Market Growth Drivers: Key Developments in Advanced Packaging

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- TRACK INNOVATION
- IDENTIFY TRENDS
- ANALYZE GROWTH
- INFLUENCE DECISIONS

RELEVANT, ACCURATE, TIMELY
Economic Issues Resulting from Covid-19 Pandemic

• IMF is predicting a 4.9% decline in the global economy for 2020
  – 90% of countries experiencing lower per capita income
  – Prolonged pandemic will worsen economic conditions

• Countries around the globe increase spending to dampen negative impact
  – U.S. spending $3 trillion
  – Germany and France have proposed a $545 billion in a recovery fund
  – China spending $205 billion on projects (5G, rail, power grid)

• Consumer purchases account for 70% of U.S. economic activity
  – Impacts smartphone and consumer product sales
  – Some out-of-cycle purchases of laptops, tablets, and game systems

Source: Dreamstime.com
Smartphone Sales Projected to Decline in 2020

- IDC projects smartphone shipments will decline 11.9% this year, but return to growth in Q1 2021
  - Huawei and Samsung seeing smartphone sales declines
  - China-based smartphone shipments were down ~26% in Q1 year-over-year
- Impacts unit shipments for CSPs
Apple iPhone 11 Pro Max

- **123 packages on the board**
  - 89 WLPs (either on board or inside another package)
  - More WLPs than any other smartphone
  - Application processor in TSMC’s InFO with memory package on top (InFO PoP)
  - Many packages are underfilled

- **>30 chip suppliers**
5G Still Key to Smartphone Sales

- Qualcomm predicts 5G smartphone shipments of 175 to 225 million units in 2020
  - Most will be sub-6 GHz
  - Apple is expected to launch 5G smartphone, but may have some delay
- IDC projects 5G smartphones will account for ~28% of sales by 2023
- Drives CSP growth
- Drives WLP growth

Source: Digited.
5G Phone = Package Count Increase: RF, Baseband, WLPs

- Compared to S10, the S10 5G has 1.8x more of RF/BB packages with 49% greater total package area
  - 5G phones have stand alone baseband
- More filters
- More WLPs

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<tr>
<th></th>
<th>S10 5G</th>
<th>S10/S10+</th>
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<tbody>
<tr>
<td>Total WLP Count</td>
<td>41</td>
<td>33</td>
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S10 5G package area 569 mm²
S10 package area 383 mm²
5G mmWave = Changes in Package Design and Construction

• 5G potentially means new radios, new modems, new PA, and new FEM
  – System-in-package designs with fully integrated antenna (so antenna design capabilities are important)
  – Thermal and electrical modeling become more critical
  – Electromagnetic compatibility and EMI shielding become more important

• Antenna for sub-6 GHz can be on PCB, but mmWave needs RF IC closer to antenna, therefore antenna-in-package (AiP) design critical

Source: ASE.
Source: Amkor Technology.
5G Infrastructure Rollout

• 5G infrastructure rollout
  – Expansion in China with up to 600,000 base stations to be installed this year (sub-6 GHz, mmWave in 2 years)
    • Drives demand for RF modules
    • System-in-Package
  – China build 198,000 base stations nationwide by March 2020
  – Rollout continues in U.S. (mmWave)
  – Rollout in Europe slows (spectrum auctions delayed because of Covid-19)

• Drives demand for complex SiPs
  – Laminate substrates with AiP
Apple Watch Series 5 with LTE Teardown

- **Smartwatches**
  - 12% growth in Q1 year-over-year
  - Apple Watch top sales (55% market share)
- **104 board-level packages (many WLPs)**
- **>25 chip suppliers**
Automated Social Distancing Management by Radiant

- Workers at Ford are using Samsung wrist device that vibrates with another devices is within 6 feet
  - Uses Bluetooth and RFID application software developed by Radiant

Source: Radiant.
Increased Implementation of Telemedicine

- Physicians across the U.S. tasked with launching telemedicine in MAR/APR and the market demographic is taking shape
- Key *influencers* for Telemedicine include hospitals, doctors, and American Medical Association
- Recent case study of two MDs uncovered need to immediately buy new laptops for compatibility plus Netgear Orbi System

**AMA**

Telemedicine Requirements by AMA
- ✓ High Quality Video Streaming
- ✓ Uninterrupted Coverage
- ✓ Compatibility with E.H.S.
- ✓ Security Against Cyber Attacks

Netgear Orbi RBK50 System
Using FBGAs, QFNs, WLPs
Growth Areas Despite Covid-19

- Increase in laptop and tablet sales driven by work from home and educational demand
  - Out-of-cycle demand
  - Potential for increase demand as schools remain closed this fall
- Increased use of Telemedicine
- Demand increasing for networking
- Datacenter and cloud computing expansion
- Server volumes increased in Q1, some increase in Q2
  - Driving FC-BGA substrate capacity expansion
  - Drives demand for DIMMs
- AI accelerator demand increasing
  - TSMC reports CoWoS production line at full capacity for Q2 2020
  - Future designs with FO on substrate such as ASE’s FOCoS, Amkor’s Substrate-SWIFT®, and TSMC InFO_MS

Source: Anandtech.com

Source: TSMC.
Fan-out on Substrate

- **ASE’s Fan-Out Chip on Substrate (FOCoS)**
  - RDL with 2/2µm L/S
  - Up to 3 RDLs plus UBM
  - High I/O (>1,000)
  - Production with chip first since 2016 (Hi-Silicon Network Switch)
  - Chip last qualified

- **TSMC Integrated Fan-Out on Substrate (InFO_oS) and InFO_MS**
  - RDL with 2/2µm L/S
  - Up to 3 RDLs plus UBM

- **Amkor’s Substrate Silicon Wafer Integrated Fan-out Technology (Substrate-SWIFT®)**
  - RDL with 2/2µm L/S
  - Up to 3 RDLs plus UBM

Source: ASE.

Source: Amkor.
TSMC’s InFO_oS: Homogeneous Integration

- Homogeneous Integration (split die) for MediaTek
  - 67.5 mm x 67.5 mm
  - Three RDLs
  - 2µm L/S
  - No µbump (uses C4 bump), no TSV
  - Cost is slightly less than using a Si interposer
  - Offers better electrical performance because RDLs instead of silicon (dielectric constant better with RDL than silicon)
Growth in Datacenters and AI Accelerators

• **Datacenters, cloud computing, and AI accelerator growth drivers**
  – Large amounts of data such as commercialization of 5G services, smart factory (Industry 4.0)
  – Remote working and online meetings driving demand
  – Internet shopping malls and movie streaming services
  – IBM CEO says pandemic will dramatically accelerate adoption of AI and cloud computing

• **Major cloud computing service providers**
  – Amazon, Microsoft with Azure, Google, Facebook, Baidu, Alibaba, Tencent, ByteDance, and others

Source: Google.
IC Package Substrate Expansion

- IC substrate suppliers expanding capacity for build-up substrates
  - Ajinomoto build-up material used exclusively, adding capacity
  - Servers and networking equipment driving demand
  - New GPU and CPU offerings
  - ABF substrates used with silicon interposers, FO on Substrate, and active silicon interposers
- Larger body sizes and higher layer counts require increased capacity
- Substrate suppliers including Unimicron, Ibiden, Shinko Electronic, Kinsus, Nan Ya PCB increasing capacity

Source: Intel.
Chiplets: Key Enabler for Next 10-20 Years

- Chiplet demand driven by:
  - Need for a more cost-effective solution given the economic challenging of continued silicon scaling
  - Desire to reuse IP
  - New test flows
  - Improved electrical performance
  - Reduced power consumption
  - Faster time-to-market

AMD’s Chiplet design on organic substrate

TSMC’s SoIC
Using active Si interposer

Source: TSMC.

Intel’s Foveros in Production

• In production for Samsung’s Galaxy Book 5
  – Longer battery life
  – Very thin
  – No fan

• Active interposers can include power management features, voltage regulators, DC/DC converters

• Benefits include
  – Reduced voltage drop
  – Power efficiency
  – More immediate power delivery to the CPU cores
  – Elimination of passives on substrate
  – System-wide communication across multiple chiplets/dice vs. the limited die-to-die communication capability enabled by passive Si interposers

Source: Intel.
Summary

- Continued growth in advanced packaging driven by many applications
  - OSATs benefit from this growth
- Consumer and smartphone expected to see negative impact in 2020 from pandemic-induced economic downturn
  - Growth in smartphones, driven by 5G, expected to drive growth in 2021 and beyond
- 5G infrastructure expansion with drive growth, especially in China
- Growth in datacenters and cloud computing driving growth in servers and AI accelerators
  - Drives growth in high-performance packaging
  - Drives growth for laminate substrates
  - Drives growth for memory
Thank you!

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