Reverse Costing Analysis

Apple iPhone 6S Plus Rear-Facing Camera Module

December 2015 – Version 1 – Written by Elena Barbarini
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• This full reverse costing study has been conducted to provide insight on technology data and manufacturing cost of the iPhone 6S Plus rear-facing camera module.

• The iPhone 6s Plus camera module integrates the 12Mpixel resolution CMOS Image Sensor, with aperture of f/2.2 and a pixel size of 1.22µm. The decreasing of the pixel size implies the introduction of Deep Trench Isolation structure, thus with this device Apple follows the other manufacturers and introduces this technology.

• Respect to the iPhone 6 Plus the logic ISP circuit with 45nm technology node process, the assembling structure and the 5-elements lens module are the same; otherwise technical ameliorations of the VCM brings to a better quality of the autofocus and the OIS.

• The CIS is assembled in flip-chip on a ceramic substrate with a gold stud bumping process and uses the technology from Sony (Exmor-RS). The technology consists in a stacking of two separate chips using optimized processes: a pixel array circuit which uses a Back-Side Illuminated (BSI) technology, and a logic ISP circuit.

• For this device Apple has significantly modified part of the supply chain.
Camera Module Disassembly

- Glass Plate with IR Filter
- Ceramic Substrate
- Passives components
- Ceramic Substrate with IR Filter glass Plate
- VCM Driver
- Hall element
**Auto-Focus Driver**

- **Analog Devices Driver**
  - Package type:
  - Dimensions (active):
  - Thickness:
  - Pin pitch:
  - Marking:
Camera Module Cross-Section – IR Filter

Overview

IR Filter Cross-Section – SEM View

- The top side of the glass plate holds the IR filter.
CIS View and Dimensions

- Die Area:
- Nb of PGDW per 12-inch wafer:
- Pad number:
- Pixel array:
- CIS resolution:
  - Pixel area: 1.48μm²
  - Pixel size: 1.22μm

CIS top view (microlenses and color filters removed)
CIS Pixel

Overview

Pixels – SEM View

Pixels – SEM View

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Apple iPhone 6s Plus - Camera Module
## Pixel Array Circuit Front-End Cost

<table>
<thead>
<tr>
<th>Pixel Array Circuit</th>
<th>Low Yield</th>
<th></th>
<th>Medium Yield</th>
<th></th>
<th>High Yield</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
<td>Breakdown</td>
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<tr>
<td>Raw wafer (Si epi)</td>
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<tr>
<td>Clean Room</td>
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<tr>
<td>Equipment</td>
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<tr>
<td>Consumable</td>
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<td>Labor</td>
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<tr>
<td>Yield losses</td>
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</tbody>
</table>

### Pixel Array Circuit Cost Breakdown (Medium Yield)

- **The front-end cost** for the Pixel Array Circuit ranges from **according to yield variations.**

- **The largest portion of the manufacturing cost is due to the**
<table>
<thead>
<tr>
<th></th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CIS Wafer Cost</strong></td>
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<td></td>
</tr>
<tr>
<td>Nb of potential dies per wafer</td>
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</tr>
<tr>
<td>Nb of good dies per wafer</td>
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<tr>
<td><strong>FE : Logic Circuit Cost</strong></td>
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<tr>
<td><strong>FE : Pixel Array Cost</strong></td>
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<tr>
<td><strong>FE : BSI &amp; TSV Cost</strong></td>
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</tr>
<tr>
<td><strong>FE : CIS CF+Spacer+ML Cost</strong></td>
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<tr>
<td><strong>BE 0 : Test &amp; Dicing Cost</strong></td>
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<tr>
<td><strong>BE 0 : Yield losses Cost</strong></td>
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<tr>
<td><strong>CIS Die Cost</strong></td>
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<tr>
<td><strong>Sony Gross Profit</strong></td>
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<tr>
<td><strong>CIS Die Price</strong></td>
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</tbody>
</table>

- The number of **good dies per wafer** is estimated to range from [number] to [number] according to yield variations, which results in a **die cost** ranging from [number] to [number].

- We estimate a **gross margin** of [number]% for Sony, which results in a **die price** ranging from [number] to [number]. This corresponds to the selling price to Apple.
# Camera Module Cost

<table>
<thead>
<tr>
<th>Camera Module</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>Lens Module Price</td>
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<tr>
<td>Autofocus Actuator / OIS Price</td>
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<td></td>
<td></td>
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<tr>
<td>CIS Die Price</td>
<td></td>
<td></td>
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<tr>
<td>Final Assembly &amp; Test Price</td>
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<tr>
<td><strong>Camera Module Cost</strong></td>
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</tbody>
</table>

## Camera Module Cost Breakdown (Medium Yields)

- The camera module cost ranges from [BLANK] according to yield variations.
- This corresponds to the acquisition price for Apple.
- The CIS die represents [BLANK] of the module cost.
Reverse costing analysis represents the best cost/price evaluation given the publically available data, and estimates completed by industry experts.

Given the hypothesis presented in this analysis, the major sources of correction would lead to a +/- 10% correction on the manufacturing cost (if all parameters are cumulated).

These results are open for discussion. We can reevaluate this circuit with your information. Please contact us: