Sunny Optical Folded Optics “Periscope” Camera Module

x5 optical zoom in Huawei P30 Pro

SP19469 - IMAGING report by Audrey LAHRACH
PHYSICAL ANALYSIS done by Guillaume CHEVALIER

July 2019 – Sample
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Executive Summary

This full reverse costing study has been conducted to provide insight on technology data, manufacturing cost and selling price of the Huawei P30 Pro Folded Optics Periscope Camera Module.

The competition for the best camera phone is led by Huawei with its latest flagship product, the P30 Pro. Huawei has been in this position before, as its P9 model was among the first to switch to dual cameras on the back. The module in the P30 Pro that integrates a CMOS Image Sensor (CIS) from Sony, which uses Exmor-RS Technology, has now an 8.2M pixel resolution telephoto camera offering x5 optical zoom and x50 digital zoom.

The Huawei P30 Pro Periscope Camera is integrated in a quad camera solution in the rear face of the phone. The quad camera solution includes a main camera, a wide-angle camera and a folded optic periscope for the telephoto camera function, combined with a time-of-flight (TOF) camera. This configuration produces better photo quality.

The P30 Pro telephoto camera module has dimensions of 29mm x 17.8mm x 5.85mm. It is equipped with a Sony CIS, a Sunny optical 5-element lens and prism, and a TDK autofocus (AF) and optical image stabilization (OIS) component.

This is the first camera that integrates a prism in the optical part. Thanks to the prism, the CIS receives light at 90° compared to the direction of the photo taken. This gives more space for the optical module to move compared to standard telephoto camera module.

The report includes a complete technology and cost analysis of the Huawei P30 Pro folded optic periscope camera module that includes the CIS die, the lens module, the prism, the voice coil motor (VCM) and the housing. Also, comparisons with the Huawei P20 Pro telephoto camera are provided. These comparisons highlight structures, technical choices and manufacturing cost.
Executive Summary

The reverse costing analysis is conducted in 3 phases:

Teardown analysis
- Package is analyzed and measured
- The dies are extracted in order to get overall data: dimensions, main blocks, pad number and pin out, die marking
- 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
Periscope Camera Module Views & Dimensions

- Smartphone disassembly
- Folded Optics Periscope CM
- Prism Part
- Lens Module
- Camera Module Cross-Section
- CIS Die

Physical Comparison
Manufacturing Process Flow
Cost Analysis
Cost Comparison
Selling Price Analysis
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Periscope Camera Module RX View

Periscope CM Overview – X-ray view
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Periscope Camera Module Disassembly – FPC Substrate Removed
Periscope Prism Overview
Periscope Lens Module Disassembly

Physical Analysis
- Smartphone disassembly
- Folded Optics Periscope CM
- Prism Part
- Lens Module
- Camera Module Cross-Section
- CIS Die

Physical Comparison

Manufacturing Process Flow

Cost Analysis

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Lens module Disassembly – Metal Cover removed
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Package Cross-Section

Cross-section plane #1

Physical Analysis
- Smartphone disassembly
- Folded Optics Periscope CM
- Prism Part
- Lens Module
  - Camera Module Cross-Section
- CIS Die

Physical Comparison

Manufacturing Process Flow

Cost Analysis

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CIS Overview & Dimensions

- Die Area: $xxx \text{ mm}^2$
  
  $(xxx \times xxx \text{ mm})$

- Nb of PGDW per 12-inch wafer: $xxxx$

- Pad number: $xx$
  
  Connected: $xx$

- Pixel array: $xx \text{ mm}^2$
  
  $(xxx \times xxx \text{ mm})$

- CIS resolution: $3300 \times 2475$
  
  $(8.2 \text{Mp})$
  
  Pixel area: $xxx \mu\text{m}^2$
  
  Pixel size: $xxx \mu\text{m}$
Sensor Process – Technology Node

- The process uses CMOS transistors
- MOS transistor gate length: xxnm
  - Technology node: xxnm
Sensor Cross-Section – Metal Layers

Pixel Array circuit (BSI)

Logic circuit

Microlenses & Color filters
Active silicon with pixels
CIS Circuit Metal Layers
Logic Circuit Metal Layers
Silicon Substrate
CIS Front-End Process
Logic Circuit Front-End Cost

The front-end cost for logic circuit ranges from $xxx to $xxx according to yield variations.

The largest portion of the manufacturing cost is due to the xxxxxxxx at xx%.

We estimate a gross margin of xx% for the foundry xxx, which results in a front-end price ranging from $xxx to $xxx. This corresponds to the selling price to xxxx.
## Total CIS Front-End Cost

<table>
<thead>
<tr>
<th>Total Front-End</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Breakdown</td>
<td>Cost</td>
<td>Cost</td>
<td>Cost</td>
</tr>
<tr>
<td>Raw Wafers</td>
<td>$xxxx</td>
<td>$xxxx</td>
<td>$xxxx</td>
</tr>
<tr>
<td>Logic Circuit</td>
<td>$xxxx</td>
<td>$xxxx</td>
<td>$xxxx</td>
</tr>
<tr>
<td>Pixel Array Circuit</td>
<td>$xxxx</td>
<td>$xxxx</td>
<td>$xxxx</td>
</tr>
<tr>
<td>BSI &amp; Cu-Cu Hybrid Bonding</td>
<td>$xxxx</td>
<td>$xxxx</td>
<td>$xxxx</td>
</tr>
<tr>
<td>Color Filters &amp; Microlenses</td>
<td>$xxxx</td>
<td>$xxxx</td>
<td>$xxxx</td>
</tr>
<tr>
<td>Yield losses</td>
<td>$xxxx</td>
<td>$xxxx</td>
<td>$xxxx</td>
</tr>
</tbody>
</table>

### Total CIS Front-End Cost

The **front-end cost** for the CIS ranges from $xxxx to $xxxx according to yield variations.

The largest portion of the manufacturing cost is due to the xxxx at xxx%.
### Lens Module Cost

<table>
<thead>
<tr>
<th>Lens Module CM</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
<tr>
<td>Barrel Cost</td>
<td>123.45</td>
<td>67.89</td>
<td>123.45</td>
</tr>
<tr>
<td>Plastic Lenses Cost</td>
<td>56.78</td>
<td>98.76</td>
<td>56.78</td>
</tr>
<tr>
<td>Plastic Spacer</td>
<td>98.76</td>
<td>98.76</td>
<td>98.76</td>
</tr>
<tr>
<td><strong>Lens Module BOM Cost</strong></td>
<td><strong>56.78</strong></td>
<td><strong>98.76</strong></td>
<td><strong>56.78</strong></td>
</tr>
<tr>
<td>Assembly Cost</td>
<td>123.45</td>
<td>67.89</td>
<td>123.45</td>
</tr>
<tr>
<td>Yield losses Cost</td>
<td>98.76</td>
<td>98.76</td>
<td>98.76</td>
</tr>
<tr>
<td><strong>Lens Module Total Cost</strong></td>
<td><strong>222.22</strong></td>
<td><strong>166.66</strong></td>
<td><strong>222.22</strong></td>
</tr>
<tr>
<td>Gross Profit</td>
<td>222.22</td>
<td>166.66</td>
<td>222.22</td>
</tr>
<tr>
<td><strong>Lens Module Total Price</strong></td>
<td><strong>222.22</strong></td>
<td><strong>166.66</strong></td>
<td><strong>222.22</strong></td>
</tr>
</tbody>
</table>
Camera Module Cost

<table>
<thead>
<tr>
<th>Component</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
<tr>
<td>CIS Dies Cost</td>
<td>$1,000</td>
<td>95.7%</td>
<td>$1,000</td>
</tr>
<tr>
<td>Lens Modules Cost</td>
<td>$200</td>
<td>6.1%</td>
<td>$200</td>
</tr>
<tr>
<td>AFA / OIS</td>
<td>$300</td>
<td>5.2%</td>
<td>$300</td>
</tr>
<tr>
<td>Prism Part</td>
<td>$400</td>
<td>3.9%</td>
<td>$400</td>
</tr>
<tr>
<td>Final Assembly &amp; Test Cost</td>
<td>$500</td>
<td>3.0%</td>
<td>$500</td>
</tr>
</tbody>
</table>

Component Cost Breakdown (Medium Yield)

Cost Analysis
- Cost Analysis Summary
- Yields Explanation & Hypotheses
- CIS Sensor Cost
- Camera Module Assembly Cost
- Camera Module Cost

Cost Comparison

Selling Price Analysis

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IMAGING
• Mobile CMOS Image Sensor Comparison 2019
• Mobile Camera Module Comparison 2019
• Huawei Mate 20 Pro’s 3D Depth-Sensing System

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
• CMOS Image Sensor Service – Imaging Research
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