MARKET OVERVIEW AND FD SOI OPPORTUNITIES

JULY 11, 2018
TOP-LEVEL PERSPECTIVE IN SEMICONDUCTOR INDUSTRY

- Semiconductor market will grow by 12.5% in 2018 and 7.3% in 2019
  
  There is relatively high probability that market will be in downturn in 2020

- Smartphones will continue to be largest user of semiconductors, and next phase is based on AR

- AI phase is emerging, with strong growth for processors (including neural network processors) and supporting memory
  
  ADAS is example of AI, and 100TOPS throughput is needed for level 5 autonomous driving

- AI-based smart robots will replace 0.5 billion to 1.0 billion factory workers by 2030
  
  There is similar pattern in service industry where many workers will be displaced by robots

- IoT growth will accelerate, and key factors include widespread availability of 5G and increased adoption of AI
  
  NB-IoT is also important connectivity option for IoT

- Leadership AI technology is in U.S. and U.K. (DeepMind), but China is making largest investments
  
  AI will have dramatic impact on electronics industry

KEY REQUIREMENTS IN AREAS OF SEMICONDUCTOR GROWTH INCLUDE HIGH PERFORMANCE AND LOW POWER CONSUMPTION
SEMICONDUCTOR MARKET BY PRODUCT

HIGHEST GROWTH PRODUCTS ARE DRAM AND NAND
BANDWIDTH TREND AND EMERGENCE OF 5G

PEAK DOWNLOAD RATES OF 5G WILL BE 100Gbps BY 2030

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SLIDE 4
5G ACTIVITIES

- U.S. is focused on fixed 5G (mmWave spectrums) and places lower priority on mobile 5G
  Sprint and T-Mobile have access to spectrums for mobile 5G but are in merger discussions
- 5G will support UHD video, gaming, ADAS, and IoT
- IMT-2020 (5G) Promotion Group announced China will likely distribute 5G frequency bands in H2/2018 (many bands)
  - Deployment of 5G networks is expected in H2/2019 or H1/2020
  - Large-scale commercialization of mobile 5G is planned for 2020 in China
  - Huawei has announced availability of 5G-enabled processors in H1/2019
- China expects to have one billion 5G mobile users by 2025 to 2028
- Huawei is global leader in 5G infrastructure followed by Ericsson, Nokia, Samsung, and ZTE
- 5G modems will be available from Qualcomm, HiSilicon, MediaTek, Intel, Samsung, and Unigroup Spreadtrum & RDA
  Key requirement is full application solution

5G WILL BE IMPORTANT CAPABILITY FOR WIDE RANGE OF APPLICATIONS
SMARTPHONE VOLUME

CHINESE VENDORS PRODUCE HIGHEST VOLUME OF SMARTPHONES
GATE COST OF FD SOI, FINFET, AND HKMG

FD SOI IS COST COMPETITIVE AND GIVES LOW POWER CONSUMPTION
PRODUCT OPPORTUNITIES FOR FD SOI

- Products that can obtain competitive advantages from FD SOI include:
  - ISP that is part of camera module (chip-to-chip bonding): Ultra-low power
  - ISP that is part of chipset outside of camera module: High performance and low power
  - Transceiver for LTE Advanced Pro and 5G mobile broadband (sub-6GHz): Good linearity and low noise
  - Transceiver for 5G fixed broadband (>24GHz): Good linearity and low noise
  - IoT devices with integrated RF: Ultra-low power
  - Controller products with eNVM: Metal mask integration (three to four mask steps)
  - Wearable devices: Ultra-low power

- Key factors for adoption of FD SOI include ultra-low power, relatively high performance, effective integration of RF functionality, and cost competitiveness due to lower number of mask steps for HKMG bulk CMOS and FinFETs

TECHNOLOGY IS COMPETITIVE, BUT ECOSYSTEM NEEDS TO STRENGTHEN
ISP WILL BE LARGE MARKET OPPORTUNITY FOR SUPPORT OF CIS
MATURE TECHNOLOGIES CONTINUE TO GENERATE LARGE REVENUES
FD SOI TAM

FD SOI IS WELL POSITIONED FROM PERFORMANCE, POWER CONSUMPTION, AND RF CONNECTIVITY

TAM FD SOI FOUNDRY

TAM FOR FD SOI PRODUCTS
TECHNOLOGY TRENDS

- 5nm is scheduled to be in high-volume production in 2020 (based on TSMC’s definition)
- 4nm, 3nm, and potentially 2nm structures are being developed
- 7nm FinFET is in high-volume production for chipsets for smartphones, ASICs for cryptocurrency mining, and GPUs
- 10nm represented 25% of TSMC’s revenues in Q4/2017 but will be 10% in Q4/2018
  This gives visibility in strengths and weakness of FinFETs
- Samsung is global process technology leader at ≤10nm
  TSMC, however, has strongest design enablement capabilities
- 16/14/12nm continue to be in high volume, but their volume will decline as digital designs migrate to 7nm
  Key reason is difficulty in integrating RF
TECHNOLOGY TRENDS (CONTINUED)

- 28nm and 22nm HKMG bulk CMOS are experiencing growth for integration of RF
  - Potential high growth for eMRAM
  - Samsung is leader with its STT MRAM structures
- 28/22/18nm FD SOI provides competitive advantages for:
  - Ultra-low power consumption with back biasing
  - Effective integration of RF
    - This will be important for wearables and IoT and other applications
  - Cost competitiveness with bulk CMOS and lower cost than FinFETs
- Large opportunity for FD SOI based on technology advantages
  - Key issue for FD SOI is design enablement capabilities

WIDE BREADTH OF APPLICATIONS REQUIRE DIFFERENT TYPES OF TECHNOLOGIES
CONCLUSION

▪ Semiconductor market growth is based primarily on DRAM and NAND
  Potential for decline in 2020
▪ Many applications require ultra-low power
  Demand for integrated RF is also strong
  22FDX is best technology for integrated RF
▪ Large opportunities for eNVM
  Samsung MRAM with 28nm FD SOI is best technology option
▪ Momentum is building for FD SOI
  Growth, however, is lower than expected due to very strong market position of TSMC
  Design enablement ecosystem for FD SOI has also not strengthened rapidly enough
▪ RF SOI has gained very strong market position

FD SOI IS EXPECTED TO BUILD MOMENTUM RELATIVELY RAPIDLY IN INTERIM TIME FRAME