Smartphone Camera Module Comparison 2020 Volume 1

Overview of the latest flagship smartphone cameras released in 2019, including detailed technical and cost analyses of the Huawei P30 Pro, Samsung Galaxy S10 5G/S10+ and Apple iPhone 11 Pro.

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Physical Analysis done by Guillaume CHEVALIER & Youssef EL GHALI
March 2020 – Sample
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Executive Summary

The best way to understand the camera module market and its technology trends is a complete and detailed study of all released products.

We have chosen the latest flagship smartphones in this volume, from Samsung, Huawei and Apple, to show Camera Module choices for these three manufacturers.

The analyses cover the cameras integrated in the Samsung Galaxy S10 5G - Korea Version and S10+, the Huawei P30 Pro and finally the Apple iPhone 11 Pro. They show the complete structure, the design and the cost of the front and rear facing camera modules, from the technology node of the CMOS Image Sensor (CIS) to the camera lens.

This report is also an updated combined report of the previous “Mobile Camera Module Comparison 2019” and “Mobile CMOS Image Sensor Comparison 2019”.

Notable developments include the periscope camera in the Huawei P30 Pro and the transition to three cameras on the back for Samsung and Apple.

This report also includes an overview of cameras released in H2 of 2019 from different manufacturers. It allows monitoring of technological developments, manufacturers’ choices for CIS and Camera Module structures, the supply chain and manufacturing costs for flagship smartphones.

This report offers an overview of how different manufacturers’ technical choices have evolved. For example, the total silicon area per smartphone is 130mm² for the latest Huawei model, compared with 144mm² for Samsung’s S10 5G Korea Version. It also includes camera module and CIS die costs.

In conclusion, we perform a detailed teardown to identify the CMOS manufacturing technology and its 3D integration format, such as hybrid bonding or through-silicon-via (TSV) connections.
Reverse Costing Methodology

The reverse costing analysis is conducted in 4 phases:

**Component choice**
- Teardown of the smartphone in order to have access to the Consumer Camera Module.

**Physical Analysis**
- Package is analyzed and measured
- Molded packages are decapsulated and dies are extracted to get data on dimensions, technology node, pad number and die marking.
- Cross-section is made to have access to process structure
- Setup of the manufacturing process.

**Costing analysis**
- Setup of the manufacturing environment
- Cost simulation of the process steps

**Selling price analysis**
- Supply chain analysis
- Analysis of the selling price
Camera Modules Overview

- Samsung Galaxy S10 5G (Korea Version)
- Samsung Galaxy S10 Plus
- Huawei P30 Pro
- Apple iPhone 11 Pro

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CIS Manufacturer’s choice by OEM
Samsung Galaxy S10 5G (Korea Version) – Camera Modules Overview

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Front

Total Camera Volume:
Total CM Cost:
Total CM Price:
Release date: Feb. 2019

Front Color Camera Cross-Section
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Wide Angle Rear CM Cross-Section
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Ultra Wide-Angle Rear CM Cross-Section
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Telephoto Rear CM Cross-Section
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Module Dim.
Without flex
OIS/AF
Lenses number
Average Lens Diameter
Filter Material
TTL Distance
Mnf. Assembly

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Samsung Galaxy S10 5G (Korea Version) – CMOS Image Sensors Overview

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Huawei P30 Pro – Front Camera Module

Front Color Camera - CIS Die Overview
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Front Color Camera Cross-Section
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Detailed Physical Analysis
  - Samsung Galaxy S10
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    - Rear Tri Camera
  - Huawei P30 Pro
    - Front Camera
    - Rear Tri Camera
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    - Front Camera
    - Rear Dual Camera

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## Summary of all CCM Analyzed

<table>
<thead>
<tr>
<th>brand</th>
<th>Camera Module Overview</th>
<th>5G (Korea Version)</th>
<th>Rear Ultra Wide</th>
<th>Rear Wide</th>
<th>Rear Tele</th>
<th>Front</th>
<th>Lens Number</th>
<th>CMOS Type</th>
<th>Module Dimension (mm)</th>
<th>Module Dimension (mm)</th>
<th>Module Dimension (mm)</th>
<th>Pixel Number</th>
<th>Pixel Area (µm)</th>
<th>Diagonal (mm)</th>
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<tr>
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<td>Galaxy S10</td>
<td>Rear Ultra Wide</td>
<td>Rear Wide</td>
<td>Rear Tele</td>
<td>Front</td>
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<td>CMOS</td>
<td>16 M</td>
<td>12 M</td>
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<td>10 M</td>
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<td>HUAWEI</td>
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<td>Rear Ultra Wide</td>
<td>Rear Wide</td>
<td>Rear Tele</td>
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<tr>
<td>Apple</td>
<td></td>
<td>iPhone 11 Pro</td>
<td>Rear Ultra Wide</td>
<td>Rear Wide</td>
<td>Rear Tele</td>
<td>Front</td>
<td>3</td>
<td>CMOS</td>
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All camera modules have which uses a substrate and a substrate on all these camera modules as well as an assembly of the CIS in flip chip configuration.

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**General Module Structure - Example**

- Example

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**Cost Comparison**
- General Module Structure
  - Sony Process Description
  - Samsung Process Description
  - Process Comparison
  - CIS Die Cost Comparison
    - Front Facing
    - Rear Facing
  - Total CIS Die Price
- CM Cost Comparison
  - Front Facing
  - Rear Facing
  - Total CM Price

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**Detailed Physical Analysis**

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# Front Camera CIS – Front-End Cost

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<th>Samsung Galaxy S10</th>
<th>Samsung Galaxy S10+</th>
<th>Samsung Galaxy S10e</th>
<th>Huawei P30 Pro</th>
<th>Apple iPhone 11 Pro</th>
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<tr>
<td><strong>Front Facing</strong></td>
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<td>Raw wafer Cost ($)</td>
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<td>Clean Room Cost</td>
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<td>Equipment Cost</td>
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<td>Consumable Cost</td>
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<td>Labor Cost</td>
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<td>Yield Losses Cost</td>
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<td><strong>Total CIS Die Price</strong></td>
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<tr>
<td><strong>CM Cost Comparison</strong></td>
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<td><strong>Rear Facing</strong></td>
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<td><strong>Total CM Price</strong></td>
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**Detailed Physical Analysis**

- BSF & Cu-Cu Hybrid Bonding / TSV
- Front Camera CIS – Front-End Cost
- Rear Camera CIS – Front-End Cost
## Front Camera CIS – CIS Die Cost

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  - Rear Facing
- Total CM Price

### Cost Comparison

- FE: Logic Circuit Cost
- FE: Pixel Array Cost
- FE: BSI & Cu-Cu Hybrid Bonding Cost
- FE: CIS CF+Spacer+ML Cost
- BE0: Probe & Optical Test Cost
- BE0: Dicing Cost

<table>
<thead>
<tr>
<th></th>
<th>Samsung Galaxy S10</th>
<th>Samsung Galaxy S10+</th>
<th>Samsung Galaxy S10+</th>
<th>Huawei P30 Pro</th>
<th>Apple iPhone 11 Pro</th>
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<tbody>
<tr>
<td><strong>Front</strong></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
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<td><strong>Main</strong></td>
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<td><strong>Second</strong></td>
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<tr>
<td><strong>Total Wafer Cost</strong></td>
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Huawei P30 Pro - Main Rear CM – CIS Delaying & Cross-Section

- Delayering – Optical View
- Transistor in Logic Circuit – SEM View
- Pixels – SEM View
- Pixel Array + Logic Circuits Cross-section – SEM View

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Apple iPhone 11 Pro – Main Front Camera – CIS Delayering

Pixel Array circuit (BSI)
- Microlenses & Color filters
- Active silicon with pixels
- CIS Circuit XX Metal Layers
- Logic Circuit XXX Metal Layers
- Silicon Substrate

Logic circuit
- SIN
- Oxide
- XXX Bonding

Technology Node estimated
- Wafer Bonding

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Apple iPhone 11 Pro - Telephoto Rear CM Cross-Section - Overview
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IMAGING
- Mobile camera Module Comparison 2020
- Mobile CMOS Image Sensor Comparison 2020
- Sunny Optical Folded Optics “Periscope” Camera Module

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- Status of the Camera Module Industry 2019 – Focus on Wafer Level Optics
- Status of the CMOS Image Sensor Industry 2019
- CMOS Image Sensor Service – Imaging Research