                                   | 118.4%   | 17.9%    | -11.9%   | -1.5%    | 11.5%    | -0.2%    | 9.4%     | 31.1%    | 8.8%     | -1.0%    | 9.6%     | 2.3%     | 3.3%     |         |          |          |
| Wafer Fab Equipment (WFE) (\$bn)      | \$34.3   | \$40.1   | \$33.2   | \$29.0   | \$33.6   | \$33.3   | \$37.0   | \$49.7   | \$56.1   | \$51.3   | \$60.1   | \$65.0   | \$69.6   | 7.6%    | 6.5%     | 12.6%    |
| YoY                                   | 138.8%   | 16.9%    | -17.1%   | -12.8%   | 15.9%    | -1.0%    | 11.4%    | 34.3%    | 12.9%    | -8.5%    | 17.0%    | 8.2%     | 7.1%     |         |          |          |
| Other non-wafer-level spending (\$bn) | \$22.2   | \$26.5   | \$25.5   | \$28.9   | \$30.9   | \$31.1   | \$33.4   | \$42.6   | \$44.3   | \$48.0   | \$48.8   | \$46.4   | \$45.5   | -3.4%   | 4.7%     | 9.4%     |
| YoY                                   | 93.1%    | 19.5%    | -3.9%    | 13.1%    | 7.1%     | 0.6%     | 7.3%     | 27.7%    | 4.0%     | 8.5%     | 1.7%     | -4.9%    | -1.9%    |         |          |          |
| Wafer Fab Equipment ex-EUV (\$bn)     | \$34.3   | \$39.9   | \$33.2   | \$28.9   | \$33.2   | \$33.2   | \$36.7   | \$48.4   | \$53.9   | \$48.2   | \$55.0   | \$58.7   | \$59.9   | 4.3%    | 4.3%     | 10.6%    |
| YoY                                   | 138.8%   | 16.4%    | -16.9%   | -12.9%   | 14.8%    | 0.0%     | 10.5%    | 32.1%    | 11.3%    | -10.5%   | 14.1%    | 6.7%     | 2.0%     |         |          |          |

Source: BofA Global Research, Gartner, SIA

We expect capital intensity (capex as a % of semi sales) to increase 80bps to 25% in 2020E, above the long-term average 23%. We expect WFE capital intensity (WFE as a % of semi sales) to grow to 13.7% in 2020E (up from 12.5% in 2019), which is above the long-term average of 12.3% but well within long-term 6-17% range. Importantly, we expect WFE as a % of memory, logic, and MPU semi sales to grow to 21%, slightly above the l-t average of 20%. We expect WFE as a % of semi capital spending (capex) to grow to 55% in 2020E (vs. 52% in 2019), above the long-term average of 54%.

**Table 7: We expect WFE capital intensity to increase ~120bps YoY in CY20 to 13.7%**

|   | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020E | 2021E | 2022E | MIN   | AVG.  | MAX   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Semi capital intensity (% of sales)                   | 18.9% | 22.3% | 20.1% | 18.9% | 19.2% | 19.2% | 20.8% | 22.4% | 21.4% | 24.1% | 24.9% | 23.6% | 22.7% | 11.4% | 22.9% | 34.1% |
| Non-memory  | 14.9% | 19.4% | 19.5% | 17.8% | 16.8% | 15.1% | 15.6% | 16.7% | 15.8% | 17.8% | 19.3% | 18.3% | 17.9% | 14.9% | 16.9% | 19.5% |
| Memory  | 32.1% | 33.5% | 22.9% | 22.9% | 27.0% | 32.9% | 38.5% | 36.5% | 34.1% | 42.3% | 39.8% | 37.1% | 33.7% | 22.9% | 32.3% | 42.3% |
| WFE capital intensity (% of semi sales)               | 11.5% | 13.4% | 11.4% | 9.5%  | 10.0% | 9.9%  | 10.9% | 12.1% | 12.0% | 12.5% | 13.7% | 13.8% | 13.7% | 6.3%  | 12.3% | 17.0% |
| Non-memory  | 6.9%  | 10.4% | 10.5% | 8.3%  | 7.1%  | 6.2%  | 7.5%  | 7.6%  | 6.3%  | 10.2% | 11.0% | 10.9% | 11.0% | 6.2%  | 8.1%  | 10.5% |
| Memory  | 26.6% | 25.1% | 15.2% | 13.8% | 19.5% | 22.4% | 22.7% | 22.5% | 23.1% | 18.8% | 21.0% | 21.2% | 19.9% | 13.8% | 21.0% | 26.6% |
| WFE capital intensity (% of memory, logic, MPU sales) | 18.4% | 21.8% | 18.4% | 14.9% | 15.6% | 15.7% | 17.5% | 18.4% | 17.9% | 19.7% | 21.0% | 20.9% | 20.6% | 10.1% | 19.8% | 29.2% |
| WFE % of semiconductor capital spending               | 60.7% | 60.2% | 56.6% | 50.1% | 52.1% | 51.7% | 52.6% | 53.9% | 55.9% | 51.7% | 55.2% | 58.3% | 60.5% | 48.4% | 54.0% | 61.1% |
| Memory WFE % of memory capex                          | 82.9% | 74.9% | 66.3% | 60.5% | 72.4% | 68.1% | 58.9% | 61.6% | 67.7% | 44.4% | 52.8% | 57.1% | 59.1% | 44.4% | 65.8% | 82.9% |
| Non-memory WFE % of non-memory capex                  | 46.2% | 53.7% | 53.8% | 46.4% | 42.1% | 41.0% | 48.0% | 45.5% | 39.9% | 57.7% | 57.0% | 59.3% | 61.6% | 39.9% | 47.4% | 57.7% |

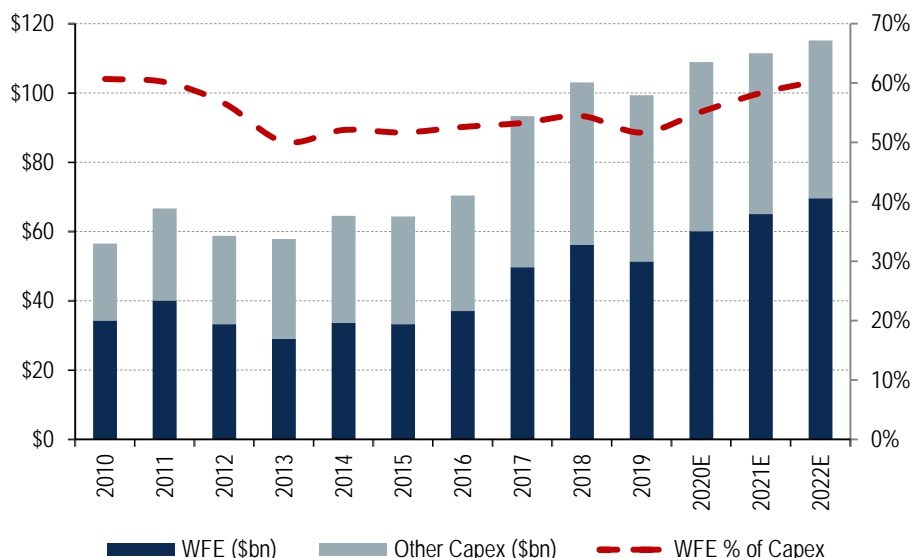
Source: BofA Global Research, Gartner, SIA





We expect WFE as a % of capex to grow in 2020E to 55% from 52% in 2019 and continue to climb towards 60% through 2022E. This is above the long-term average of 54% and within long-term range of 48-61%.

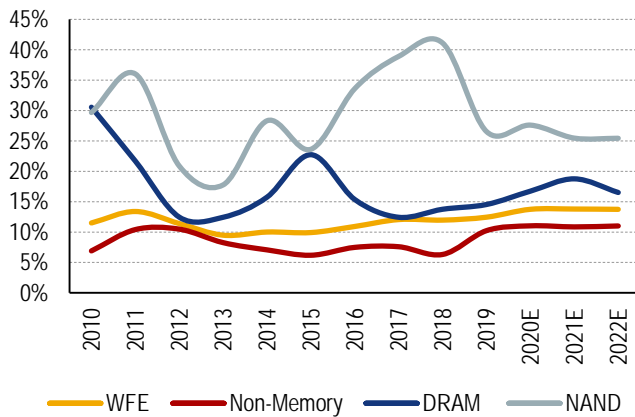
**Chart 1: WFE portion of capex to grow slightly in 2020E to 55% from 51.7% in 2019**



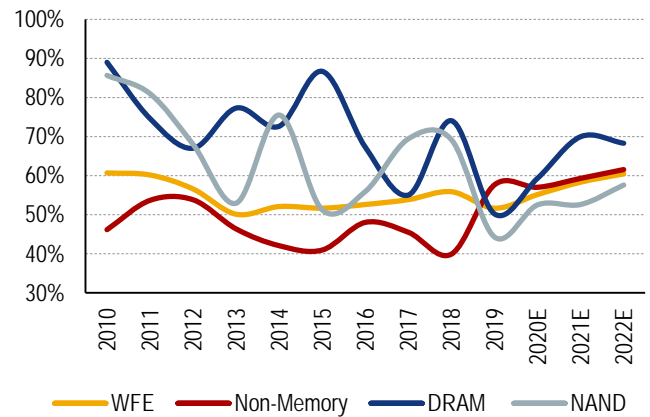
Source: BofA Global Research estimates, company data, Gartner

Over the last 10 years, WFE capital intensity (WFE as a percent of semi sales) has remained relatively steady between 10%-14%. In 2020E, we forecast WFE as a % of semiconductor sales within this range at 13.7%. We believe WFE capital intensity could remain elevated above historical average for the next few years as China spends to build out its domestic semi manufacturing industry, but does not yet translate this investment into semi revenue. Memory WFE capital intensity (memory WFE as a percent of memory semiconductor sales) has been more volatile over the last 10 years, ranging from 14% to 27%. NAND WFE intensity is highest of all the product categories and saw a big upturn in 2015-2017 with the 3D NAND ramp. DRAM capital intensity is typically in the 15%-20% range and we expect it to remain there in 2021/2022. We expect non-memory WFE capital intensity (non-memory WFE as a percent of semiconductor sales ex-memory) to grow in 2020E to 11.0% and stay there in 2021/2022E, at the high end of long-term 6-11% range.

As noted, WFE as a percent of capex has ranged from 48% to 61% over the last 10 years. We expect memory WFE as a percent of memory capex of 53% in 2020E, up from 44% in 2019 but within the long-term range of 47%-83% and below the long-term average of 66%. DRAM WFE as a % of capex bottomed out in 2019 and we expect it to continue to grow in 2021/2022 back to more normal ~70% range. NAND WFE as a % of capex is lowest of all the product categories and we expect it to stay in the mid-to-high 50% range in 2021/2022. We expect non-memory WFE as a percentage of non-memory capex of 57%, slightly below 2019 levels (57.7%) but well above the long-term average of 47%. Overall, WFE as a percentage of capex is expected to be ~55% of semi capex in 2020, and grow to 58%/60% in 2021/2022 within long-term range.

**Chart 2: WFE as a % of semiconductor sales**

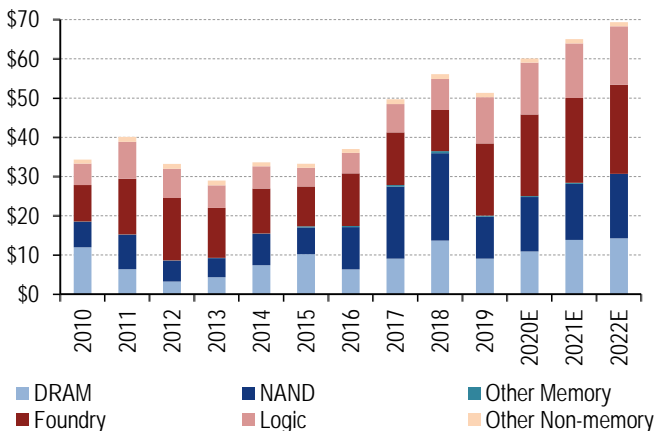
Source: BofA Global Research, Gartner, SIA

**Chart 3: WFE as a % of semiconductor capital spending**

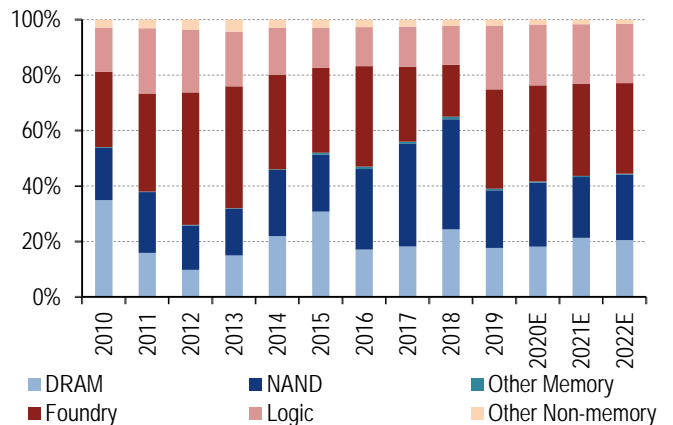
Source: BofA Global Research, Gartner, SIA

## Overall semi capex and WFE estimates by device type

We expect 2020E WFE of \$60.1bn to be at record levels. Non-memory WFE should remain at record levels (with Foundry/Logic WFE expected to increase +13%/+12% YoY) while memory WFE should grow nicely (+25% YoY), though well below peak levels seen in 2018 (\$36.5bn vs \$25.0bn today).

**Chart 4: We expect 2020 to be a record WFE year at \$60.1bn**

Source: BofA Global Research estimates, Gartner

**Chart 5: Memory is now 40-50% of WFE vs. less than 40% in 2011-2013**

Source: BofA Global Research estimates, Gartner





Table 8: Overall semiconductor capex by device type

| Capex (\$mn) | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018    | 2019   | 2020E   | 2021E   | 2022E   | CAGRs    |          |          |
|--------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|---------|---------|---------|----------|----------|----------|
|              |        |        |        |        |        |        |        |        |         |        |         |         |         | '20-'22E | '17-'20E | '15-'20E |
| Memory       | 22,341 | 20,335 | 13,043 | 15,326 | 21,368 | 25,381 | 29,537 | 45,232 | 53,855  | 45,064 | 47,429  | 49,697  | 52,337  | 5.0%     | 1.6%     | 13.3%    |
| YoY          | -      | -9.0%  | -35.9% | 17.5%  | 39.4%  | 18.8%  | 16.4%  | 53.1%  | 19.1%   | -16.3% | 5.2%    | 4.8%    | 5.3%    |          |          |          |
| % of total   | 39.5%  | 30.5%  | 22.2%  | 26.5%  | 33.1%  | 39.4%  | 42.0%  | 48.5%  | 52.3%   | 45.3%  | 43.5%   | 44.6%   | 45.4%   |          |          |          |
| DRAM         | 13,456 | 8,537  | 4,854  | 5,598  | 10,160 | 11,792 | 9,398  | 16,448 | 18,448  | 18,098 | 18,369  | 19,785  | 20,880  | 6.6%     | 3.8%     | 9.3%     |
| YoY          | -      | -36.6% | -43.1% | 15.3%  | 81.5%  | 16.1%  | -20.3% | 75.0%  | 12.2%   | -1.9%  | 1.5%    | 7.7%    | 5.5%    |          |          |          |
| % of total   | 23.8%  | 12.8%  | 8.3%   | 9.7%   | 15.7%  | 18.3%  | 13.4%  | 17.6%  | 17.9%   | 18.2%  | 16.9%   | 17.8%   | 18.1%   |          |          |          |
| NAND         | 7,529  | 10,862 | 7,806  | 9,215  | 10,589 | 13,304 | 19,241 | 26,467 | 32,217  | 24,081 | 26,393  | 27,137  | 28,506  | 3.9%     | -0.1%    | 14.7%    |
| YoY          | -      | 44.3%  | -28.1% | 18.0%  | 14.9%  | 25.6%  | 44.6%  | 37.6%  | 21.7%   | -25.3% | 9.6%    | 2.8%    | 5.0%    |          |          |          |
| % of total   | 13.3%  | 16.3%  | 13.3%  | 15.9%  | 16.4%  | 20.7%  | 27.3%  | 28.4%  | 31.3%   | 24.2%  | 24.2%   | 24.3%   | 24.7%   |          |          |          |
| Other        | 1,355  | 935    | 383    | 513    | 619    | 285    | 898    | 2,317  | 3,190   | 2,885  | 2,667   | 2,775   | 2,951   | 5.2%     | 4.8%     | 56.4%    |
| YoY          | -      | -31.0% | -59.0% | 34.0%  | 20.6%  | -53.9% | 214.6% | 158.1% | 37.7%   | -9.5%  | -7.6%   | 4.1%    | 6.3%    |          |          |          |
| % of total   | 2.4%   | 1.4%   | 0.7%   | 0.9%   | 1.0%   | 0.4%   | 1.3%   | 2.5%   | 3.1%    | 2.9%   | 2.4%    | 2.5%    | 2.6%    |          |          |          |
| Foundry      | 13,740 | 16,742 | 16,785 | 17,951 | 18,973 | 19,088 | 20,703 | 23,394 | 21,002  | 24,238 | 33,896  | 32,529  | 33,250  | -1.0%    | 13.2%    | 12.2%    |
| YoY          | -      | 21.8%  | 0.3%   | 6.9%   | 5.7%   | 0.6%   | 8.5%   | 13.0%  | -10.2%  | 15.4%  | 39.8%   | -4.0%   | 2.2%    |          |          |          |
| % of total   | 24.3%  | 25.1%  | 28.6%  | 31.0%  | 29.4%  | 29.7%  | 29.4%  | 25.1%  | 20.4%   | 24.4%  | 31.1%   | 29.2%   | 28.9%   |          |          |          |
| IDM/Logic    | 15,657 | 22,291 | 23,762 | 20,232 | 19,309 | 13,467 | 14,618 | 19,044 | 19,647  | 23,474 | 21,002  | 22,626  | 22,987  | 4.6%     | 3.3%     | 9.3%     |
| YoY          | -      | 42.4%  | 6.6%   | -14.9% | -4.6%  | -30.3% | 8.5%   | 30.3%  | 3.2%    | 19.5%  | -10.5%  | 7.7%    | 1.6%    |          |          |          |
| % of total   | 27.7%  | 33.4%  | 40.5%  | 35.0%  | 29.9%  | 20.9%  | 20.8%  | 20.4%  | 19.1%   | 23.6%  | 19.3%   | 20.3%   | 20.0%   |          |          |          |
| Other        | 4,788  | 7,282  | 5,152  | 4,332  | 4,860  | 6,418  | 5,534  | 5,635  | 8,550   | 6,609  | 6,609   | 6,609   | 6,609   | 0.0%     | 5.5%     | 0.6%     |
| YoY          | -      | 52.1%  | -29.3% | -15.9% | 12.2%  | 32.1%  | -13.8% | 1.8%   | 51.7%   | -22.7% | 0.0%    | 0.0%    | 0.0%    |          |          |          |
| % of total   | 8.5%   | 10.9%  | 8.8%   | 7.5%   | 7.5%   | 10.0%  | 7.9%   | 6.0%   | 8.3%    | 6.6%   | 6.1%    | 5.9%    | 5.7%    |          |          |          |
| Total        | 56,526 | 66,650 | 58,742 | 57,840 | 64,509 | 64,355 | 70,392 | 93,305 | 103,053 | 99,385 | 108,936 | 111,460 | 115,183 | 2.8%     | 5.3%     | 11.1%    |
| YoY          | -      | 17.9%  | -11.9% | -1.5%  | 11.5%  | -0.2%  | 9.4%   | 32.6%  | 10.4%   | -3.6%  | 9.6%    | 2.3%    | 3.3%    |          |          |          |

Source: BofA Global Research estimates, company data, Gartner

Table 9: Wafer fab equipment (WFE) by device type

| WFE (\$mn)     | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020E  | 2021E  | 2022E  | CAGRs    |          |          |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|----------|----------|
|                |        |        |        |        |        |        |        |        |        |        |        |        |        | '20-'22E | '17-'20E | '15-'20E |
| Memory         | 18,526 | 15,239 | 8,643  | 9,276  | 15,460 | 17,294 | 17,406 | 27,842 | 36,475 | 20,026 | 25,028 | 28,388 | 30,945 | 11.2%    | -3.5%    | 7.7%     |
| YoY            | -      | -17.7% | -43.3% | 7.3%   | 66.7%  | 11.9%  | 0.6%   | 60.0%  | 31.0%  | -45.1% | 25.0%  | 13.4%  | 9.0%   |          |          |          |
| % of total     | 54.0%  | 38.0%  | 26.0%  | 32.0%  | 46.0%  | 52.0%  | 47.0%  | 56.0%  | 65.0%  | 39.0%  | 41.6%  | 43.7%  | 44.4%  |          |          |          |
| % of capex     | 82.9%  | 74.9%  | 66.3%  | 60.5%  | 72.4%  | 68.1%  | 58.9%  | 61.6%  | 67.7%  | 44.4%  | 52.8%  | 57.1%  | 59.1%  |          |          |          |
| DRAM           | 11,978 | 6,370  | 3,253  | 4,327  | 7,381  | 10,223 | 6,323  | 9,053  | 13,663 | 9,085  | 10,902 | 13,845 | 14,260 | 14.4%    | 6.4%     | 1.3%     |
| YoY            | -      | -46.8% | -48.9% | 33.0%  | 70.6%  | 38.5%  | -38.2% | 43.2%  | 50.9%  | -33.5% | 20.0%  | 27.0%  | 3.0%   |          |          |          |
| % of total     | 34.9%  | 15.9%  | 9.8%   | 14.9%  | 22.0%  | 30.7%  | 17.1%  | 18.2%  | 24.3%  | 17.7%  | 18.1%  | 21.3%  | 20.5%  |          |          |          |
| % of capex     | 89.0%  | 74.6%  | 67.0%  | 77.3%  | 72.6%  | 86.7%  | 67.3%  | 55.0%  | 74.1%  | 50.2%  | 59.3%  | 70.0%  | 68.3%  |          |          |          |
| NAND           | 6,450  | 8,796  | 5,308  | 4,879  | 7,996  | 6,816  | 10,766 | 18,381 | 22,292 | 10,665 | 13,864 | 14,280 | 16,422 | 8.8%     | -9.0%    | 15.3%    |
| YoY            | -      | 36.4%  | -39.7% | -8.1%  | 63.9%  | -14.8% | 58.0%  | 70.7%  | 21.3%  | -52.2% | 30.0%  | 3.0%   | 15.0%  |          |          |          |
| % of total     | 18.8%  | 21.9%  | 16.0%  | 16.8%  | 23.8%  | 20.5%  | 29.1%  | 37.0%  | 39.7%  | 20.8%  | 23.1%  | 22.0%  | 23.6%  |          |          |          |
| % of capex     | 85.7%  | 81.0%  | 68.0%  | 53.0%  | 75.5%  | 51.2%  | 56.0%  | 69.4%  | 69.2%  | 44.3%  | 52.5%  | 52.6%  | 57.6%  |          |          |          |
| Other          | 98     | 73     | 82     | 70     | 83     | 255    | 317    | 407    | 519    | 276    | 262    | 262    | 262    | 0.0%     | -13.6%   | 0.6%     |
| YoY            | -      | -25.4% | 12.1%  | -14.6% | 18.5%  | 207.7% | 24.4%  | 28.4%  | 27.4%  | -46.8% | -5.0%  | 0.0%   | 0.0%   |          |          |          |
| % of total     | 0.3%   | 0.2%   | 0.2%   | 0.2%   | 0.2%   | 0.8%   | 0.9%   | 0.8%   | 0.9%   | 0.5%   | 0.4%   | 0.4%   | 0.4%   |          |          |          |
| % of capex     | 7.2%   | 7.8%   | 21.4%  | 13.6%  | 13.4%  | 89.4%  | 35.3%  | 17.6%  | 16.3%  | 9.6%   | 9.8%   | 9.5%   | 8.9%   |          |          |          |
| Foundry        | 9,312  | 14,169 | 15,877 | 12,739 | 11,490 | 10,175 | 13,412 | 13,407 | 10,482 | 18,420 | 20,815 | 21,648 | 22,730 | 4.5%     | 15.8%    | 15.4%    |
| YoY            | -      | 52.1%  | 12.1%  | -19.8% | -9.8%  | -11.4% | 31.8%  | 0.0%   | -21.8% | 75.7%  | 13.0%  | 4.0%   | 5.0%   |          |          |          |
| % of total     | 27.1%  | 35.3%  | 47.8%  | 43.9%  | 34.2%  | 30.6%  | 36.2%  | 27.0%  | 18.7%  | 35.9%  | 34.6%  | 33.3%  | 32.6%  |          |          |          |
| % of capex     | 67.8%  | 84.6%  | 94.6%  | 71.0%  | 60.6%  | 53.3%  | 64.8%  | 57.3%  | 49.9%  | 76.0%  | 61.4%  | 66.5%  | 68.4%  |          |          |          |
| IDM/Logic      | 5,469  | 9,446  | 7,471  | 5,723  | 5,659  | 4,788  | 5,216  | 7,219  | 7,908  | 11,777 | 13,190 | 13,916 | 14,890 | 6.2%     | 22.3%    | 22.5%    |
| YoY            | -      | 72.7%  | -20.9% | -23.4% | -1.1%  | -15.4% | 8.9%   | 38.4%  | 9.5%   | 48.9%  | 12.0%  | 5.5%   | 7.0%   |          |          |          |
| % of total     | 15.9%  | 23.6%  | 22.5%  | 19.7%  | 16.8%  | 14.4%  | 14.1%  | 14.5%  | 14.1%  | 22.9%  | 21.9%  | 21.4%  | 21.4%  |          |          |          |
| % of capex     | 34.9%  | 42.4%  | 31.4%  | 28.3%  | 29.3%  | 35.6%  | 35.7%  | 37.9%  | 40.2%  | 50.2%  | 62.8%  | 61.5%  | 64.8%  |          |          |          |
| Other          | 1,000  | 1,250  | 1,250  | 1,250  | 1,000  | 1,000  | 1,000  | 1,250  | 1,250  | 1,125  | 1,069  | 1,069  | 1,069  | 0.0%     | -5.1%    | 1.3%     |
| YoY            | -      | 25.0%  | 0.0%   | 0.0%   | -20.0% | 0.0%   | 0.0%   | 25.0%  | 0.0%   | -10.0% | -5.0%  | 0.0%   | 0.0%   |          |          |          |
| % of total     | 2.9%   | 3.1%   | 3.8%   | 4.3%   | 3.0%   | 3.0%   | 2.7%   | 2.5%   | 2.2%   | 2.2%   | 1.8%   | 1.6%   | 1.5%   |          |          |          |
| % of capex     | 20.9%  | 17.2%  | 24.3%  | 28.9%  | 20.6%  | 15.6%  | 18.1%  | 22.2%  | 14.6%  | 17.0%  | 16.2%  | 16.2%  | 16.2%  |          |          |          |
| Total          | 34,308 | 40,104 | 33,241 | 28,988 | 33,610 | 33,258 | 37,033 | 49,717 | 56,115 | 51,348 | 60,102 | 65,020 | 69,633 | 7.6%     | 6.5%     | 12.6%    |
| YoY            | -      | 16.9%  | -17.1% | -12.8% | 15.9%  | -1.0%  | 11.4%  | 34.3%  | 12.9%  | -8.5%  | 17.0%  | 8.2%   | 7.1%   |          |          |          |
| WFE % of capex | 60.7%  | 60.2%  | 56.6%  | 50.1%  | 52.1%  | 51.7%  | 52.6%  | 53.3%  | 54.5%  | 51.7%  | 55.2%  | 58.3%  | 60.5%  |          |          |          |

Source: BofA Global Research estimates, company data, Gartner



## Bottom-up capex estimates by top spenders

Table 10: Bottom-up semiconductor capex for top spenders

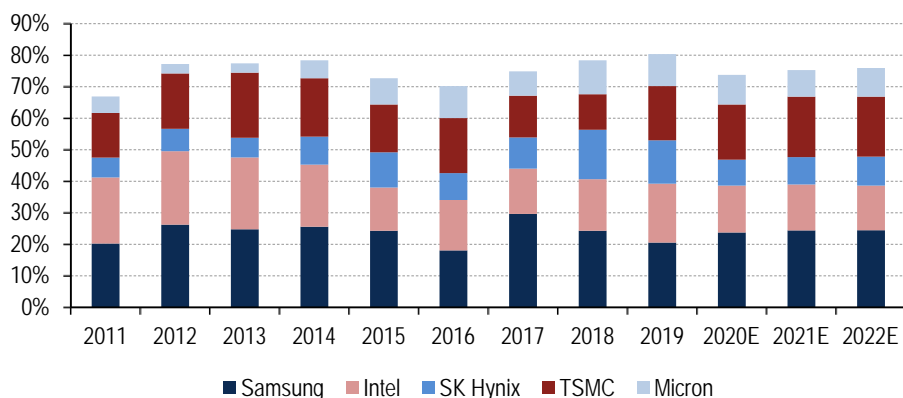
| Capex by company (\$mn) | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020E  | 2021E  | 2022E   | CAGRs    |          |          |
|-------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|----------|----------|----------|
|                         |        |        |        |        |        |        |        |        |        |        |        |        |         | '20-'22E | '17-'20E | '15-'20E |
| Samsung                 | 10,404 | 10,395 | 12,392 | 11,616 | 13,122 | 13,022 | 10,850 | 24,218 | 22,558 | 17,841 | 22,920 | 24,113 | 25,077  | 4.6%     | -1.8%    | 12.0%    |
| YoY                     | -      | -0.1%  | 19.2%  | -6.3%  | 13.0%  | -0.8%  | -16.7% | 123.2% | -6.9%  | -20.9% | 28.5%  | 5.2%   | 4.0%    |          |          |          |
| % of total              | 27.3%  | 20.3%  | 26.2%  | 24.8%  | 25.6%  | 24.3%  | 18.0%  | 29.6%  | 24.3%  | 20.6%  | 23.8%  | 24.4%  | 24.5%   |          |          |          |
| Intel                   | 5,207  | 10,764 | 11,027 | 10,711 | 10,105 | 7,326  | 9,625  | 11,778 | 15,181 | 16,213 | 14,342 | 14,400 | 14,500  | 0.5%     | 6.8%     | 14.4%    |
| YoY                     | -      | 106.7% | 2.4%   | -2.9%  | -5.7%  | -27.5% | 31.4%  | 22.4%  | 28.9%  | 6.8%   | -11.5% | 0.4%   | 0.7%    |          |          |          |
| % of total              | 13.7%  | 21.0%  | 23.3%  | 22.8%  | 19.7%  | 13.7%  | 16.0%  | 14.4%  | 16.4%  | 18.7%  | 14.9%  | 14.6%  | 14.2%   |          |          |          |
| SK Hynix                | 2,933  | 3,220  | 3,347  | 2,928  | 4,559  | 5,989  | 5,133  | 8,070  | 14,575 | 11,944 | 7,922  | 8,602  | 9,402   | 8.9%     | -0.6%    | 5.8%     |
| YoY                     | -      | 9.8%   | 4.0%   | -12.5% | 55.7%  | 31.4%  | -14.3% | 57.2%  | 80.6%  | -18.1% | -33.7% | 8.6%   | 9.3%    |          |          |          |
| % of total              | 7.7%   | 6.3%   | 7.1%   | 6.2%   | 8.9%   | 11.2%  | 8.5%   | 9.9%   | 15.7%  | 13.8%  | 8.2%   | 8.7%   | 9.2%    |          |          |          |
| TSMC                    | 5,930  | 7,281  | 8,322  | 9,689  | 9,521  | 8,112  | 10,497 | 10,845 | 10,474 | 14,923 | 16,917 | 19,000 | 19,500  | 7.4%     | 16.0%    | 15.8%    |
| YoY                     | -      | 22.8%  | 14.3%  | 16.4%  | -1.7%  | -14.8% | 29.4%  | 3.3%   | -3.4%  | 42.5%  | 13.4%  | 12.3%  | 2.6%    |          |          |          |
| % of total              | 15.5%  | 14.2%  | 17.6%  | 20.6%  | 18.6%  | 15.2%  | 17.5%  | 13.3%  | 11.3%  | 17.2%  | 17.5%  | 19.2%  | 19.0%   |          |          |          |
| Micron                  | 1,229  | 2,671  | 1,414  | 1,395  | 2,917  | 4,464  | 6,119  | 6,311  | 9,972  | 8,812  | 9,028  | 8,300  | 9,333   | 1.7%     | 12.7%    | 15.1%    |
| YoY                     | -      | 117.3% | -47.1% | -1.3%  | 109.1% | 53.0%  | 37.1%  | 3.1%   | 58.0%  | -11.6% | 2.5%   | -8.1%  | 12.4%   |          |          |          |
| % of total              | 3.2%   | 5.2%   | 3.0%   | 3.0%   | 5.7%   | 8.3%   | 10.2%  | 7.7%   | 10.7%  | 10.2%  | 9.4%   | 8.4%   | 9.1%    |          |          |          |
| SMIC                    | 492    | 950    | 431    | 770    | 653    | 1,231  | 2,757  | 2,342  | 1,804  | 1,870  | 5,900  | 3,200  | 3,200   | -26.4%   | 36.1%    | 36.8%    |
| YoY                     | -      | 93.2%  | -54.6% | 78.7%  | -15.2% | 88.4%  | 124.0% | -15.1% | -23.0% | 3.7%   | 215.6% | -45.8% | 0.0%    |          |          |          |
| % of total              | 1.3%   | 1.9%   | 0.9%   | 1.6%   | 1.3%   | 2.3%   | 4.6%   | 2.9%   | 1.9%   | 2.2%   | 6.1%   | 3.2%   | 3.1%    |          |          |          |
| GlobalFoundries         | 2,750  | 4,900  | 3,800  | 4,000  | 3,500  | 3,700  | 1,400  | 2,000  | 1,000  | 600    | 700    | 700    | 700     | 0.0%     | -29.5%   | -28.3%   |
| YoY                     | -      | 78.2%  | -22.4% | 5.3%   | -12.5% | 5.7%   | -62.2% | 42.9%  | -50.0% | -40.0% | 16.7%  | 0.0%   | 0.0%    |          |          |          |
| % of total              | 7.2%   | 9.5%   | 8.0%   | 8.5%   | 6.8%   | 6.9%   | 2.3%   | 2.4%   | 1.1%   | 0.7%   | 0.7%   | 0.7%   | 0.7%    |          |          |          |
| YMTC                    | 138    | 143    | 129    | 110    | 100    | 300    | 2,800  | 2,000  | 2,000  | 2,200  | 3,500  | 3,500  | 3,500   | 0.0%     | 20.5%    | 63.5%    |
| YoY                     | -      | 3.5%   | -10.0% | -14.4% | -9.1%  | 200.0% | 833.3% | -28.6% | 0.0%   | 10.0%  | 59.1%  | 0.0%   | 0.0%    |          |          |          |
| % of total              | 0.4%   | 0.3%   | 0.3%   | 0.2%   | 0.2%   | 0.6%   | 4.7%   | 2.4%   | 2.2%   | 2.5%   | 3.6%   | 3.5%   | 3.4%    |          |          |          |
| Fujian Jinhua IC        | -      | -      | -      | -      | -      | -      | -      | 1,700  | 1,200  | 700    | 700    | 700    | 700     | 0.0%     | -25.6%   | NA       |
| YoY                     | -      | -      | -      | -      | -      | -      | -      | -      | -29.4% | -41.7% | 0.0%   | 0.0%   | 0.0%    |          |          |          |
| % of total              | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 2.1%   | 1.3%   | 0.8%   | 0.7%   | 0.7%   | 0.7%    |          |          |          |
| Shanghai Huali Micro    | 500    | 500    | 500    | 250    | 263    | 263    | 263    | 1,500  | 1,300  | 850    | 700    | 700    | 700     | 0.0%     | -22.4%   | 21.6%    |
| YoY                     | -      | 0.0%   | 0.0%   | -50.0% | 5.0%   | 0.2%   | 0.0%   | 470.3% | -13.3% | -34.6% | -17.6% | 0.0%   | 0.0%    |          |          |          |
| % of total              | 1.3%   | 1.0%   | 1.1%   | 0.5%   | 0.5%   | 0.5%   | 0.4%   | 1.8%   | 1.4%   | 1.0%   | 0.7%   | 0.7%   | 0.7%    |          |          |          |
| Infineon                | 510    | 1,398  | 806    | 468    | 720    | 781    | 842    | 1,083  | 1,411  | 1,279  | 1,379  | 1,888  | 2,061   | 22.2%    | 8.4%     | 12.1%    |
| YoY                     | -      | 173.8% | -42.3% | -41.9% | 53.8%  | 8.5%   | 7.9%   | 28.6%  | 30.3%  | -9.3%  | 7.8%   | 36.9%  | 9.1%    |          |          |          |
| % of total              | 1.3%   | 2.7%   | 1.7%   | 1.0%   | 1.4%   | 1.5%   | 1.4%   | 1.3%   | 1.5%   | 1.5%   | 1.4%   | 1.9%   | 2.0%    |          |          |          |
| STMicroelectronics      | 1,034  | 1,258  | 476    | 531    | 496    | 503    | 611    | 1,301  | 1,263  | 1,181  | 1,200  | 1,500  | 1,500   | 11.8%    | -2.7%    | 19.0%    |
| YoY                     | -      | 21.7%  | -62.2% | 11.6%  | -6.6%  | 1.4%   | 21.5%  | 112.9% | -2.9%  | -6.5%  | 1.6%   | 25.0%  | 0.0%    |          |          |          |
| % of total              | 2.7%   | 2.5%   | 1.0%   | 1.1%   | 1.0%   | 0.9%   | 1.0%   | 1.6%   | 1.4%   | 1.4%   | 1.2%   | 1.5%   | 1.5%    |          |          |          |
| UMC                     | 1,800  | 1,800  | 1,750  | 1,100  | 1,400  | 1,905  | 2,800  | 1,400  | 650    | 574    | 1,000  | 1,000  | 1,000   | 0.0%     | -10.6%   | -12.1%   |
| YoY                     | -      | 0.0%   | -2.8%  | -37.1% | 27.3%  | 36.0%  | 47.0%  | -50.0% | -53.6% | -11.7% | 74.2%  | 0.0%   | 0.0%    |          |          |          |
| % of total              | 4.7%   | 3.5%   | 3.7%   | 2.3%   | 2.7%   | 3.6%   | 4.7%   | 1.7%   | 0.7%   | 0.7%   | 1.0%   | 1.0%   | 1.0%    |          |          |          |
| Texas Instruments       | 1,199  | 815    | 494    | 412    | 385    | 551    | 531    | 695    | 1,131  | 847    | 573    | 569    | 601     | 2.4%     | -6.2%    | 0.8%     |
| YoY                     | -      | -32.0% | -39.4% | -16.6% | -6.6%  | 43.1%  | -3.6%  | 30.9%  | 62.7%  | -25.1% | -32.4% | -0.6%  | 5.5%    |          |          |          |
| % of total              | 3.1%   | 1.6%   | 1.0%   | 0.9%   | 0.8%   | 1.0%   | 0.9%   | 0.9%   | 1.2%   | 1.0%   | 0.6%   | 0.6%   | 0.6%    |          |          |          |
| Sony                    | 578    | 1,743  | 902    | 665    | 747    | 1,991  | 1,047  | 743    | 750    | 700    | 650    | 650    | 650     | 0.0%     | -4.3%    | -20.1%   |
| YoY                     | -      | 201.8% | -48.2% | -26.3% | 12.3%  | 166.6% | -47.4% | -29.1% | 1.0%   | -6.7%  | -7.1%  | 0.0%   | 0.0%    |          |          |          |
| % of total              | 1.5%   | 3.4%   | 1.9%   | 1.4%   | 1.5%   | 3.7%   | 1.7%   | 0.9%   | 0.8%   | 0.8%   | 0.7%   | 0.7%   | 0.6%    |          |          |          |
| Nanya Technology        | 761    | 360    | 65     | 198    | 191    | 121    | 694    | 966    | 677    | 178    | 355    | 678    | 678     | 38.3%    | -28.4%   | 24.0%    |
| YoY                     | -      | -52.7% | -81.9% | 203.8% | -3.5%  | -36.7% | 473.5% | 39.2%  | -29.8% | -73.8% | 99.4%  | 91.2%  | 0.0%    |          |          |          |
| % of total              | 2.0%   | 0.7%   | 0.1%   | 0.4%   | 0.4%   | 0.2%   | 1.2%   | 1.2%   | 0.7%   | 0.2%   | 0.4%   | 0.7%   | 0.7%    |          |          |          |
| Changxin Memory Tech.   | -      | -      | -      | -      | -      | -      | -      | -      | 900    | 1,200  | 3,000  | 3,000  | 3,000   | 0.0%     | NA       | NA       |
| YoY                     | -      | -      | -      | -      | -      | -      | -      | -      | -      | 33.3%  | 150.0% | 0.0%   | 0.0%    |          |          |          |
| % of total              | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 1.0%   | 1.4%   | 3.1%   | 3.0%   | 2.9%    |          |          |          |
| Shanghai Huahong Grace  | -      | -      | -      | -      | -      | -      | -      | -      | 1,000  | 1,050  | 1,350  | 1,350  | 1,350   | 0.0%     | NA       | NA       |
| YoY                     | -      | -      | -      | -      | -      | -      | -      | -      | -      | 5.0%   | 28.6%  | 0.0%   | 0.0%    |          |          |          |
| % of total              | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 0.0%   | 1.1%   | 1.2%   | 1.4%   | 1.4%   | 1.3%    |          |          |          |
| Other                   | 2,668  | 3,116  | 1,404  | 2,088  | 2,623  | 3,267  | 4,170  | 4,800  | 5,000  | 3,800  | 4,300  | 5,000  | 5,000   | 7.8%     | -3.6%    | 5.6%     |
| YoY                     | -      | -      | -55.0% | 48.8%  | 25.7%  | 24.5%  | 27.6%  | 15.1%  | 4.2%   | -24.0% | 13.2%  | 16.3%  | 0.0%    |          |          |          |
| % of total              | 0.0%   | 6.1%   | 3.0%   | 4.4%   | 5.1%   | 6.1%   | 6.9%   | 5.9%   | 5.4%   | 4.4%   | 4.5%   | 5.1%   | 4.9%    |          |          |          |
| Total for top spenders  | 38,133 | 51,313 | 47,259 | 46,931 | 51,302 | 53,525 | 60,139 | 81,751 | 92,846 | 86,762 | 96,435 | 98,851 | 102,451 | 3.1%     | 5.7%     | 12.5%    |
| YoY                     | -      | 34.6%  | -7.9%  | -0.7%  | 9.3%   | 4.3%   | 12.4%  | 35.9%  | 13.6%  | -6.6%  | 11.1%  | 2.5%   | 3.6%    |          |          |          |

Source: BofA Global Research, company data



Here we observe that the top 5 capex spenders (Samsung, Intel, SK Hynix, TSMC, Micron) have grown as a % of total capex from ~65% in 2011 to nearly 75% today.

**Chart 6: Top 5 spenders as a percent of total capex**



Source: BofA Global Research, company reports, Gartner

## WFE estimates by process type

**Table 11: Wafer fab equipment (WFE) by process type**

|                             | 2004          | 2005          | 2006          | 2007          | 2008          | 2009          | 2010          | 2011          | 2012          | 2013          | 2014          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020E         |
|-----------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>WFE (\$mn)</b>           |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Deposition                  | 6,058         | 5,180         | 6,755         | 7,396         | 4,890         | 3,015         | 7,817         | 8,011         | 5,891         | 5,605         | 7,409         | 7,387         | 7,941         | 12,337        | 13,123        | 11,982        | 12,888        |
| Etch                        | 3,799         | 3,275         | 4,598         | 5,387         | 3,236         | 1,769         | 4,613         | 4,337         | 3,809         | 3,836         | 5,628         | 6,252         | 7,263         | 10,773        | 12,164        | 10,806        | 11,636        |
| Lithography                 | 5,586         | 5,335         | 6,746         | 7,470         | 5,657         | 2,606         | 6,762         | 9,011         | 6,586         | 6,390         | 7,142         | 6,282         | 6,572         | 8,521         | 11,270        | 11,705        | 12,836        |
| Process control             | 3,711         | 3,672         | 4,216         | 4,536         | 3,116         | 1,738         | 3,510         | 4,423         | 4,416         | 4,019         | 4,324         | 4,230         | 4,702         | 5,487         | 6,407         | 6,243         | 6,889         |
| Cleaning                    | 2,186         | 2,112         | 2,684         | 2,986         | 1,839         | 1,071         | 2,525         | 3,129         | 2,801         | 2,078         | 2,589         | 2,405         | 2,795         | 3,373         | 4,093         | 3,657         | 3,966         |
| Manuf. automation & control | 1,290         | 1,313         | 1,368         | 1,690         | 1,341         | 625           | 1,425         | 1,851         | 1,727         | 1,696         | 1,435         | 1,627         | 2,007         | 2,452         | 2,459         | 2,865         | 3,038         |
| Planarization (CMP)         | 1,343         | 1,119         | 1,320         | 1,230         | 772           | 477           | 1,163         | 1,225         | 768           | 710           | 818           | 902           | 1,274         | 1,746         | 1,849         | 1,447         | 1,539         |
| Photoresist processing      | 1,664         | 1,400         | 1,730         | 1,916         | 1,356         | 557           | 1,541         | 1,988         | 1,618         | 1,306         | 1,580         | 1,446         | 1,447         | 1,778         | 2,247         | 2,060         | 2,250         |
| RTP and oxidation/diffusion | 1,060         | 1,121         | 1,770         | 2,062         | 1,196         | 680           | 1,266         | 1,374         | 1,116         | 990           | 468           | 411           | 587           | 899           | 1,541         | 1,403         | 1,518         |
| Ion implant/doping          | 1,266         | 1,122         | 1,364         | 1,337         | 797           | 346           | 1,023         | 1,203         | 1,033         | 813           | 833           | 1,032         | 984           | 1,321         | 1,509         | 1,244         | 1,334         |
| Other                       | 388           | 303           | 1,456         | 1,360         | 1,159         | 742           | 1,332         | 1,858         | 1,824         | 1,538         | 1,384         | 1,283         | 1,462         | 2,031         | 2,282         | 2,068         | 2,209         |
| <b>Total</b>                | <b>28,351</b> | <b>25,952</b> | <b>35,461</b> | <b>38,731</b> | <b>26,518</b> | <b>14,368</b> | <b>34,308</b> | <b>40,104</b> | <b>33,241</b> | <b>28,988</b> | <b>33,610</b> | <b>33,258</b> | <b>37,033</b> | <b>49,717</b> | <b>56,115</b> | <b>51,348</b> | <b>60,102</b> |
| <b>% of total</b>           |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Deposition                  | 21.4%         | 20.0%         | 19.0%         | 19.1%         | 18.4%         | 21.0%         | 22.8%         | 20.0%         | 17.7%         | 19.3%         | 22.0%         | 22.2%         | 21.4%         | 24.8%         | 23.4%         | 21.6%         | 21.4%         |
| Etch                        | 13.4%         | 12.6%         | 13.0%         | 13.9%         | 12.2%         | 12.3%         | 13.4%         | 10.8%         | 11.5%         | 13.2%         | 16.7%         | 18.8%         | 19.6%         | 21.7%         | 21.7%         | 19.5%         | 19.4%         |
| Lithography                 | 19.7%         | 20.6%         | 19.0%         | 19.3%         | 21.3%         | 18.1%         | 19.7%         | 22.5%         | 19.8%         | 22.0%         | 21.2%         | 18.9%         | 17.7%         | 17.1%         | 20.1%         | 21.1%         | 21.4%         |
| Process control             | 13.1%         | 14.2%         | 11.9%         | 11.7%         | 11.7%         | 12.1%         | 10.2%         | 11.0%         | 13.3%         | 13.9%         | 12.9%         | 12.7%         | 12.7%         | 11.0%         | 11.4%         | 11.3%         | 11.5%         |
| Cleaning                    | 7.7%          | 8.1%          | 7.6%          | 7.7%          | 6.9%          | 7.5%          | 7.4%          | 7.8%          | 8.4%          | 7.2%          | 7.7%          | 7.2%          | 7.5%          | 6.8%          | 7.3%          | 6.6%          | 6.6%          |
| Manuf. automation & control | 4.6%          | 5.1%          | 3.9%          | 4.4%          | 5.1%          | 4.3%          | 4.2%          | 4.6%          | 5.2%          | 5.9%          | 4.3%          | 4.9%          | 5.4%          | 4.9%          | 4.4%          | 5.2%          | 5.1%          |
| Planarization (CMP)         | 4.7%          | 4.3%          | 3.7%          | 3.2%          | 2.9%          | 3.3%          | 3.4%          | 3.1%          | 2.3%          | 2.4%          | 2.4%          | 2.7%          | 3.4%          | 3.5%          | 3.3%          | 2.6%          | 2.6%          |
| Photoresist processing      | 5.9%          | 5.4%          | 4.9%          | 4.9%          | 5.1%          | 3.9%          | 4.5%          | 5.0%          | 4.9%          | 4.5%          | 4.7%          | 4.3%          | 3.9%          | 3.6%          | 4.0%          | 3.7%          | 3.7%          |
| RTP and oxidation/diffusion | 3.7%          | 4.3%          | 5.0%          | 5.3%          | 4.5%          | 4.7%          | 3.7%          | 3.4%          | 3.4%          | 3.4%          | 1.4%          | 1.2%          | 1.6%          | 1.8%          | 2.7%          | 2.5%          | 2.5%          |
| Ion implant/doping          | 4.5%          | 4.3%          | 3.8%          | 3.5%          | 3.0%          | 2.4%          | 3.0%          | 3.0%          | 3.1%          | 2.8%          | 2.5%          | 3.1%          | 2.7%          | 2.7%          | 2.7%          | 2.2%          | 2.2%          |
| Other                       | 1.4%          | 1.2%          | 4.1%          | 3.5%          | 4.4%          | 5.2%          | 3.9%          | 4.6%          | 5.5%          | 5.3%          | 4.1%          | 3.9%          | 3.9%          | 4.1%          | 4.1%          | 3.7%          | 3.7%          |
| <b>Total</b>                | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> | <b>100.0%</b> |
| <b>YoY</b>                  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Deposition                  | 74.0%         | -14.5%        | 30.4%         | 9.5%          | -33.9%        | -38.3%        | 159.2%        | 2.5%          | -26.5%        | -4.9%         | 32.2%         | -0.3%         | 7.5%          | 55.4%         | 6.4%          | -8.7%         | 7.6%          |
| Etch                        | 95.7%         | -13.8%        | 40.4%         | 17.2%         | -39.9%        | -45.3%        | 160.8%        | -6.0%         | -12.2%        | 0.7%          | 46.7%         | 11.1%         | 16.2%         | 48.3%         | 12.9%         | -11.2%        | 7.7%          |
| Lithography                 | 58.4%         | -4.5%         | 26.5%         | 10.7%         | -24.3%        | -53.9%        | 159.5%        | 33.3%         | -26.9%        | -3.0%         | 11.8%         | -12.0%        | 4.6%          | 29.7%         | 32.3%         | 3.9%          | 9.7%          |
| Process control             | 51.6%         | -1.0%         | 14.8%         | 7.6%          | -31.3%        | -44.2%        | 101.9%        | 26.0%         | -0.2%         | -9.0%         | 7.6%          | -2.2%         | 11.2%         | 16.7%         | 16.8%         | -2.6%         | 10.4%         |
| Cleaning                    | 70.7%         | -3.4%         | 27.0%         | 11.3%         | -38.4%        | -41.8%        | 135.8%        | 23.9%         | -10.5%        | -25.8%        | 24.6%         | -7.1%         | 16.2%         | 20.7%         | 21.4%         | -10.7%        | 8.5%          |
| Manuf. automation & control | 44.9%         | 1.8%          | 4.1%          | 23.6%         | -20.7%        | -53.4%        | 128.0%        | 29.9%         | -6.7%         | -1.8%         | -15.4%        | 13.4%         | 23.3%         | 22.2%         | 0.3%          | 16.5%         | 6.0%          |
| Planarization (CMP)         | 84.4%         | -16.6%        | 17.9%         | -6.8%         | -37.3%        | -38.2%        | 144.0%        | 5.3%          | -37.3%        | -7.6%         | 15.2%         | 10.3%         | 41.2%         | 37.1%         | 5.9%          | -21.8%        | 6.4%          |
| Photoresist processing      | 98.2%         | -15.9%        | 23.5%         | 10.8%         | -29.3%        | -58.9%        | 176.6%        | 29.0%         | -18.6%        | -19.3%        | 21.0%         | -8.4%         | 0.1%          | 22.9%         | 26.4%         | -8.3%         | 9.2%          |
| RTP and oxidation/diffusion | 68.5%         | 5.7%          | 57.9%         | 16.5%         | -42.0%        | -43.1%        | 86.1%         | 8.5%          | -18.8%        | -11.3%        | -52.8%        | -12.2%        | 42.8%         | 53.1%         | 71.5%         | -9.0%         | 8.2%          |
| Ion implant/doping          | 67.9%         | -11.3%        | 21.6%         | -2.0%         | -40.4%        | -56.6%        | 195.9%        | 17.6%         | -14.1%        | -21.3%        | 2.4%          | 23.9%         | -4.7%         | 34.2%         | 14.2%         | -17.5%        | 7.2%          |
| Other                       | 78.5%         | -22.0%        | 380.7%        | -6.6%         | -14.8%        | -36.0%        | 79.5%         | 39.5%         | -1.9%         | -15.7%        | -10.0%        | -7.3%         | 13.9%         | 38.9%         | 12.4%         | -9.4%         | 6.8%          |
| <b>Total</b>                | <b>69.4%</b>  | <b>-8.5%</b>  | <b>36.6%</b>  | <b>9.2%</b>   | <b>-31.5%</b> | <b>-45.8%</b> | <b>138.8%</b> | <b>16.9%</b>  | <b>-17.1%</b> | <b>-12.8%</b> | <b>15.9%</b>  | <b>-1.0%</b>  | <b>11.4%</b>  | <b>34.3%</b>  | <b>12.9%</b>  | <b>-8.5%</b>  | <b>17.0%</b>  |

Source: BofA Global Research estimates, company data, Gartner

## WFE Sensitivity Analysis

We conducted sensitivity analysis on WFE depending on the level of cumulative memory, MPU, logic sales growth (most crucial product categories for leading edge manufacturing), and memory, MPU, and logic WFE capital intensity (WFE as a % of sales). In our base case scenario, we expect this market to grow 8% in 2020 with capital intensity at 21%, within long-term 10-29% range, resulting in WFE of ~\$65bn. Based on our sensitivity analysis, we see a range for 2021E WFE between \$50bn-\$82bn. Similarly, in 2022E we see a range of \$54bn-\$89bn in WFE, with our base case model of \$70bn.

**Exhibit 1: We believe 2021 WFE could range between \$50bn-\$82bn**

| 2021 WFE Scenario Analysis |                                  |      |      |      |      |      |      |      |
|----------------------------|----------------------------------|------|------|------|------|------|------|------|
| Capital Intensity          | Memory, MPU, Logic Market Growth |      |      |      |      |      |      |      |
|                            |                                  | 2%   | 4%   | 6%   | 8%   | 10%  | 12%  | 14%  |
|                            | 17%                              | \$50 | \$51 | \$52 | \$53 | \$54 | \$55 | \$56 |
|                            | 19%                              | \$56 | \$57 | \$58 | \$59 | \$60 | \$61 | \$62 |
|                            | 21%                              | \$61 | \$63 | \$64 | \$65 | \$66 | \$67 | \$69 |
|                            | 23%                              | \$67 | \$69 | \$70 | \$71 | \$73 | \$74 | \$75 |
|                            | 25%                              | \$73 | \$75 | \$76 | \$77 | \$79 | \$80 | \$82 |

Source: BofA Global Research estimates, company reports, Gartner

**Exhibit 2: We believe 2022 WFE could range between \$54bn-\$89bn**

| 2022 WFE Scenario Analysis |                                  |      |      |      |      |      |      |      |
|----------------------------|----------------------------------|------|------|------|------|------|------|------|
| Capital Intensity          | Memory, MPU, Logic Market Growth |      |      |      |      |      |      |      |
|                            |                                  | 2%   | 4%   | 6%   | 8%   | 10%  | 12%  | 14%  |
|                            | 17%                              | \$54 | \$55 | \$56 | \$57 | \$58 | \$59 | \$60 |
|                            | 19%                              | \$60 | \$61 | \$63 | \$64 | \$65 | \$66 | \$67 |
|                            | 21%                              | \$67 | \$68 | \$69 | \$70 | \$72 | \$73 | \$74 |
|                            | 23%                              | \$73 | \$74 | \$76 | \$77 | \$79 | \$80 | \$81 |
|                            | 25%                              | \$79 | \$81 | \$82 | \$84 | \$85 | \$87 | \$89 |

Source: BofA Global Research estimates, company reports, Gartner



# Smartphones

## Bull Points

- Still in very early earnings of major 5G upgrade cycle that could drive \$6-\$7 of incremental content per phone
- RF TAM to grow at a 12% CAGR through 2022E, after being mostly unchanged from 2016-2019

## Bear Points

- High leverage to Apple creates customer concentration risks
- Increased competition from Qualcomm in RF could offset benefit from 5G content increase

Despite smartphone unit sales tracking down 5%-10% in CY20, major smartphone semi vendors have seen solid YoY growth in CY20, benefitting from increased content opportunities in new 5G devices. We highlight (1) Our **SWKS/QCOM** outlook (QCOM covered by Tal Liani) of double-digit sales/EPS CAGR (CY20-22E) as each benefit from the rollout of the 5G iPhone (Apple is ~56% of SWKS sales and saw content gains in 5G iPhone while QCOM is main beneficiary of mmWave adoption); (2) **QRVO** projected to see sales/EPS growth in line with peers as the firm benefits from 5G given material exposure to Samsung/mid-tier Chinese OEMs (which even created tougher CY20 comps).

**Table 12: BofA sales/EPS outlook for smartphone vendors**

| Ticker     | Sales (\$mn) |          |          |          | Sales CAGR<br>2020-2022E | EPS (\$) |        |        |         | EPS CAGR<br>2020-2022E | P/E   |       | YTD performance<br>CY20 YTD |
|------------|--------------|----------|----------|----------|--------------------------|----------|--------|--------|---------|------------------------|-------|-------|-----------------------------|
|            | 2019         | 2020E    | 2021E    | 2022E    |                          | 2019     | 2020E  | 2021E  | 2022E   |                        | 2021E | 2022E |                             |
| QCOM       | \$19,659     | \$24,808 | \$31,809 | \$31,856 | 13%                      | \$3.33   | \$5.37 | \$8.06 | \$7.79  | 20%                    | 18.5x | 19.1x | 69%                         |
| QRVO       | \$3,132      | \$3,696  | \$4,176  | \$4,597  | 12%                      | \$5.94   | \$8.14 | \$9.64 | \$11.06 | 17%                    | 15.5x | 13.5x | 28%                         |
| SWKS       | \$3,301      | \$3,515  | \$3,846  | \$4,378  | 12%                      | \$6.02   | \$6.50 | \$7.27 | \$8.79  | 16%                    | 19.5x | 16.1x | 17%                         |
| CRUS       | \$1,242      | \$1,329  | \$1,366  | \$1,444  | 4%                       | \$3.68   | \$4.28 | \$4.04 | \$4.66  | 4%                     | 19.3x | 16.7x | -5%                         |
| Smartphone |              |          |          |          | 12%                      |          |        |        |         | 16%                    | 18.9x | 16.4x | 23%                         |

Source: BofA Global Research estimates, Bloomberg

## Raising RF TAM ahead of mmWave adoption

We update our industry model for radio frequency (RF) chips with the mass adoption of 5G technology offering 50%+ content expansion across 5G smartphones and other smart/connected devices. We remain cautious near-term as we gain clarity on 5G iPhone sell-through trends and impacts of COVID-19 2<sup>nd</sup> wave on consumers, but believe the market is poised to see multi-year upside, benefitting from strong content/unit growth.

Notably, we raise our RF TAM outlook to \$18.2bn by 2022E versus \$18.0bn prior as we incorporate additional upside potential from mmWave penetration (offering upwards of 75%-100%+ of incremental RF content vs 5G sub-6GHz devices) which should accelerate long-term with the adoption of the 5G iPhone. Despite overall smartphone units likely declining mid/high-single digits in CY20E, 5G penetration is allowing RF vendors to see modest CY20 mobile growth, benefitting from (1) incremental content in 5G phones (even excluding mmWave devices, 5G offers 25%+ content increases in premium devices and 2x gains in the low/mid-tier), and (2) resilient adoption in China, with 5G accounting for 64%+ of mobile phone shipments in the region (well above ~30% levels seen in Q1). Declining ASPs have also accelerated 5G adoption, with 5G device wholesale prices declining ~50% YoY (to approx.. \$450 as of Q2), benefitting from the early rollouts of low-/mid-tier Chinese OEMs (China mobile phone shipments ~125mn YTD, with 183 new 5G models released during the year). While we expect ASPs will increase as the iPhone 12 product line enters the market, we see affordable prices driving long-term adoption.

Overall, with the inclusion of mmWave devices, we believe the RF market could grow at a 16% CAGR through 2022 (which could be conservative as we assume mmWave only accounts for a low-teens percentage of overall 5G handsets versus 20%-25% long-term

potential). Ex-mmWave, we believe the market could still grow at a solid 12% CAGR through CY22, benefitting from a multi-year unit recovery and increasing 5G penetration.

**Table 13: We forecast the RF TAM will grow from \$12.6bn in 2019 to \$18.2bn by 2022E (above \$18.0bn prior)**

|                        | 2013    | 2014    | 2015     | 2016     | 2017     | 2018     | 2019     | 2020E    | 2021E    | 2022E    |
|------------------------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|
| Total RF TAM (\$mn)    | \$7,354 | \$8,166 | \$10,330 | \$11,680 | \$12,527 | \$12,889 | \$12,626 | \$13,429 | \$16,182 | \$18,177 |
| YoY (%)                |         | 11.0%   | 26.5%    | 13.1%    | 7.3%     | 2.9%     | -2.0%    | 6.4%     | 20.5%    | 12.3%    |
| 4G/other RF TAM (\$mn) | \$7,354 | \$8,166 | \$10,330 | \$11,680 | \$12,527 | \$12,889 | \$12,340 | \$9,044  | \$5,968  | \$3,635  |
| YoY (%)                |         | 11.0%   | 26.5%    | 13.1%    | 7.3%     | 2.9%     | -4.3%    | -26.7%   | -34.0%   | -39.1%   |
| 5G RF TAM (\$mn)       | -       | -       | -        | -        | -        | -        | \$286    | \$4,385  | \$10,214 | \$14,542 |
| YoY (%)                | -       | -       | -        | -        | -        | -        | -        | 1432.1%  | 132.9%   | 42.4%    |
| Sub-6GHz RF TAM        | -       | -       | -        | -        | -        | -        | \$286    | \$3,988  | \$8,874  | \$12,661 |
| % of 5G RF TAM         | -       | -       | -        | -        | -        | -        | 100%     | 90.9%    | 86.9%    | 87.1%    |
| mmWave RF TAM          | -       | -       | -        | -        | -        | -        | -        | \$397    | \$1,340  | \$1,881  |
| % of 5G RF TAM         | -       | -       | -        | -        | -        | -        | 0%       | 9.1%     | 13.1%    | 12.9%    |

|                    |     |       |       |      |      |       |      |       |      |      |
|--------------------|-----|-------|-------|------|------|-------|------|-------|------|------|
| <b>Units (mn)</b>  |     |       |       |      |      |       |      |       |      |      |
| 5G                 | -   | -     | -     | -    | -    | -     | 19   | 250   | 500  | 815  |
| Apple (sub-6GHz)   | -   | -     | -     | -    | -    | -     | -    | 35    | 116  | 115  |
| Apple (mmWave)     | -   | -     | -     | -    | -    | -     | -    | 15    | 54   | 77   |
| Android (sub-6GHz) | -   | -     | -     | -    | -    | -     | 19   | 195   | 315  | 598  |
| Android (mmWave)   | -   | -     | -     | -    | -    | -     | -    | 5     | 15   | 25   |
| 4G/other           | 990 | 1265  | 1428  | 1454 | 1472 | 1388  | 1370 | 1020  | 842  | 580  |
| Apple              | 153 | 193   | 232   | 215  | 215  | 205   | 192  | 140   | 47   | 15   |
| Android            | 837 | 1072  | 1196  | 1239 | 1256 | 1182  | 1178 | 880   | 795  | 565  |
| Total Units        | 990 | 1265  | 1428  | 1454 | 1472 | 1388  | 1389 | 1270  | 1342 | 1395 |
|                    |     | 27.7% | 12.9% | 1.8% | 1.2% | -5.7% | 0.1% | -8.6% | 5.7% | 3.9% |

|                                |        |         |         |         |         |         |         |         |         |         |
|--------------------------------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>RF Content (\$)</b>         |        |         |         |         |         |         |         |         |         |         |
| 5G Blended Content (\$)        | NA     | NA      | NA      | NA      | NA      | NA      | \$15.06 | \$17.54 | \$20.43 | \$17.84 |
| Apple                          | -      | -       | -       | -       | -       | -       | -       | \$36.46 | \$35.38 | \$35.70 |
| Apple (sub-6GHz content)       | \$0.00 | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$29.76 | \$28.57 | \$27.44 |
| Apple (mmWave incr. content)   | \$0.00 | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$22.32 | \$21.43 | \$20.58 |
| Android                        | -      | -       | -       | -       | -       | -       | \$15.06 | \$12.81 | \$12.73 | \$12.34 |
| Android (sub-6GHz)             | \$0.00 | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$15.06 | \$12.50 | \$12.17 | \$11.86 |
| Android (mmWave incr. content) | \$0.00 | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$0.00  | \$12.50 | \$12.17 | \$11.86 |
| 4G/other Blended Content (\$)  | \$7.43 | \$6.46  | \$7.23  | \$8.03  | \$8.51  | \$9.29  | \$9.01  | \$8.87  | \$7.09  | \$6.27  |
| Apple                          | \$7.75 | \$10.00 | \$12.80 | \$15.00 | \$19.00 | \$24.00 | \$24.00 | \$23.76 | \$22.57 | \$21.44 |
| Android                        | \$7.37 | \$5.82  | \$6.16  | \$6.82  | \$6.71  | \$6.73  | \$6.56  | \$6.50  | \$6.17  | \$5.86  |
| Total Blended Content          | \$7.43 | \$6.46  | \$7.23  | \$8.03  | \$8.51  | \$9.29  | \$9.09  | \$10.57 | \$12.06 | \$13.03 |

|                        |         |         |          |          |          |          |          |          |          |          |
|------------------------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|
| <b>RF Sales (\$mn)</b> |         |         |          |          |          |          |          |          |          |          |
| 5G                     | -       | -       | -        | -        | -        | -        | \$286    | \$4,385  | \$10,214 | \$14,542 |
| Sub-6GHz               | -       | -       | -        | -        | -        | -        | \$286    | \$3,988  | \$8,874  | \$12,661 |
| Apple (sub-6GHz)       | -       | -       | -        | -        | -        | -        | -        | \$1,488  | \$4,857  | \$5,269  |
| Android (sub-6GHz)     | -       | -       | -        | -        | -        | -        | \$286    | \$2,500  | \$4,017  | \$7,391  |
| mmWave                 | -       | -       | -        | -        | -        | -        | -        | \$397    | \$1,340  | \$1,881  |
| Apple                  | -       | -       | -        | -        | -        | -        | -        | \$335    | \$1,157  | \$1,585  |
| Android (mmWave)       | -       | -       | -        | -        | -        | -        | -        | \$62     | \$183    | \$297    |
| 4G/other               | \$7,354 | \$8,166 | \$10,330 | \$11,680 | \$12,527 | \$12,889 | \$12,340 | \$9,044  | \$5,968  | \$3,635  |
| Apple                  | \$1,189 | \$1,926 | \$2,964  | \$3,231  | \$4,093  | \$4,929  | \$4,608  | \$3,326  | \$1,061  | \$322    |
| Android                | \$6,165 | \$6,240 | \$7,367  | \$8,449  | \$8,434  | \$7,959  | \$7,732  | \$5,718  | \$4,907  | \$3,313  |
| Total RF Sales (\$mn)  | \$7,354 | \$8,166 | \$10,330 | \$11,680 | \$12,527 | \$12,889 | \$12,626 | \$13,429 | \$16,182 | \$18,177 |

Source: BofA Global Research estimates





## Diversified (Auto/Industrial)

### Bull Points

- Key beneficiaries of cyclical recovery in automotive and industrial end markets
- Best in class free cash flow generation and returns

### Bear Points

- EPS outlook at 29% CAGR 2020-2022E already highest within semis, limiting upside potential
- Typically GDP+ growth industry so money could potentially be more well spent in faster growth compute markets

Though consensus sees major diversified vendors growing at similar levels to compute/smartphone vendors (9% CAGR from CY20E-22E on average), utilization improvement should lead to strong margin upside, as highlighted by Street projections of 24% EPS CAGR. Gross margin improvement will be dependent on a topline recovery, relying on sustained auto strength seen in late Q2/Q3. As cyclical markets rebound from a Q2 bottom, we note (1) NXPI is trading almost ~4x below peers (16x cons CY22 P/E vs 20x peer median) despite leading auto exposure (~45%) of sales; (2) MCHP is also trading 4x below peers despite limited concentration across end markets, high compute exposure (~20% of sales), and leverage to key secular trends (5G, EV/ADAS, AI/machine learning, data center).

**Table 14: BofA sales/EPS outlook for diversified vendors**

| Ticker      | Sales (\$mn) |          |          |          | Sales CAGR<br>2020-2022E | EPS (\$) |        |        |        | EPS CAGR<br>2020-2022E | P/E    |        | YTD performance<br>CY20 YTD |
|-------------|--------------|----------|----------|----------|--------------------------|----------|--------|--------|--------|------------------------|--------|--------|-----------------------------|
|             | 2019         | 2020E    | 2021E    | 2022E    |                          | 2019     | 2020E  | 2021E  | 2022E  |                        | 2021E  | 2022E  |                             |
| TXN         | \$14,383     | \$13,935 | \$14,888 | \$15,704 | 6%                       | \$5.23   | \$5.48 | \$6.01 | \$6.73 | 11%                    | 26.4x  | 23.5x  | 24%                         |
| IFX         | \$8,930      | \$10,461 | \$12,734 | \$14,022 | 16%                      | \$0.86   | \$0.67 | \$1.18 | \$1.46 | 48%                    | 27.4x  | 22.2x  | 45%                         |
| STM         | \$9,556      | \$9,871  | \$11,029 | \$11,983 | 10%                      | \$1.08   | \$1.05 | \$1.54 | \$1.90 | 34%                    | 23.9x  | 19.4x  | 37%                         |
| NXPI        | \$8,877      | \$8,555  | \$9,585  | \$10,286 | 10%                      | \$7.58   | \$6.00 | \$7.86 | \$9.03 | 23%                    | 19.4x  | 16.9x  | 20%                         |
| ADI         | \$5,754      | \$5,620  | \$6,034  | \$6,452  | 7%                       | \$4.84   | \$5.03 | \$5.46 | \$6.09 | 10%                    | 25.0x  | 22.4x  | 15%                         |
| MCHP        | \$5,278      | \$5,289  | \$5,758  | \$6,190  | 8%                       | \$5.64   | \$6.15 | \$6.69 | \$7.38 | 10%                    | 20.0x  | 18.2x  | 28%                         |
| ON          | \$5,518      | \$5,159  | \$5,612  | \$6,028  | 8%                       | \$1.48   | \$0.75 | \$1.36 | \$1.74 | 52%                    | 20.4x  | 15.9x  | 14%                         |
| AMBA        | \$229        | \$211    | \$235    | \$259    | 11%                      | \$0.68   | \$0.18 | \$0.30 | \$0.52 | 70%                    | 219.7x | 126.9x | 9%                          |
| Diversified |              |          |          |          | 9%                       |          |        |        |        | 29%                    | 24.5x  | 20.8x  | 22%                         |

Source: BofA Global Research estimates, Bloomberg

\*Consensus estimates

Below, we highlight end market exposure for major diversified vendors. Renesas (autos 51% of sales), NXP Semiconductor (47%) and Infineon (46%) are well levered to the automotive market. While Buy-rated ADI/MCHP are less exposed to autos, we highlight their robust exposure to the resilient industrial market (>50% of sales for ADI, largest end market for MCHP).

**Table 16: Approximate end market exposure by major auto/industrial vendors**

| Company      | Ticker | Semi Sales<br>(CY2019) | Auto | Consumer | PC | Ent./CloudData Ctr | Industrial | Wired<br>Network | Wireless<br>Network | Mobile | Key Customers         |
|--------------|--------|------------------------|------|----------|----|--------------------|------------|------------------|---------------------|--------|-----------------------|
| Ambarella    | AMBA   | \$229                  | 19%  | 17%      | 0% | 0%                 | 63%        | 1%               | 0%                  | 0%     | Hikvision, Dahua      |
| Analog Dev.  | ADI    | \$5,754                | 15%  | 4%       | 4% | 0%                 | 51%        | 9%               | 14%                 | 3%     | Apple                 |
| Infineon     | IFX    | \$8,891                | 46%  | 7%       | 7% | 5%                 | 33%        | 2%               | 0%                  | 1%     | -                     |
| Microchip    | MCHP   | \$5,278                | 20%  | 12%      | 4% | 9%                 | 35%        | 12%              | 6%                  | 2%     | -                     |
| NXP          | NXPI   | \$8,877                | 47%  | 7%       | 6% | 3%                 | 18%        | 2%               | 3%                  | 13%    | Continental, Apple    |
| ON Semi      | ON     | \$5,518                | 32%  | 11%      | 7% | 4%                 | 26%        | 5%               | 3%                  | 12%    | Robert Bosch, Denso   |
| Renesas      | *      | \$6,589                | 51%  | 12%      | 8% | 2%                 | 13%        | 10%              | 1%                  | 4%     | -                     |
| ROHM         | *      | \$3,371                | 38%  | 32%      | 7% | 1%                 | 13%        | 1%               | 0%                  | 8%     | -                     |
| Silicon Labs | SLAB   | \$837                  | 11%  | 20%      | 0% | 0%                 | 17%        | 11%              | 6%                  | 36%    | Samsung               |
| STMicro      | STM    | \$9,556                | 30%  | 10%      | 5% | 4%                 | 20%        | 3%               | 2%                  | 26%    | Apple, Samsung, Bosch |
| Texas Instr. | TXN    | \$14,383               | 20%  | 12%      | 8% | 4%                 | 37%        | 7%               | 7%                  | 5%     | Apple                 |

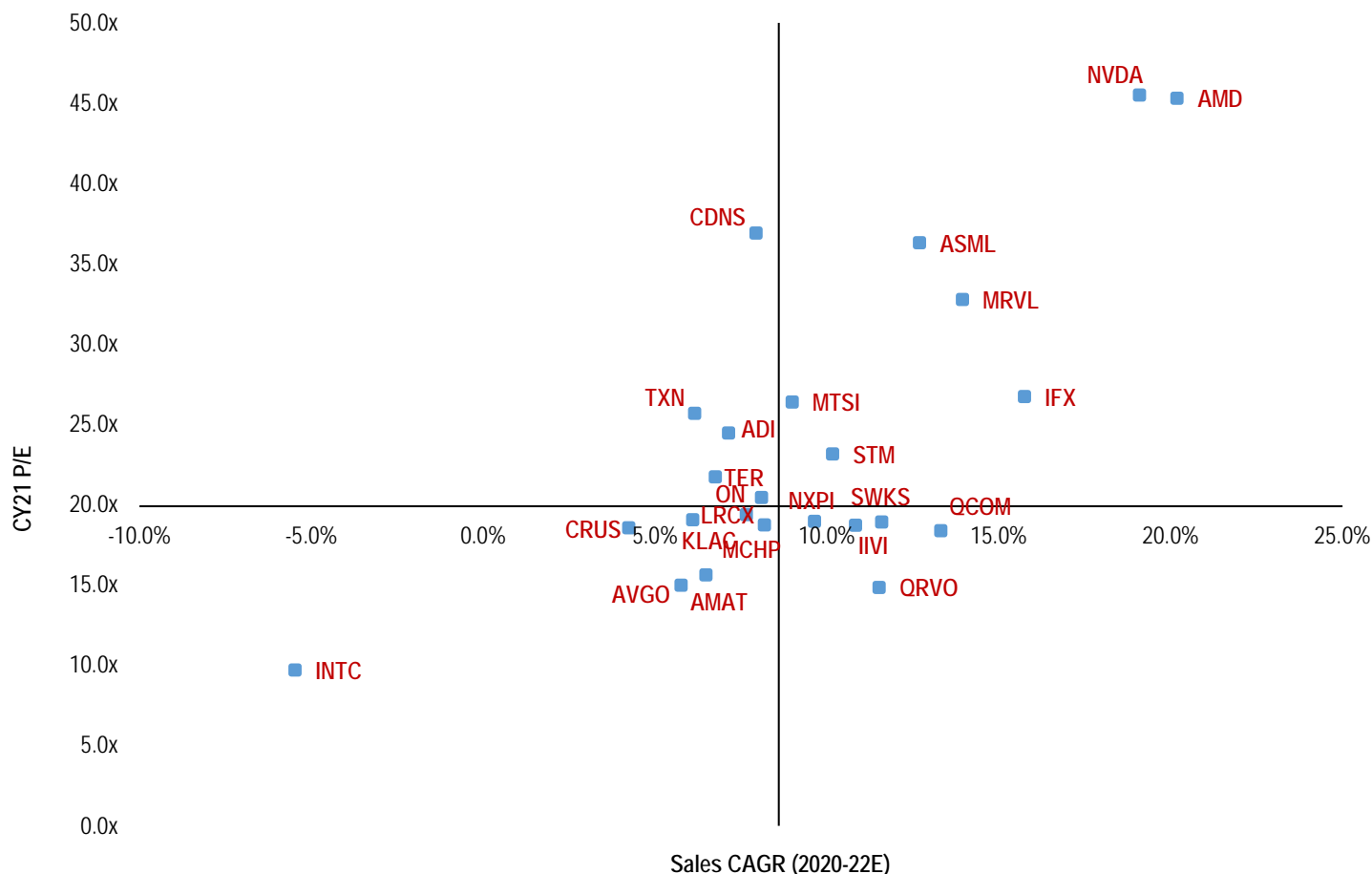
Source: BofA Global Research, Bloomberg



## Growth and Valuation

Below, we analyze CY21E P/E valuation relative to projected sales CAGR from 2020E-22E. We highlight (1) high-growth compute vendors **NVDA/AMD** projected to see sales increase well above peers as they benefit from unique secular trends (data center growth, gaming), but are also trading at a premium to the group (46x/45x CYe P/E vs peer average around 18x-20x); (2) **INTC** is trading at a discount to overall semis (at 10x CY21E P/E) but capacity constraints and manufacturing delays continue to impact growth opportunities as the firm cedes CPU share to competitor AMD (with no fix to near-term manufacturing delays in sight); (3) Smartphone vendors (**SWKS**, **QCOM**, **QRVO**) are expected to outgrow overall semis over the next few years and are trading in line to below peers.

**Exhibit 3: AMD/NVDA trading at a premium but are well exposed to unique, high-growth opportunities**



Source: BofA Global Research estimates, Bloomberg



# Summary of PO Changes

**Table 17: Summary of PO Changes**

| Ticker | Company Name      | NEW PO | OLD PO | Valuation Methodology  |
|--------|-------------------|--------|--------|--|
| AMAT   | Applied Materials | \$93   | \$78   | Our PO of \$93 is based on 17x our CY22E EPS estimate (vs 14x prior), given higher outlook for WFE, at the high end of the historical range 8x-18x, but still at normal 2-3 turn discount to semicap peers   |
| IIVI   | IIVI              | \$80   | \$70   | We assign an \$80 PO based on 21x CY22E P/E (vs 18x prior, on expected automotive recovery, especially in EVs, with IIVI benefitting from increased usage of SiC/GaN materials in EVs), at the high end of its historical 9x-25x range, justified, in our view, based on strong multi-year secular drivers (5G, data center) and opportunity for share gains in key end markets (3D sensing) |
| KLAC   | KLA               | \$268  | \$225  | We assign a \$268 PO based on 19x CY22E PE (vs 16x prior), given higher outlook for WFE, within KLAC's historical range of 8x-22x. We believe KLAC has a unique position as a key enabler of semi manufacturing technology, a less cyclical top line, and industry-leading profit margins  |
| LRCX   | Lam Research      | \$485  | \$420  | We assign a \$485 PO based on 19x cash adjusted CY22E PE (vs 17x prior), given higher outlook for WFE, at the high end of its historical range of 8x-20x but justified in our view given we are in a multi-year memory recovery where LRCX looks best positioned to benefit.   |
| NXPI   | NXP Semiconductor | \$175  | \$160  | Our PO of \$175 is based on 20x 2022E EV/FCF (vs 19x prior, on expected automotive recovery, especially in EVs, with NXPI being the largest auto semi vendor), our preferred metric for diversified semi stocks, below the median of diversified comps trading at median 23x (range 14x-30x), justified, in our view, due to NXP's lower margin profile.                                     |
| SWKS   | Skyworks          | \$165  | \$180  | Our \$165 PO is based on 18x CY 2022E PE (ex. stock comp expense, cash adjusted) vs 20x prior, lower given limited clarity on 5G iPhone sell-through trends, but still at the high end of the historical 7x-21x range but given 1-t 5G upside and solid unlevered balance sheet.   |

Source: BofA Global Research estimates



## Valuation Sheet

## Exhibit 4: BofA Semiconductor Industry Comp Sheet

| Name                | Ticker | Rating  | Price      | Mkt Cap  | NC/Sh     | Div Yld | PE<br>(as reported) |        |        | EV/EBITDA<br>(as reported) |        |       | EV/Adj. FCF<br>(unlevered) |        |       | EV/Sales |       |       | Sales YoY |       |       | EP \$ YoY |       |       | FCF<br>Margin |       |       | Stock<br>Performance |       |       |
|---------------------|--------|---------|------------|----------|-----------|---------|---------------------|--------|--------|----------------------------|--------|-------|----------------------------|--------|-------|----------|-------|-------|-----------|-------|-------|-----------|-------|-------|---------------|-------|-------|----------------------|-------|-------|
|                     |        |         |            |          |           |         | 2020E               | 2021E  | 2022E  | 2020E                      | 2021E  | 2022E | 2020E                      | 2021E  | 2022E | 2020E    | 2021E | 2022E | 2020E     | 2021E | 2022E | 2020E     | 2021E | 2022E | 2020E         | 2021E | 2022E | 2020E                | 2021E | 2022E |
| Computer/Networking |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
| Nvidia              | NVDA   | BUY     | \$523.51   | \$324.1  | \$5.04    | 0.1%    | 54.0x               | 44.8x  | 36.7x  | 41.9x                      | 34.3x  | 28.8x | 34.8x                      | 48.7x  | 39.1x | 19.8x    | 16.4x | 14.0x | 51%       | 21%   | 17%   | 67%       | 21%   | 22%   | 28%           | 40%   | 42%   | 122%                 | 148%  |       |
| Intel               | INTC   | UNDERP  | \$45.39    | \$186.0  | (\$5.66)  | 2.9%    | 9.1x                | 9.9x   | 9.8x   | 5.9x                       | 5.9x   | 6.1x  | 13.5x                      | 13.9x  | 13.1x | 2.9x     | 3.1x  | 3.2x  | 5%        | -8%   | -3%   | 0%        | -5%   | 1%    | 24%           | 26%   | 28%   | -24%                 | -22%  |       |
| Broadcom Limited    | AVGO   | BUY     | \$383.33   | \$155.1  | (\$83.33) | 3.4%    | 16.7x               | 15.2x  | 14.1x  | 14.1x                      | 13.1x  | 12.3x | 16.6x                      | 16.1x  | 15.2x | 8.1x     | 7.6x  | 7.2x  | 8%        | 7%    | 5%    | 10%       | 9%    | 8%    | 50%           | 46%   | 46%   | 21%                  | 23%   |       |
| AMD                 | AMD    | BUY     | \$84.64    | \$101.8  | \$1.15    |         | 68.2x               | 46.8x  | 36.6x  | 53.2x                      | 37.2x  | 27.8x | 246.7x                     | 124.5x | 93.1x | 10.7x    | 8.7x  | 7.4x  | 41%       | 22%   | 18%   | 93%       | 46%   | 28%   | 7%            | 9%    | 10%   | 85%                  | 107%  |       |
| Marvell             | MRVL   | BUY     | \$43.96    | \$29.5   | (\$0.92)  | 0.5%    | 47.7x               | 33.3x  | 25.4x  | 34.9x                      | 25.5x  | 20.0x | 54.6x                      | 37.9x  | 28.6x | 10.1x    | 8.9x  | 7.8x  | 10%       | 14%   | 14%   | 40%       | 43%   | 31%   | 26%           | 29%   | 33%   | 66%                  | 67%   |       |
| II-VI               | IIVI   | BUY     | \$64.78    | \$6.7    | (\$7.33)  |         | 19.3x               | 19.5x  | 16.7x  | 10.9x                      | 9.4x   | 9.7x  | 28.9x                      | 37.8x  | 29.3x | 2.6x     | 2.4x  | 2.2x  | 67%       | 12%   | 10%   | 53%       | -1%   | 17%   | 10%           | 9%    | 10%   | 92%                  | 132%  |       |
| Maxim               | MTSI   | UNDERP  | \$42.75    | \$2.9    | (\$5.14)  |         | 32.1x               | 26.7x  | 22.5x  | 22.8x                      | 20.9x  | 18.7x | 21.4x                      | 23.6x  | 24.0x | 5.9x     | 5.5x  | 5.0x  | 19%       | 9%    | 9%    | -429%     | 20%   | 19%   | 31%           | 27%   | 25%   | 61%                  | 74%   |       |
| Maxlinear           | MXL    | NC      | \$29.22    | \$2.2    | (\$1.75)  |         | 34.2x               | 16.6x  | 14.5x  | 19.5x                      | 11.7x  | 12.0x | -49.6x                     | 29.5x  | 35.6x | 5.2x     | 3.2x  | 3.1x  | 50%       | 60%   | 5%    | 7%        | 107%  | 14%   | 17%           | 14%   | 38%   | 46%                  |       |       |
| Amberline           | AMBA   | UNDERP  | \$66.46    | \$2.3    | \$11.91   |         | 389.4x              | 221.1x | 127.7x | 140.8x                     | 120.6x | 74.3x |                            |        |       | 8.9x     | 8.0x  | 7.3x  | -8%       | 12%   | 10%   | -73%      | 67%   | 73%   | 6%            | 8%    | 12%   | 10%                  | 19%   |       |
| Median              |        |         |            |          |           | 1.7%    | 34.2x               | 26.7x  | 22.5x  | 22.8x                      | 20.9x  | 18.7x | 25.1x                      | 33.7x  | 28.9x | 8.1x     | 7.6x  | 7.2x  | 19%       | 12%   | 10%   | 10%       | 21%   | 19%   | 25%           | 26%   | 25%   | 61%                  | 67%   |       |
| Smartphone          |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
| Qualcomm            | QCOM   | BUY*    | \$146.03   | \$165.2  | (\$4.37)  | 1.8%    | 33.8x               | 23.4x  | 20.8x  | 22.3x                      | 16.5x  | 15.7x | 27.7x                      | 24.0x  | 21.1x | 6.9x     | 5.6x  | 5.2x  | 26%       | 23%   | 8%    | 56%       | 37%   | 11%   | 27%           | 25%   | 26%   | 66%                  | 71%   |       |
| Skyworks            | SWKS   | BUY     | \$140.39   | \$23.3   | \$5.81    | 1.4%    | 21.6x               | 19.3x  | 16.0x  | 15.8x                      | 16.6x  | 13.8x | 40.1x                      | 29.0x  | 25.6x | 6.5x     | 5.9x  | 5.2x  | 6%        | 9%    | 14%   | 8%        | 12%   | 21%   | 21%           | 25%   | 25%   | 16%                  | 46%   |       |
| Qorvo               | QRVO   | BUY     | \$147.39   | \$16.8   | (\$5.43)  |         | 18.1x               | 15.3x  | 13.3x  | 13.2x                      | 11.5x  | 10.1x | 24.7x                      | 16.9x  | 15.7x | 4.8x     | 4.3x  | 3.9x  | 18%       | 13%   | 10%   | 37%       | 18%   | 15%   | 20%           | 26%   | 26%   | 27%                  | 45%   |       |
| Cirrus Logic        | CRUS   | BUY     | \$77.31    | \$4.5    | \$10.19   |         | 18.1x               | 19.1x  | 16.6x  | 11.7x                      | 12.1x  | 10.5x | 36.8x                      | 30.2x  | 15.4x | 3.0x     | 3.0x  | 2.8x  | 7%        | 3%    | 6%    | 16%       | -6%   | 15%   | 13%           | 15%   | 23%   | -6%                  | 10%   |       |
| Synaptics           | SYNA   | NC      | \$80.33    | \$2.8    | \$4.55    |         | 12.0x               | 11.1x  | 11.7x  | 10.9x                      | 10.1x  | 10.4x | 25.7x                      | 21.0x  | 16.0x | 2.4x     | 2.4x  | 2.4x  | -5%       | 3%    | 0%    | 50%       | 8%    | -5%   | 12%           | 16%   | 18%   | 22%                  | 41%   |       |
| Median              |        |         |            |          |           | 1.6%    | 18.1x               | 19.1x  | 16.6x  | 13.2x                      | 12.1x  | 10.5x | 27.7x                      | 24.0x  | 16.0x | 4.8x     | 4.3x  | 3.9x  | 7%        | 9%    | 8%    | 37%       | 12%   | 15%   | 20%           | 25%   | 25%   | 22%                  | 45%   |       |
| Industrial/Auto/IoT |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
| Texas Instruments   | TXN    | BUY     | \$156.82   | \$144.0  | (\$1.38)  | 2.6%    | 27.5x               | 25.6x  | 23.3x  | 22.7x                      | 20.8x  | 19.2x | 30.0x                      | 25.9x  | 23.3x | 10.5x    | 9.9x  | 9.4x  | -3%       | 7%    | 5%    | 5%        | 10%   | 12%   | 37%           | 40%   | 42%   | 22%                  | 35%   |       |
| Analog Devices      | ADI    | BUY     | \$134.88   | \$49.8   | (\$12.10) | 1.8%    | 26.8x               | 24.7x  | 22.2x  | 21.6x                      | 20.1x  | 18.6x | 27.5x                      | 24.1x  | 22.8x | 9.7x     | 9.1x  | 8.5x  | -2%       | 7%    | 7%    | 4%        | 9%    | 12%   | 35%           | 38%   | 38%   | 13%                  | 24%   |       |
| NXP Semiconductors  | NXPI   | BUY     | \$150.57   | \$42.1   | (\$20.72) | 1.0%    | 25.1x               | 19.2x  | 16.7x  | 17.3x                      | 14.1x  | 12.3x | 29.9x                      | 24.4x  | 22.1x | 5.6x     | 5.0x  | 4.7x  | -4%       | 12%   | 7%    | -21%      | 31%   | 15%   | 19%           | 21%   | 22%   | 18%                  | 31%   |       |
| Infinion Tech       | FX     | BUY*    | €27.23     | €35.6    | €-3.15    | 0.8%    | 42.0x               | 27.2x  | 22.0x  | 24.2x                      | 13.3x  | 11.8x | 36.2x                      | 39.4x  | 29.5x | 4.5x     | 3.8x  | 3.4x  | 15%       | 17%   | 10%   | -19%      | 45%   | 21%   | 12%           | 9%    | 11%   | 34%                  | 43%   |       |
| Microchip           | MCHP   | BUY     | \$130.98   | \$34.1   | (\$26.78) | 1.1%    | 21.3x               | 19.6x  | 17.7x  | 18.9x                      | 17.4x  | 16.0x | 33.2x                      | 24.2x  | 22.7x | 8.0x     | 7.3x  | 6.8x  | 0%        | 9%    | 8%    | 9%        | 9%    | 10%   | 32%           | 29%   | 30%   | 25%                  | 44%   |       |
| STMicroelectronics  | STM    | BUY*    | €31.13     | €28.4    | €0.72     | 0.5%    | 29.6x               | 20.2x  | 16.4x  | 13.3x                      | 10.4x  | 8.9x  | 69.5x                      | 32.6x  | 21.9x | 2.8x     | 2.5x  | 2.3x  | 3%        | 12%   | 9%    | -8%       | 41%   | 21%   | 6%            | 9%    | 12%   | 30%                  | 42%   |       |
| ON Semi             | ON     | UNDERP  | \$27.44    | \$11.3   | (\$6.18)  |         | 36.6x               | 20.2x  | 15.8x  | 14.0x                      | 10.9x  | 9.2x  | 29.2x                      | 18.0x  | 14.3x | 2.7x     | 2.5x  | 2.3x  | -7%       | 9%    | 7%    | -49%      | 81%   | 28%   | 8%            | 13%   | 16%   | 13%                  | 32%   |       |
| Monolithic Power    | MPWR   | NC      | \$315.73   | \$14.2   | \$9.65    | 0.6%    | 63.9x               | 58.2x  | 48.5x  | 53.0x                      | 48.4x  | 39.2x | 101.6x                     | 98.5x  | 61.3x | 16.4x    | 14.6x | 12.7x | 33%       | 12%   | 15%   | 27%       | 10%   | 20%   | 26%           | 23%   | 28%   | 77%                  | 98%   |       |
| Silicon Labs        | SLAB   | NC      | \$111.40   | \$4.9    | \$7.67    |         | 38.4x               | 32.8x  | 25.9x  | 29.1x                      | 25.1x  | 20.2x | 50.1x                      | 62.5x  | 37.1x | 5.4x     | 4.9x  | 4.6x  | 4%        | 10%   | 7%    | -10%      | 17%   | 27%   | 16%           | 14%   | 17%   | -4%                  | 7%    |       |
| Semtech             | SMTX   | NC      | \$68.94    | \$4.5    | \$1.32    |         | 41.2x               | 33.0x  | 28.0x  | 28.3x                      | 23.2x  | 18.2x | 64.0x                      | 55.9x  |       | 7.7x     | 6.9x  | 6.3x  | 3%        | 11%   | 10%   | 6%        | 25%   | 18%   | 19%           | 19%   | NA    | 30%                  | 40%   |       |
| Cree                | CRGE   | NC      | \$82.10    | \$9.1    | \$4.00    |         |                     |        | 137.2x | 117.1x                     | 62.7x  | 34.0x |                            |        |       | 11.5x    | 15.2x | 10.7x | -25%      | -24%  | 42%   |           |       |       |               |       |       | 78%                  | 86%   |       |
| Power Integrated    | POWI   | NC      | \$69.18    | \$4.1    | \$6.61    | 0.6%    | 44.5x               | 39.5x  | 26.6x  | 30.6x                      | 27.4x  |       | 73.3x                      | 46.5x  | 41.6x | 7.9x     | 7.0x  | 5.2x  | 11%       | 13%   | 35%   | 19%       | 13%   | 48%   | 16%           | 20%   | 16%   | 40%                  | 53%   |       |
| Median              |        |         |            |          |           | 0.9%    | 36.6x               | 25.6x  | 22.7x  | 23.5x                      | 20.4x  | 18.2x | 36.2x                      | 32.6x  | 23.0x | 7.8x     | 7.0x  | 5.7x  | 2%        | 11%   | 8%    | 4%        | 17%   | 20%   | 19%           | 20%   | 19%   | 27%                  | 41%   |       |
| SEMI\$ ONLY         |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
|                     |        |         |            |          |           | 1.1%    | 32.1x               | 23.4x  | 21.4x  | 21.9x                      | 17.0x  | 15.7x | 30.0x                      | 29.2x  | 23.3x | 6.7x     | 5.7x  | 5.2x  | 7%        | 11%   | 9%    | 8%        | 18%   | 18%   | 20%           | 21%   | 24%   | 28%                  | 44%   |       |
| Semicap Equipment   |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
| ASML                | ASML   | BUY*    | \$423.59   | \$180.3  | \$3.29    | 0.7%    | 55.2x               | 43.4x  | 35.2x  | 36.9x                      | 29.7x  | 24.9x | 101.3x                     | 47.4x  | 36.7x | 11.3x    | 10.1x | 8.9x  | 14%       | 13%   | 13%   | 24%       | 27%   | 23%   | 12%           | 22%   | 25%   | 43%                  | 58%   |       |
| Applied Materials   | AMAT   | BUY     | \$76.73    | \$70.1   | \$1.98    | 1.1%    | 17.2x               | 15.9x  | 14.1x  | 13.0x                      | 11.7x  | 10.6x | 21.5x                      | 14.6x  | 14.8x | 3.8x     | 3.6x  | 3.4x  | 20%       | 6%    | 7%    | 39%       | 8%    | 13%   | 19%           | 26%   | 24%   | 26%                  | 29%   |       |
| Lam Research        | LRX    | BUY     | \$433.64   | \$62.4   | (\$4.45)  | 1.2%    | 21.7x               | 19.6x  | 17.2x  | 17.2x                      | 15.3x  | 14.1x | 26.2x                      | 20.7x  | 19.9x | 5.5x     | 5.1x  | 4.7x  | 23%       | 8%    | 7%    | 38%       | 11%   | 14%   | 22%           | 25%   | 25%   | 48%                  | 58%   |       |
| KLA-Tencor          | KLAC   | BUY     | \$242.57   | \$37.5   | (\$8.80)  | 1.5%    | 21.3x               | 19.4x  | 17.5x  | 15.8x                      | 15.4x  | 14.4x | 23.9x                      | 19.7x  | 19.3x | 6.5x     | 6.1x  | 5.8x  | 14%       | 7%    | 6%    | 30%       | 10%   | 10%   | 27%           | 31%   | 30%   | 36%                  | 40%   |       |
| Teradine            | TER    | NEUTRAL | \$106.33   | \$17.7   | \$5.07    | 0.4%    | 23.7x               | 22.0x  | 20.9x  | 17.8x                      | 18.4x  | 17.6x | 28.8x                      | 22.8x  | 19.7x | 6.1x     | 5.6x  | 5.3x  | 34%       | 8%    | 6%    | 57%       | 8%    | 5%    | 22%           | 26%   | 28%   | 56%                  | 67%   |       |
| Tokyo Electron      | 8035   | BUY*    | ¥32,140.00 | ¥5,052.8 | ¥2,142.0  | 2.1%    | 22.6x               | 20.6x  | 18.0x  | 16.8x                      | 12.8x  | 11.7x | 29.7x                      | 27.9x  | 23.1x | 3.7x     | 3.4x  | 3.2x  | 15%       | 8%    | 5%    | 17%       | 10%   | 14%   | 13%           | 12%   | 14%   | 34%                  | 48%   |       |
| Advantest           | 6857   | BUY*    | ¥7,000.00  | ¥1,397.0 | ¥585.6    | 1.1%    | 28.5x               | 28.6x  | 22.0x  | 24.1x                      | 16.6x  | 14.2x | 25.5x                      | 26.5x  | 23.3x | 4.7x     | 4.4x  | 4.0x  | 2%        | 6%    | 11%   | 0%        | 0%    | 30%   | 19%           | 17%   | 17%   | 14%                  | 35%   |       |
| SEMICAP EQP ONLY    |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
|                     |        |         |            |          |           | 1.1%    | 22.6x               | 20.6x  | 18.0x  | 17.2x                      | 15.4x  | 14.2x | 26.2x                      | 22.8x  | 19.9x | 5.5x     | 5.1x  | 4.7x  | 15%       | 8%    | 7%    | 30%       | 10%   | 14%   | 19%           | 25%   | 25%   | 36%                  | 48%   |       |
| EDA/Software        |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
| Synopsys            | SNPS   | BUY     | \$218.51   | \$33.2   | \$5.89    |         | 35.6x               | 34.1x  | NA     | 22.0x                      | 21.0x  | NA    | 42.7x                      | 39.5x  | NA    | 8.6x     | 8.1x  | NA    | 14%       | 6%    | NA    | 36%       | 4%    | NA    | 26%           | 26%   | NA    | 57%                  | 55%   |       |
| Cadence             | CDNS   | BUY     | \$112.79   | \$31.5   | \$3.43    |         | 41.8x               | 37.6x  | 33.9x  | 25.8x                      | 23.4x  | 21.2x | 51.2x                      | 44.0x  | 37.9x | 11.5x    | 10.7x | 9.9x  | 14%       | 8%    | 8%    | 23%       | 11%   | 11%   | 29%           | 31%   | 32%   | 63%                  | 67%   |       |
| ANSYS               | ANSS   | NC      | \$318.26   | \$27.3   | \$3.03    |         | 42.6x               | 38.5x  | 35.0x  | 39.3x                      | 33.2x  | 30.0x | 90.9x                      | 63.8x  | 51.9x | 16.6x    | 14.8x | 13.5x | 7%        | 12%   | 10%   | -4%       | 11%   | 10%   | 26%           | 30%   | 32%   | 24%                  | 30%   |       |
| CEVA Inc.           | CEVA   | NC      | \$38.46    | \$0.9    | \$8.04    |         | 78.0x               | 54.0x  | 33.0x  |                            |        |       |                            |        |       | 7.6x     | 7.2x  | 6.0x  | 9%        | 6%    | 19%   | -15%      | 41%   | 64%   |               |       |       | 43%                  | 50%   |       |
| EDA/Software ONLY   |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
|                     |        |         |            |          |           | 0.9%    | 42.2x               | 38.0x  | 33.0x  | 28.2x                      | 27.3x  | 24.5x | 51.2x                      | 42.5x  | 35.9x | 11.2x    | 9.9x  | 9.2x  | 13%       | 10%   | 12%   | 19%       | 10%   | 14%   | 29%           | 30%   | 32%   | 40%                  | 52%   |       |
| SECTOR              |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
|                     |        |         |            |          |           | 1.1%    | 33.5x               | 26.2x  | 22.1x  | 22.7x                      | 20.4x  | 17.6x | 34.3x                      | 30.7x  | 24.8x | 7.7x     | 7.0x  | 5.9x  | 12%       | 9%    | 10%   | 16%       | 11%   | 15%   | 21%           | 25%   | 25%   |                      |       |       |
| SOX                 |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      |       |       |
| S&P                 |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      | 38%   | 49%   |
| NASDAQ              |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      | 10%   | 14%   |
|                     |        |         |            |          |           |         |                     |        |        |                            |        |       |                            |        |       |          |       |       |           |       |       |           |       |       |               |       |       |                      | 32%   | 39%   |

**Stocks mentioned**

| BofA Ticker | Bloomberg ticker | Company name       | Price       | Rating |
|-------------|------------------|--------------------|-------------|--------|
| AMD         | AMD US           | Advanced Micro     | US\$ 84.64  | C-1-9  |
| AMBA        | AMBA US          | Ambarella          | US\$ 66.46  | C-3-9  |
| ADI         | ADI US           | Analog Devices     | US\$ 134.88 | B-1-7  |
| AMAT        | AMAT US          | Applied Materials  | US\$ 76.725 | B-1-7  |
| AVGO        | AVGO US          | Broadcom           | US\$ 383.33 | B-1-7  |
| CRUS        | CRUS US          | Cirrus Logic       | US\$ 77.31  | B-1-9  |
| IIVI        | IIVI US          | II-VI              | US\$ 64.78  | B-1-9  |
| INTC        | INTC US          | Intel              | US\$ 45.39  | B-3-7  |
| KLAC        | KLAC US          | KLA Corp           | US\$ 242.57 | B-1-7  |
| LRCX        | LRCX US          | Lam Research       | US\$ 433.64 | B-1-7  |
| MTSI        | MTSI US          | M/A-Com            | US\$ 42.75  | C-3-9  |
| MRVL        | MRVL US          | Marvell            | US\$ 43.96  | B-1-7  |
| MCHP        | MCHP US          | Microchip          | US\$ 130.98 | B-1-7  |
| NVDA        | NVDA US          | Nvidia             | US\$ 523.51 | B-1-7  |
| NXPI        | NXPI US          | NXP Semiconductors | US\$ 150.57 | B-1-7  |
| ON          | ON US            | ON Semiconductor   | US\$ 27.44  | C-3-9  |
| QRVO        | QRVO US          | Qorvo Inc.         | US\$ 147.39 | B-1-9  |
| SWKS        | SWKS US          | Skyworks           | US\$ 140.39 | B-1-7  |
| TXN         | TXN US           | Texas Instr.       | US\$ 156.82 | B-1-7  |

Source: BofA Global Research

**Price objective basis & risk****Advanced Micro Devices, Inc (AMD)**

Our \$110 price objective (PO) is based on 48x our 2022E non-GAAP EPS which is in line with EPS growth CAGR from CY19-22E, and well supported by AMD's ability to take share in large markets.

Downside risks: 1) Sharp correction in share price following strong rally to-date, 2) Strong competition from larger names, 3) Lumpy nature of consumer and enterprise spending that could create delays in acceptance and success of new products, 4) Reliance on multiple outsourced manufacturing partners, 5) Maturity of current game console cycle.

**Ambarella (AMBA)**

Our price objective of \$50 is based on 6x FY22E (CY21E) EV/S. This is inline with vision/compute semi peers median and reflects AMBA's long-term growth potential offset by near-term headwinds/uncertainty

Downside risks to our PO: Macro/COVID headwinds, US-China trade tensions which could negatively impact security camera market sales, semiconductor cyclicality, further deterioration in legacy consumer businesses, failure to successfully penetrate target auto/security markets with new computer vision chip roadmap.

Upside risks to our PO: Faster penetration of CV chip technology in focus automotive/security markets, semiconductor industry consolidation.

**Analog Devices Inc. (ADI)**

We assign a \$145 PO based on 24x CY2021E EV/FCF, within diversified peer range of 14x-38x, and justified based on ADI's best in class profitability and differentiated/secular comms exposure.

Downside risks to our price objective are: 1) Economic downturn can reduce demand for automotive, industrial products. 2) Inability to realize the planned cost synergies with Linear Tech. 3) Higher than historical debt leverage could limit valuation multiples and increase risks in a cyclical downturn. 4) Customer concentration, with Apple contributing 10% of sales on an average and much higher during seasonally stronger quarters. 5) Competition from larger vendors such as TXN which have lower-cost production facilities.

#### **Applied Materials, Inc. (AMAT)**

Our PO of \$93 is based on 17x our CY22E EPS estimate, within historical range 8x-18x, but a discount to peers given sluggish display trends.

Upside risks to our PO are: stronger-than-expected electronics demand that would tighten up semiconductor capacity, driving increased semiconductor equipment sales and/or increasing market share. Downside risks to our PO are: slower-than-expected capital spending cycle, delay in memory capacity adds, market share loss in etch or clean segments, merger & integrations risk, and macro headwinds.

#### **Broadcom Inc (AVGO)**

Our \$450 price objective for Broadcom is based on 20x CY21E EV/FCF, at the lower end of large-cap diversified peer range of 20x-25x to reflect AVGO's higher debt leverage and non-synergistic software M&A.

Downside risks to our price objective are: 1) Semiconductor cycle risks including sensitivity to US/China trade relations, 2) High exposure to Apple with potential design out risks, 3) Competitive risks in networking, smartphone, storage, enterprise software markets, 4) Frequent acquirer of assets which increases financial and integration risks, and 5) Recent strategy towards moving into non-core software businesses creates mis-execution risks.

#### **Cirrus Logic (CRUS)**

Our price objective of \$85 is based on 18x CY22E pf-PE, at the high-end of CRUS normalized five year range (9x-25x) and reflects CRUS' content growth opportunities in Apple/Android.

Upside risks to our PO: faster unit/content growth in flagship smartphone models from top customers Apple and Samsung, faster penetration of Android smartphone market, quicker market transition to digital headsets, and potential M&A tailwinds increasing valuations across the semiconductor sector.

Downside risks to our PO: Macro headwinds, slower smartphone unit growth, increased sales/margin pressures from content loss and/or ASP degradation at Apple/Samsung, failure to diversify and grow into targeted customer/market adjacencies.

#### **II-VI (IIVI)**

We assign a \$80 PO based on 21x CY22 P/E (inline with historical 9x-25x range), justified based on strong multi-year secular drivers (5G, data center) and opportunity for share gains in key end markets (3D sensing)

Downside risks to our PO are: 1) inability to realized planned cost synergies with Finisar acquisition, 2) Lumpy telecom/hyperscaler capex trends, 3) frequent M&A activity increasing leverage limiting valuation multiples, 4) sustained COVID-19 headwinds





impacting 5G/cloud capex, 5) heightened trade tensions impacting opportunities in growing Asia markets

### **Intel (INTC)**

Our \$45 price objective is based on 12x EV/FCF our 2021 estimate, at low end of large diversified peers, which we view as appropriate given manufacturing uncertainties.

Upside risks to our price objective are: 1) Clarity or breakthrough on yields for 7nm process technology, 2) new products allowing Intel to limit share loss, 3) improving product mix which can drive upside to gross margins, 4) manufacturing slip up at key foundry competitors. Downside risks to our price objective are: 1) Weaker-than-expected trends in a mature PC market, which is largest revenue generator for Intel, 2) further delays in 7nm process technology and roadmap, 3) accelerated share loss to AMD, 4) more competition in profitable data center market.

### **KLA Corporation (KLAC)**

We assign a \$268 PO based on 19x CY22E PE, within KLAC's historical range of 8x-22x. We continue to believe KLAC has a unique position as a key enabler of semiconductor manufacturing technology, a less cyclical topline, industry leading profit margins, and best-in-class shareholder returns.

Downside risks to our PO are the cyclical nature of the semiconductor capital spending and its impact on earnings, competitive price and market share issues, particularly against Applied Materials, ability to get new products and technologies into the market in a timely manner.

### **Lam Research Corp. (LRCX)**

We assign a \$485 PO based on 19x cash adjusted CY22E PE, at the high end of its historical range of 8x-20x but justified in our view given we are at the start of a multi-year memory recovery where LRCX is best positioned to benefit.

Upside risks to our PO are: stronger-than-expected electronics demand that would tighten up semiconductor capacity, driving increased semiconductor equipment sales and/or increasing market share. Downside risks are slower than expected capital spending cycle, delay in memory capacity adds, market share loss in etch or clean segments, merger & integrations risk, and macro headwinds.

### **M/A-Com (MTSI)**

Our \$32 PO is based on a 17x CY22E P/E, towards the lower end of Smidcap growth comps trading 15x-35x given MTSI's high debt leverage.

Downside risks to our price objective are: (1) Semiconductor cyclicality driven by weak macroeconomic conditions, demand or inventory corrections, (2) Large private ownership with limited public float could add volatility to the stock price, (3) Demand fluctuations in optical, aerospace and defense markets, and (4) High degree of leverage could limit Macom's flexibility and ability to engage in buybacks/dividends.

Upside risks are: (1) Faster recovery in core telecoms business, (2) potential for M&A in a consolidating industry.

### **Marvell Technology Group Ltd. (MRVL)**

Our \$50 PO is based on a 38x FY22E/CY21E pf-EPS, in line with growth peers and well-supported by the 38% longer-term compounded annual EPS growth potential, driven by potential success in 5G over the next few years. This multiple is also in line with other SMidcap semiconductor growth peers at early stages of new product cycles.

Downside risks: 1) Integration risks in recent deals, 2) Financial risks related to going to



net debt from net cash position, and in achieving expected cost synergies in a timely manner, and 3) Cyclical industry risks including potential slowdown in legacy hard disk drive and storage assets, 4) Competitive risks against larger well resourced rivals such as AVGO, INTC and NVDA.

### **Microchip (MCHP)**

We assign a \$142 PO based on 21x our 2022E EV/FCF, which is in between comps trading 18x-38x range and justified, in our view, based on MCHP's mix of growth, execution, profitability, and leverage.

Upside risks to our PO: better than expected synergies from the MSCC acquisition, continued strong share gains in the 8/32bit MCU category, and M&A tailwind increasing valuation across the board.

Downside risks to our PO: macro headwinds related to trade/COVID-19 and increased competition capping any market share gains.

### **NVIDIA Corporation (NVDA)**

Our \$665 PO is based on 46x CY22E PE ex cash at the high-end of NVDA's historical 20x-54x PE range reflecting Nvidia's superior long-term growth profile in large, underpenetrated markets.

Risks to our price objective are: 1) exposure to PC market, 2) Competition with INTC & PLD companies in HPC/accelerated computing markets and MCU vendors in Autos. 3) Lumpy and unpredictable sales in new enterprise, data center, and autos markets, 4) Potential for decelerating capital returns, 5) potential for autos slowdown until ADAS becomes more meaningful, and 6) elevated opex growth.

### **NXP Semiconductors NV (NXPI)**

Our PO of \$175 is based on 20x 2022E EV/FCF, our preferred metric for diversified semi stocks, below the median of diversified comps trading at median 23x (range 14x-30x), justified, in our view, due to NXP's lower margin profile.

Downside risks: 1) Semiconductor cycle risks, 2) Lumpy nature of projects in key identification segment, 3) Some exposure to and growth driven by Apple, which could add volatility, 4) Execution risk surrounding management's capability to reengage following two-year hiatus, 5) Macroeconomic supply/demand disruption.

### **ON Semiconductor (ON)**

We assign a \$19 PO based on 11x 2022E EV/FCF, at the low end of peer range of 11x-37x, due to ON's lower margin profile.

Upside risks to our PO are: 1) Stronger than expected content growth or units in automotive, 5G and cloud server markets, 2) Restructuring initiatives that can help expand gross margins higher than our model and 3) faster than expected macroeconomic recovery that can drive upside to sales growth.

Downside risks to our PO are: 1) Macro/cyclical risks given high exposure to automotive and industrial markets, makes ON susceptible to any potential global trade tensions/tariffs, 2) Analog chips have long product cycles that could mask competitive issues and/or share shifts, 3) PC and consumer end-markets could weaken further, 4) Mobile growth is slowing as penetration rates flatten and the mix shifts toward lower priced devices, 5) Pricing pressures in standard products where fixed costs are high and there is little competitive differentiation, 6) Developing differentiated and higher valued analog IC's could result in elevated levels of R&D spending and lower profitability for several years, 7) The semi industry is very cyclical where demand sometimes increases or decreases rapidly, and 8) M&A integration risks. Other risks to ON Semi's operational



and/or financial performance are manufacturing, currency risks, intellectual property and other litigation, political climate, etc.

### **Qorvo Inc. (QRVO)**

Our \$170 price objective is based on 15x our CY22E Non-GAAP EPS (excluding stock comp), inline with the long-term 8x-20x range but consistent with elevated multiple ahead of major product ramps and similar re-rating of 5G related peers.

Downside risks to our PO are: 1) Potential share losses in handset power amplifiers (PAs) where product cycles are short (6-12 months) resulting in changes in power amplifier selection by key customers, 2) Customer concentration at Apple and Samsung, 3) Gross margin headwinds associated with lower factory utilization due to weaker design win momentum, 4) Weaker smartphone growth trajectory, and 5) Semiconductor cyclicality driven by strong macroeconomic conditions and/or supply chain expansion, 6) COVID-19 headwinds further impacting supply chain or creating demand destruction.

Upside risks to our PO are: 1) higher RF content growth in new smartphones more than offsets quarterly unit volatility in Q4, 2) M&A that diversifies the business away from mobile and adds more long life cycle business, and 3) substantial share gain against peers in smartphone driven by higher R&D spend.

### **Skyworks Solutions, Inc. (SWKS)**

Our \$165 PO is based on 18x CY 2022E PE (ex. stock comp expense, cash adjusted), towards the high end of the historical 7x-21x range but justified given 5G cycle and solid unlevered balance sheet and FCF generation.

Downside risks to our price objective: (1) High exposure to mature smartphone market and to daily sentiment shifts around large customers Apple, Huawei and Samsung, (2) exposure to Chinese smartphone customers who could be impacted by global trade/tariff tensions, (3) Competitive risks from AVGO, QRVO and QCOM, (4) High capex requirements for filter manufacturing, (5) Semiconductor cycle risk especially in the broad markets business, and (6) Financial/integration risks with any potential M&A.

Upside risks to our price objective: (1) Share gains, (2) Earlier than expected boost from 5G adoption, (3) semis consolidation

### **Texas Instruments Inc. (TXN)**

We assign a \$175 PO based on 25x 2022E EV/FCF, within diversified peers trading range of 16x-40x and justified, in our view, based on TXN's best in class profitability and cash flow returns.

Risks to our price objective: 1) Macro/cyclical risks given high exposure to automotive, industrial, and telco capex markets, also makes TXN susceptible to any potential global trade tensions/tariffs, 2) Increasing capex intensity and higher depreciation burden could be a headwind to gross margins, 3) Increased R&D spending pressure to maintain an edge versus the competition, 4) Inventory cycles and potential double ordering by customers that can often create mismatches between real supply and demand, 5) Exposure to several mature markets such as PC and other consumer.

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**US - Semiconductors and Semiconductor Capital Equipment Coverage Cluster**

| Investment rating   | Company                        | BofA Ticker | Bloomberg symbol | Analyst    |
|---------------------|--------------------------------|-------------|------------------|------------|
| <b>BUY</b>          |                                |             |                  |            |
|                     | Advanced Micro Devices, Inc    | AMD         | AMD US           | Vivek Arya |
|                     | Analog Devices Inc.            | ADI         | ADI US           | Vivek Arya |
|                     | Applied Materials, Inc.        | AMAT        | AMAT US          | Vivek Arya |
|                     | Broadcom Inc                   | AVGO        | AVGO US          | Vivek Arya |
|                     | Cadence                        | CDNS        | CDNS US          | Vivek Arya |
|                     | Cirrus Logic                   | CRUS        | CRUS US          | Vivek Arya |
|                     | II-VI                          | IIVI        | IIVI US          | Vivek Arya |
|                     | KLA Corporation                | KLAC        | KLAC US          | Vivek Arya |
|                     | Lam Research Corp.             | LRCX        | LRCX US          | Vivek Arya |
|                     | Marvell Technology Group Ltd.  | MRVL        | MRVL US          | Vivek Arya |
|                     | Microchip                      | MCHP        | MCHP US          | Vivek Arya |
|                     | NVIDIA Corporation             | NVDA        | NVDA US          | Vivek Arya |
|                     | NXP Semiconductors NV          | NXPI        | NXPI US          | Vivek Arya |
|                     | Qorvo Inc.                     | QRVO        | QRVO US          | Vivek Arya |
|                     | Skyworks Solutions, Inc.       | SWKS        | SWKS US          | Vivek Arya |
|                     | Synopsys                       | SNPS        | SNPS US          | Vivek Arya |
|                     | Texas Instruments Inc.         | TXN         | TXN US           | Vivek Arya |
| <b>NEUTRAL</b>      |                                |             |                  |            |
|                     | Teradyne                       | TER         | TER US           | Vivek Arya |
| <b>UNDERPERFORM</b> |                                |             |                  |            |
|                     | Ambarella                      | AMBA        | AMBA US          | Vivek Arya |
|                     | Intel                          | INTC        | INTC US          | Vivek Arya |
|                     | M/A-Com                        | MTSI        | MTSI US          | Vivek Arya |
|                     | ON Semiconductor               | ON          | ON US            | Vivek Arya |
| <b>RSTR</b>         |                                |             |                  |            |
|                     | Maxim Integrated Products Inc. | MXIM        | MXIM US          | Vivek Arya |
|                     | Xilinx Inc.                    | XLNX        | XLNX US          | Vivek Arya |

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| Coverage Universe | Count | Percent | Inv. Banking Relationships* | Count | Percent |
|-------------------|-------|---------|-----------------------------|-------|---------|
| Buy               | 38    | 69.09%  | Buy                         | 14    | 36.84%  |
| Hold              | 9     | 16.36%  | Hold                        | 5     | 55.56%  |
| Sell              | 8     | 14.55%  | Sell                        | 2     | 25.00%  |

**Equity Investment Rating Distribution: Technology Group (as of 30 Sep 2020)**

| Coverage Universe | Count | Percent | Inv. Banking Relationships* | Count | Percent |
|-------------------|-------|---------|-----------------------------|-------|---------|
| Buy               | 172   | 60.99%  | Buy                         | 115   | 66.86%  |
| Hold              | 54    | 19.15%  | Hold                        | 35    | 64.81%  |
| Sell              | 56    | 19.86%  | Sell                        | 24    | 42.86%  |

**Equity Investment Rating Distribution: Global Group (as of 30 Sep 2020)**

| Coverage Universe | Count | Percent | Inv. Banking Relationships* | Count | Percent |
|-------------------|-------|---------|-----------------------------|-------|---------|
| Buy               | 1749  | 54.79%  | Buy                         | 1114  | 63.69%  |
| Hold              | 677   | 21.21%  | Hold                        | 415   | 61.30%  |
| Sell              | 766   | 24.00%  | Sell                        | 386   | 50.39%  |

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| Investment rating | Total return expectation (within 12-month period of date of initial rating) | Ratings dispersion guidelines for coverage cluster* |
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| Neutral           | ≥ 0%  | ≤ 30%   |
| Underperform      | N/A   | ≥ 20%   |

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