Mobile CIS Comparison 2019
Physical Analysis & Cost Comparison

Imaging report by Audrey LAHRACH
Physical Analysis done by Guillaume CHEVALIER
March 2019 – version 1
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Executive Summary

To offer an idea of the actual state-of-the-art in CMOS Image Sensors for leading flagships sold in 2018, Yole Developpement and SystemPlus Consulting offer two connected reports. Along with Yole Development’s “Status of CMOS Image Sensor Industry 2018”, this overview will give you a comprehensive technical and cost evaluation of the main OEM choices.

We have conducted this comparative study to provide insights into the structure and technology of 28 CIS die in seven flagship smartphones from several major brands: the Apple iPhone X; Samsung Galaxy S9 Plus; Huawei P20 Pro; Huawei Mate 20 Pro; Xiaomi Mi8 Explorer Version; Oppo Find X; and Vivo X21UD. This report is connected to the SystemPlus Consulting’s “Mobile Camera Module Comparison 2019” report, which gives an overview and details about the structure of each camera module.

The report has shown that the four manufacturers of CIS presented in the flagships, Sony, Samsung, Omnivision and STMicroelectronics, have totally different approaches. For example, Sony is the only manufacturer using hybrid bonding in the analyzed devices, having completely dropped fusion bonding with Through-Silicon Vias (TSVs). We have extracted further technical choices from the four players from the analysis and comparisons.

We analyze the CIS dies integrated in rear and front-facing CMOS Camera Modules (CCMs) including main cameras, wide angle, telephoto and near global shutter infrared, from technology node to die size. Additionally, we have studied the costs of the CISs to compare the economic choices of the manufacturers.
The reverse costing analysis is conducted in 3 phases:

1. **Teardown analysis**
   - The dies are extracted in order to get overall data: dimensions, technology node, pad number and die marking.
   - Setup of the manufacturing process.

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

3. **Selling price analysis**
   - Supply chain analysis
   - Analysis of the selling price
Camera Module Overview: Breakdown per Type and CIS Manufacturer
Overview From Smartphones Level to CIS Die Level

Overview / Introduction

Company Profile
- Smartphones Level
  - 6 OEMs
    - Teardown smartphones
- CIS Level
  - 3 Visible CIS Mnf.
  - 3 Infrared CIS Mnf.

Physical Comparison
Physical Evolution
Manufacturing Process
Cost Comparison
Detailed Physical Analysis
Related Reports
About System Plus

RGB Front Camera Module Overview
©2019 by System Plus Consulting

Camera Module Extraction Example

Example of Camera Module Exploded View

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Apple iPhone X – CMOS Image Sensors Overview

Overview / Introduction

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  - 3 Infrared CIS Mnf.

Physical Comparison

Physical Evolution

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Related Reports

About System Plus

Total Silicon Die Area: xxxmm²

Die Area: xxxmm² (xx x xx mm)
Pad number: xxx
Pixel array: xxxmm²
Resolution: xxxx
→ Pixel size: xxxµm

NIR Front Color Camera - CIS Die Overview
©2019 by System Plus Consulting

Front Color Camera - CIS Die Overview
©2019 by System Plus Consulting

Front

Rear

Die Area: xxxmm² (xx x xx mm)
Pad number: xx
Pixel array: xxxmm²
Resolution: xxxx
→ Pixel size: xµm

Telephoto Camera - CIS Die Overview
©2019 by System Plus Consulting

Wide Angle Camera - CIS Die Overview
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## Summary of all CCM Analyzed

<table>
<thead>
<tr>
<th>OEM</th>
<th>Smartphone</th>
<th>Position</th>
<th>CM Number</th>
<th>Sensor Ref.</th>
<th>Sensor Mfr.</th>
<th>Wafer Bonding Process</th>
<th>Sensor die size (mm²)</th>
<th>PDAW per 12-inch wafer</th>
<th>PAW Numbers</th>
<th>Pixel Array Circuit Process</th>
<th>Trans. Metal Layer Height (µm)</th>
<th>Metal Layer Height (µm)</th>
<th>Metal Layer Height (µm)</th>
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<th>Pixel Array Width (cm)</th>
<th>Pixel Array Diagonal (cm)</th>
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<tbody>
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<td>Samsung</td>
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</table>
Both pixel arrays are close to xxmm² but the Huawei P20 Pro CIS die has a xxx xxx more xxx than the Vivo X21 UD. Huawei has integrated a xxxx CIS die which used a pixel size of xxxµm and a xxxxx xxxxxx process unlike Vivo that has integrated a sensor from xxxx which used a pixel size of xxxµm with a xxxxxx process.
Xiaomi has kept the same die from XXXX for his telephoto camera in the Xiaomi Mi6 and the Mi8. The second die (wide angle) from XXXX has changed, they have kept the same XXXXXX but has changed the XXXXX and so the XXXX.
Cu-Cu Hybrid Bonding Process
### Infrared Front CM – CIS Front-End Cost

<table>
<thead>
<tr>
<th></th>
<th>Front-End</th>
<th>iPhone X</th>
<th>Mate 20 Pro</th>
<th>Xiaomi Mi8</th>
<th>Oppo Find X</th>
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<td>Raw wafer Cost (Si)</td>
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<td>NIR Image Sensor Front-End Cost</td>
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<td>Spacer, Microlenses &amp; CF Front-End Cost</td>
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</tbody>
</table>
# Infrared Front CM – CIS Front-End Cost

## Overview / Introduction

- Company Profile
- Physical Comparison
- Physical Evolution
- Manufacturing Process

## Cost Comparison
- **Visible**
  - Sony
  - Omnipision
- **Infrared**
  - Omnipision
  - STMicroelectronics
  - Samsung

## Detailed Physical Analysis

## Related Reports

## About System Plus

### Table: Total Front-End Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>iPhone X</th>
<th>Mate 20 Pro</th>
<th>Xiaomi Mi8</th>
<th>Oppo Find X</th>
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<td><strong>Breakdown</strong></td>
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<td>Raw Substrate (Si 24mm)</td>
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<td>Microlenses</td>
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<td>Yield Losses Cost</td>
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</table>
## Infrared Front CM – CIS Die Cost

### Table: Infrared Front CM – CIS Die Cost

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<thead>
<tr>
<th></th>
<th>iPhone X</th>
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<th>Xiaomi Mi8</th>
<th>Oppo Find X</th>
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<td><strong>Visible</strong></td>
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<td>Samsung</td>
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### Detailed Physical Analysis

- **Front-End Cost**
  - BE: Probe Test Cost
  - BE: Dicing Cost

### Related Reports

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### About System Plus
Infrared Front CM – CIS Die Cost
## CIS Manufacturer’s choice by OEM

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<th>CIS Manufacturer</th>
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<tr>
<td><strong>Apple</strong></td>
<td>iPhone X&lt;br&gt;iPhone XS Max&lt;br&gt;iPhone X©</td>
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<td>Galaxy S9+</td>
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<td><strong>oppo</strong></td>
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<td><strong>vivo</strong></td>
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<td><strong>huawei</strong></td>
<td>P20 Pro&lt;br&gt;Mate20 Pro</td>
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        - Xiaomi Mi8
        - Vivo X21UD
        - Huawei P20 Pro
        - Mate 20 Pro

Related Reports
About System Plus

Total CIS Die Area per smartphone

3 Camera Modules
4 Camera Modules
5 Camera Modules

iPhone X
mi8
Vivo X21
Samsung galaxy S9
Oppo Find X
Xiaomi Mi8
Vivo X21UD
Huawei P20 Pro
Mate 20 Pro

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Rear CIS Die xxx – Cross-Section – ‘Manufacturer’ – xxx Bonding

Pixel Array circuit (BSI)

Logic circuit

Silicon Substrate

Active silicon with pixels

CIS Circuit × Metal Layers

Logic Circuit × Metal Layers

Microlenses & Color filters

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Rear CIS Die xxx – Cross-Section – ‘Manufacturer’ – xxx Bonding

Pixel Array circuit (BSI)

Logic circuit

Active silicon with pixels

CIS Circuit 4 Metal Layers

Logic Circuit x Metal Layers

Silicon Substrate

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Pixel Array + Logic Circuits Cross-section – SEM View
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Proliferation of cameras for imaging and sensing is driving CMOS image sensor (CIS) growth

KEY FEATURES OF THE REPORT
- 2017-2023 Forecast
- 2017 M&A activity
- Ecosystem update
- Dual and 3D camera trends for mobile
- Mobile applications and technology

Bundle offer possible with the Mobile CMOS Image Sensor Comparison 2019 report by System Plus Consulting, contact us for more information.
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**IMAGING**
- Mobile Camera Module Comparison 2019
- Mantis Vision’s 3D Depth Sensing System in the Xiaomi Mi8 Explorer Edition
- Orbbec’s Front 3D Depth Sensing System in the Oppo Find X
- STMicroelectronics’ Near Infrared Camera Sensor in the Apple iPhone X
- Sony IMX400 Tri-layer Stacked CMOS Image Sensor (CIS) with Integrated DRAM and DSP

**MARKET AND TECHNOLOGY REPORTS - YOLE DÉVELOPPEMENT**

**IMAGING**
- Status of the Camera Module Industry 2019 – Focus on Wafer Level Optics
- Status of the CMOS Image Sensor Industry 2018
- 3D Imaging & Sensing 2018
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(>130 analyses per year)

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(>60 reports per year)

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The transport costs and risks are fully born by the Buyer. Should the customer wish to ensure the goods against lost or damage on the base of their real value, he must imperatively point it out to System Plus Consulting when the shipment takes place. Without any specific requirement, insurance terms for the return of goods will be the carrier current ones (reimbursement based on good weight instead of the real value).

8. FORCE MAJEURE
System Plus Consulting responsibility will not be involved in non execution or late delivery of one of its duties described in the current terms and conditions if these are the result of a force majeure case. Therefore, the force majeure includes all external event unpredictable and irresistible as defined by the article 1148 of the French Code Civil?

9. CONFIDENTIALITY
As a rule, all information handed by customers to System Plus Consulting are considered as strictly confidential. A non-disclosure agreement can be signed on demand.

10. RESPONSIBILITY LIMITATION
The Buyer is responsible for the use and interpretations he makes of the reports delivered by System Plus Consulting. Consequently, System Plus Consulting responsibility can in no case be called into question for any direct or indirect damage, financial or otherwise, that may result from the use of the results of our analysis or results obtained using one of our costing tools.

11. APPLICABLE LAW
Any dispute that may arise about the interpretation or execution of the current terms and conditions shall be resolved applying the French law.
It the dispute cannot be settled out-of-court, the competent Court will be the Tribunal de Commerce de Nantes.